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POULTRY IN THE 21ST CENTURY
AVIAN INFLUENZA AND BEYOND

International Poultry Conference
Bangkok, November 2007

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Left image: Olaf Thieme
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International Poultry Conference
Bangkok, November 2007

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2008

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During the conference Ms Jenni Kiilholma, Ms Ruchdaporn Choksombatchai (Lek) and staff from ECTAD, Bangkok, undertook the administrative and operational arrangements. Mr Terry Clayton recorded the discussions and prepared a summary report of the conference. Ms Nancy Morgan (FAO, Bangkok) and Mr Antonio Rota (IFAD) facilitated the Round Table discussions on Large Poultry Production and Small Poultry Production, respectively.

Mr Frands Dolberg (consultant) reviewed all the draft papers and made editorial suggestions. Graphic design and layout was undertaken by Mr Pablo Giallo.

The Animal Production and Health Division would also like to express its appreciation to all the participants, especially those who supported themselves, for their time and contributions.

Introduction

The global poultry sector is characterized by faster growth in consumption and trade than any other major agricultural sector. Structural changes in poultry production and marketing have been driven by the growing demands of urban markets. While the majority of poultry in developing countries are still kept by smallholders, a strong and internationally linked poultry industry has evolved by utilizing economies of scale and technology. Experiences in recent years have shown that smallholder poultry production systems can offer a useful entry point for development programmes addressing extreme poverty and food insecurity, especially where traditional and small commercial flocks are the domain of women. While these are positive features, the outbreaks of highly pathogenic avian influenza since 2003 have led to criticism of smallholder production systems.

In response, the Animal Production and Health Division (AGA) prepared the concept and programme of an international poultry conference to assess the current and future trends in the poultry sector and their social, environmental and health implications. The findings and conclusions of the conference are expected to assist in the identification of policy measures that address the consequences of structural change in the poultry sector.

Three main themes were identified for the conference:

- sector trends and impacts
- risks and opportunities for poultry production
- poultry as a development tool

For each of the themes, several authors were identified to prepare background and review papers on specific topics. Five poultry sector country studies were commissioned for important poultry producing countries, namely: Brazil, China, Egypt, India and Thailand. An expert consultation, including key authors, was held 3-4 May 2007 in Rome to further develop the topics and scope of the conference.

Participants were personally invited in order to ensure a balanced geographical, technical and institutional representation. All sectors of the poultry industry were represented including multinational corporations, poultry breeding companies, international agencies, as well as the research, development and NGO communities. It was this unique "coming together" of key stakeholders in the poultry sector that made this conference so stimulating and valuable.

The accompanying CD-Rom contains all presentations that were given during the conference as well as the background papers prepared by the authors. The booklet provides only the summary of the conference and of the background papers. This publication is intended to provide information concerning the global development of the poultry sector and to provide policy guidance for the future.

The organizers:

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Welcome address

He Changchui
FAO Assistant Director-General and Regional Representative for Asia and the Pacific
Bangkok, Thailand

Distinguished participants,
Ladies and gentlemen,

On behalf of the Food and Agriculture Organization of the United Nations, my colleague Dr Samuel Jutzi, Director of the Animal Production and Health Division, and my own behalf, I welcome you all to this important International Poultry Conference being held in the beautiful capital of Thailand.

It is a great pleasure and honour for me to open this conference, which has attracted a wide and impressive range of distinguished experts and decision makers. Participants in the conference come from the whole spectrum of the poultry sector: commercial and small scale producers, traders, research and development partners, as well as representatives from the non-governmental and donor communities. You have come together with the ambitious objective to explore and advise on best scenarios for the future of the poultry sector – a sector which faces many crucial challenges.

Meeting expanding global demands for livestock products - particularly poultry meat and eggs – the poultry sector has grown rapidly over the last couple of decades. Aided by technological advances in production, processing and marketing, annual growth in poultry production has outstripped all other agricultural commodities for many years. The rapid intensification of poultry production in developed and many developing countries was largely driven by specialization, concentration, greater biological efficiency, economies of scale and vertical integration. This trend has been particularly evidenced in Asia where annual production gains of over 6 percent allowed the industry to provide a competitive source of low-priced animal protein to consumers – although concerns have been raised about industry integration, linkages to the spread of animal diseases and environmental impact.

At the same time traditional, less intensive low input poultry production has continued to be a common and important practice in most developing countries. These traditional systems have diverse functions and respond to different social, cultural and economic objectives. While large scale, intensive production supplies rapidly expanding urban markets, the smaller scale production systems continue to satisfy local and often niche markets, as well as contributing to household food security in poor and vulnerable communities. Increasingly, there is also a growing, and economically important small to medium scale commercial sector that does not readily benefit from the economies of scale associated with the large scale sector nor from easy access to either traditional or more sophisticated urban markets.

Ladies and gentlemen,

Highly Pathogenic Avian Influenza started in Asia in late 2003 and in the meantime has spread to several continents, affecting over 60 countries. The human cost of the bird flu has attracted world attention and intense media scrutiny of the role played by the poultry sector. An international meeting dealing with poultry production can and should thus not ignore the issue and impact of the Highly Pathogenic Avian Influenza emergency.

The poultry sector has suffered severe economic losses and very substantial investments needed to be made – both by the sector itself and the donor community – in disease prevention and control. It can not be overemphasized that the international community must continue unabated efforts for the prevention and control of HPAI. HPAI has become endemic in many parts of the world, and the consequences of failure to stem the spread of the virus are just too great to ignore; in particular the risk to human health has never disappeared. This challenge is daunting, confronting nearly 19 billion poultry in the world, half of whom are resident in Asia.

FAO and its partners are addressing the multiple challenges and are committed to do so at all necessary levels. Over the past four years, FAO has designed and implemented more than 116 projects in assisting countries to fight the HPAI crisis and has mobilized more than 156 million dollars. Another 37 projects costing 66 million dollars are in the pipeline. This programme endeavours to supplement and support the substantial investments undertaken by governments of affected countries through their own domestic budgets.

Effective control of avian influenza will require, in addition to the core veterinary interventions that target the virus itself, changes in attitudes of everyone involved in the poultry food chain from production through to marketing and consumption. Certainly the challenges posed by Avian Influenza, or any other disease, raise questions about how policy makers need to respond and whether industries need to be restructured. Dialogue on these issues is critical since some of these changes may have to be radical, implying major social, environmental and public health dimensions as well as potential impact on livelihood of millions of poor and small producers.

Ladies and gentlemen,

It is clear that important technical, institutional and policy issues need to be addressed by the poultry sector as a whole if the objective of safe, environmentally and socially sound development is to be achieved. This will require innovative and courageous solutions. Given that the poultry sector is the most vigorous, dynamic and fast changing livestock sub-sector, the challenges faced by scientists, technicians, practitioners, producers and policy makers are particularly significant.

This conference provides an opportunity to assess the challenges and opportunities facing the world's poultry sector and to explore the social, economic, technical, environmental and biodiversity implications of change. The conference is expected to explore future scenarios for the sector, identify possible roadmaps for industry development, and, most importantly, to discuss priorities for action.

The wide range of expertise assembled today, representing all aspects of the poultry sector, will hopefully enable a well informed, balanced and comprehensive assessment of the challenges facing the poultry sector and the overall opportunities for contributing to sustainable agricultural development. It is my sincere hope that this consultation will serve

as an important milestone and reference point in the future development of the poultry sector.

Ladies and gentlemen,

Before concluding, may I wish you open, stimulating, constructive, productive and innovative - but also enjoyable - deliberations and debates. Let us try to turn this conference not into just another meeting but into a real opportunity to advise and guide this important agricultural sector that has such potential to support agricultural livelihoods and economic development, not only in Asia but globally.

Thank you.

Summary report

OBJECTIVES OF THE CONFERENCE

Approximately 100 participants from across the world participated in the FAO-sponsored International Conference *"Poultry in the 21st century – avian influenza and beyond"*. All sectors of the poultry industry were represented including the poultry breeding companies, other multinationals and international agencies, as well as the research, animal health, development and NGO communities. The objective was to review the global poultry sector in its entirety, to assess past developments, and to explore scenarios for its future. Special attention was given to the social, environmental and health implications of changes in the poultry sector and to the policy measures needed to address such change. The conference was opened by Mr Changchui He, Assistant Director General of FAO's Regional Office for Asia and the Pacific.

An introductory presentation highlighted the following points for participants to bear in mind during their deliberations:

1. The poultry sector is an indicator of a fundamental problem facing the global livestock sector. Largely unregulated growth in response to rapidly growing demand has created human-health and environmental risks; there is growing pressure to reduce these risks.
2. The poultry sector is flexible and responsive to external pressures – it offers opportunities to address the above-mentioned problem.
3. There is more than one possible development pathway. "Twin-track" or even "multi-track" development is likely and desirable, with backyard and industrial systems continuing to exist within the same countries; however, these very different systems should be located in different spaces.
4. Change will provide opportunities for some people, but may create negative externalities for others including vulnerable people.
5. Policy can provide an environment for economic growth while at the same time offering protection to vulnerable people.

PAPERS AND WORKING GROUPS

The conference was divided thematically into three sessions with presentation of papers followed by plenary discussions.

The first session examined sector trends and underlying drivers, and considered some of the impacts of sector development. Papers were presented on:

- Global poultry sector trends and external drivers of structural change.
- Country case studies from China, Thailand, India and Egypt.
- Assessment of inter-country differences in structural changes and expected trends.
- Future trends and developments in poultry nutrition.
- Future trends for poultry genetic resources.

- Perspectives on the global markets for poultry products.
- Challenges for global feed industries.
- Feed production inducing structural change in the poultry sector.
- Social impacts of structural change.

The second session focused on risks and challenges for poultry production. Papers were presented on:

- Risks associated with poultry production systems.
- Poultry production and the environment.
- Long-term impacts of HPAI on poultry production systems.
- OIE standards related to trade and poultry diseases.
- Animal welfare in poultry production systems: impact of European Union standards on world trade.
- Health and socio-economic impacts of contract poultry growing for rural communities: a review of the experience in the United States of America.
- Response of the Thai poultry industry to HPAI.
- A video clip on HPAI in Cambodia.
- The importance of poultry products in human nutrition.
- Risks caused by bioaerosols in poultry houses.
- Veterinary services for poultry production.

The third session reviewed the potential for small-scale poultry keeping in the future and for poultry as a development tool. Papers were presented on:

- Poultry production for livelihoods and poverty alleviation.
- Poultry production as a tool for general development initiatives.
- Opportunities for small commercial poultry producers in the future.
- Experiences in transferring and adapting the BRAC model for the development of small-scale poultry producers to other countries.
- Impact of chicken development projects on small-scale producers in Thailand.
- Formal and informal poultry contract farming in Bangladesh.
- Getting the private poultry sector involved in the development of Africa.

Two working groups examined the development of the sector and made recommendations regarding future directions. One group reviewed the future for small family-owned flocks and was asked to suggest policies and interventions that might allow this system to survive for long as it is needed to support livelihoods. The second group reviewed the future for commercial poultry systems, particularly those supplying food to urban consumers.

FINDINGS

The findings reflected in the following three sections summarize material from the presented papers and the discussions.

The likely pathway of poultry development for the foreseeable future

The poultry sector continues to grow and industrialize in many parts of the world. Demand-side factors – increasing population, purchasing power and urbanization – have been strong drivers of growth. As incomes rise so does the consumption of poultry products, rapidly at

first but than at a diminishing rate. Over the past 15 years, the demand for poultry products has grown in countries of all income levels. The exception is a slight decline in egg consumption in high-income countries, where the effect of income growth may have reached a peak and demand may be more strongly influenced by changes in consumer taste. Despite upward trends in income and in the output of poultry products, it should be noted that the poor can still only afford to consume very small amounts of poultry meat and eggs.

On the supply side, advances in breeding have given rise to birds that meet specialized purposes and are increasingly productive, but which need expert management. The development and transfer of feed, slaughter and processing technologies have increased safety and efficiency, but favour large-scale units rather than small-scale producers. Subsidies on feed and taxes or quotas on imports have shielded the development of some national poultry industries. There has been a decline in the price of poultry and poultry products in absolute terms.

A trend towards urbanization, together with the globalized nature of the poultry sector, is creating an increasing emphasis on animal health, product safety, quality and convenience in poultry value chains. Structural changes are driven by the objectives of reducing transaction costs and improving the management of value chains so that they can deliver poultry products that are low in price, but have high food safety and quality standards.

Together, these developments have led the poultry industry and the associated feed industry to scale-up rapidly, to concentrate close to input sources or final markets, and to vertically integrate. These trends have affected high-income countries such as the United States of America; upper-middle income countries such as Brazil and Turkey; lower-middle income countries such as Thailand, China and Egypt; and, to some extent, low-income countries such as India. One element of the structural change has been a move towards contract farming in the rearing phase of boiler production, allowing farmers with medium-sized flocks to gain access to advanced technology with a relatively low initial investment.

Notwithstanding its rapid growth, the sector continues to be very diverse in structural terms. Traditional small-scale, rural, family-based poultry systems continue to play a crucial role in sustaining livelihoods, providing poultry products in rural areas and, importantly, supporting women farmers. Small-scale poultry production will continue to offer opportunities for income generation and quality human nutrition as long as there is rural poverty. A clear division is developing between industrialized production systems feeding into integrated value chains, and extensive production systems supporting livelihoods and supplying local or niche markets.

Highly pathogenic avian influenza (HPAI) has been a big shock to the industry, but is by no means the only external pressure that it faces. Concerns about environmental pollution, shortages of water, rising costs of feed and (at least in the European Union) rising animal welfare standards are all putting pressure on the poultry industry and the livestock sector more broadly. Efforts to contain HPAI and reduce its impact have accelerated moves towards greater division and differentiation among production systems and value chains. There is increasing interest in compartmentalization, a system under which the whole or part of a value chain can be identified as having a distinct health status on the basis of a specified set of biosecurity management practices. A compartment can to some extent be protected from the trade-related impacts of disease or food-safety emergencies that affect other parts

of the country's livestock sector. There is also a move within the industry to differentiate poultry meat that originates from "safe" sources in order to reassure consumers.

There are strong country differences in production trends. The most rapid expansion has been concentrated in the lower middle-income group of countries, where poultry meat production has grown steadily at an annual rate of over 8 percent over the last 20 years. Low-income countries started from the lowest base and have experienced the slowest growth. Egg production has grown at similar rates.

In high-income countries, the number of birds kept under extensive conditions is low. Nonetheless, there has recently been an expanding part of the sector – including birds produced for niche markets (e.g. organic production) as well as "hobby" flocks. In low and middle-income countries, while industrialized systems are growing and taking an increasing share of the market, extensive production is practised by the majority of poultry keepers. There are also quite large numbers of independent commercial producers with small flocks kept under conditions of low biosecurity and with small profit margins.

In many countries where the sector starts to concentrate, the development of slaughter and processing facilities tends to lag behind production. Live-bird markets provide an outlet even for large commercial farms in many middle and low-income countries because of consumer preference, lack of alternative facilities, or taxation systems that disadvantage slaughterhouses. One consequence is that "spent" hens from large commercial layer units often find their way into rural markets. Countries that have an export orientation are generally more advanced in the way that poultry value chains are organized and in the management of risk.

Regional differences can also be seen within countries, driven by economic differences or by the location of the feed source or the final market. In China, growth in poultry production has been faster in the more prosperous east than in the west. In Thailand, the broiler industry is concentrated in the central region, close to the hatcheries, feed mills, and processing plants. In Brazil, grain production is moving towards the Centre-West region and chicken production is following.

A general consensus at the conference was that, the sector will continue to scale-up, concentrate and integrate, and that there may be greater segmentation of the market. Despite these trends, the assumption that modern, commercial industrial poultry production will everywhere lead to the disappearance of smallholder poultry production is probably erroneous. Twin or even multi-track poultry development is the more likely pathway for the foreseeable future.

One of the challenges facing the conference was to classify poultry production systems in a way that facilitates the analysis of these "twin tracks". FAO has previously used a classification based on four "sectors" or production systems, numbered 1 to 4 in decreasing order of biosecurity and commercialization. The conference decided that something simpler would be more useful for the task in hand. The most important distinction was considered to be between commercial flocks (of any size) selling into food chains that supply urban markets, and small family-owned flocks kept for home consumption and local sales. The primary role of the former is to supply cheap and safe food to populations divorced from the source of supply, while the role of the latter is to act as a livelihood safety net, often as one part of a diverse portfolio of income sources.

Each of the systems will face its own particular challenges, and will require specific government policy measures as well as support from the service sector and the development community. Some of these differences are summarized in the following paragraphs, while others will be discussed in the next two sections.

The large-scale commercial sector has considerable flexibility and capability to respond to challenges. One of the case studies presented at the conference described the Thai poultry sector – for some time before the onset of HPAI, the country's poultry exporters had been investing in product processing, in anticipation of the time when Thailand's relatively high wage rate would make it less competitive in the chilled meat export market, particularly in view of the prospect that China and Viet Nam would eventually be able to comply with the food-safety and animal-welfare requirements of premium import markets. The companies that showed the most foresight in making investments for the future have survived the HPAI crisis and have prospered.

The poultry sector has advantages over some of its direct competitors in terms of its environmental sustainability and its effects on human health. Poultry production has a smaller physical footprint than other livestock systems (although perhaps not less than farmed fish) and may contribute less than other segments of the livestock sector to environmental pollution. In a world where populations suffering from malnutrition and obesity co-exist within the same cities, poultry has the advantage of providing both relatively cheap products and meat that is relatively low in fat.

Small family-owned flocks kept in rural areas for home consumption or to supply local markets may be buffered from the impacts of structural change for some time. The advantages of these systems are the low levels of inputs that they require and the unique products they produce – which still command a premium price in many places. They are accessible to people who have few other options and provide a way to turn limited inputs into useful outputs very quickly. They seem likely to survive as long as there is rural poverty or as long as there are "traditional" products that are in demand and are produced mainly or only in such systems. The latter condition will be undermined if, as is now happening in Thailand, similar products produced by the commercial sector start to compete in rural markets.

It is important that small-scale systems survive as long as they are needed for social functions, food security and livelihood support among poor households. The main task for policy-makers and development organizations may be to minimize disruption to these producers: to assist them with information and basic services, to promote market linkages in areas where markets are segmented, and to tailor regulations so that they are appropriate for the markets targeted. Improvements to productivity are possible, particularly if disease and predation can be reduced by simple means, although these flocks are generally well adapted to their environments. In the experience of the PKSF, an NGO in Bangladesh, which is the world's largest apex lending and capacity-building institution, the provision of microfinance and technical services for poultry to poor women increases their income and reduces the periods of the year when they suffer food scarcity. In the future, small-scale household systems are likely to be found in the poorest countries or regions and those affected by weak governance or conflict. The conflict zones of Sri Lanka and Afghanistan were given as examples of locations where the backyard system has prevailed and where even small flocks

of poultry have served an important role as a development tool, particularly for women.

The future of small commercial flocks as a development tool is more questionable. This was a particularly difficult subject for the conference participants, and clear conclusions were not reached. In spite of the simplified two-system classification of the sector, there was still a blurred line between small family-owned flocks kept on low inputs for home consumption and local sales, and small commercial operations where the owner makes a larger investment for purely commercial purposes. Poultry has been promoted as a first step onto the ladder of capital accumulation, requiring a smaller initial investment (smaller loans) and less land than other livestock, and allowing progressive growth from a small-scale scavenging family flock to a higher-input but still small commercial unit, which in turn can be a springboard to larger livestock or other enterprises. Some people still see this as a viable development pathway, while others are more cautious, noting that there have been failures as well as successes, and that given the way the sector as a whole is developing, there are likely to be barriers to the entry of small-scale producers into any markets other than the very local.

The profits of small commercial producers are marginal; they cannot benefit from economies of scale by applying the technology available to the larger producers. In low and middle-income countries, they have limited access to services, particularly animal health. Their value chains may be severely disrupted for public-health related reasons, and they may have less flexibility to regroup and relocate than larger operators. There is already evidence that when faced with increased regulation and higher expenses some will upgrade and flourish, while others drop out. A move to contract farming is a possibility for some, and it can offer a fairly rapid pathway to capital asset accumulation, but this form of production is not risk free and is accessible only to limited numbers of people. Female owners of small commercial flocks are likely to be losers when structural change occurs, because in many places they lack access to land titles or credit.

If sustaining small-scale commercial production is considered to be an important objective, there will be a need to provide continued support in the form of physical infrastructure, technology transfer through extension, and promotion of business models that help such producers to compete in the market. Approaches that have worked in different places include cooperatives, producer companies, self-help groups, contract farming, and commercially-driven value chains that do not exclude operators who can only afford to make small investments. The need for research into small-scale poultry production systems was highlighted at the conference. While the development of new technologies for large commercial producers will be undertaken by the private sector, investment in research and development for small-scale systems requires public support.

In Europe, extensive livestock systems are commercially viable without government subsidies when they supply specialized markets (e.g. for organic produce) that demand higher standards of animal welfare and environmentally friendly production. Similar opportunities may exist in Asia for extensive duck systems. However, there is little evidence that other types of specialized extensive poultry systems are developing, and if they do develop, they may not be owned by the people who currently keep small family-owned flocks or small commercial units, but by new entrepreneurs. Thus, the survival of extensive poultry production does not necessarily mean that the livelihoods of the traditional owners will be protected.

The future of small commercial flocks is likely to be at greatest risk in countries that have already experienced HPAI, or where economic growth has already led to increased concerns about food safety, and particularly in the areas around large cities. In places where these conditions do not apply they will be more financially viable and are likely to survive for longer.

Two questions that were touched upon at the conference, but not answered, relate in a more general way to equity in development. One was the question of opportunities for people who are forced to leave the poultry sector because of increased regulation or structural changes: to what extent should they, or can they, be helped to enter other kinds of livelihood? The other question related to employment potential in the poultry industry. It is sometimes assumed that development of the sector, while it reduces employment in primary industry, will create employment in other parts of the value chain. However, it is not certain that the gains will match the losses, and it is likely that the losses and gains will be experienced by different people.

Public health risks must be addressed, and this may best be done by segregating production systems facing different types of risk

The poultry sector is associated with considerable public-health risks arising from zoonotic disease and contamination of products. These are exemplified by, but not confined to, events related to the HPAI H5N1 crisis. To reduce the level of risk, adjustments in the way poultry is produced and marketed are required (and are feasible) across the entire spectrum of the commercial poultry sector – from small to large. Poultry products supplying the cities must be seen to be safe. This will require improvements to feed safety, biosecurity and hygiene in farms, markets and slaughter and processing facilities, accompanied by certification processes appropriate to the levels of risk involved. Each system and part of the value chain carries its own disease risks; none is exempt from the need for improvements.

Quality feed is an important contributor to poultry product safety, and requires raw materials that are free of contamination and state-of-the-art processing equipment. In high-income countries and global value chains requirements have been met through careful sourcing of supply and consolidation of feed manufacturing. Ever more legislation, regulations, recommendations and guidelines are being applied to the feed industry in high-income countries; this will affect the import of poultry products into the European Union and other premium markets. In low and middle-income countries it can be difficult to find local feed sources that are not contaminated with mycotoxins.

In well-controlled industrial systems the risks of infection is reduced by the implementation of high-level biosecurity measures. However, large commercial units without good biosecurity and without safe trading practices can pose a great risk. If any large farm becomes infected with a serious disease the number of birds lost will be great and there is a high probability of subsequent local spread of the infection (depending on the density of farms in the vicinity). Biosecurity threats from the exhaust fans of poultry houses need more attention.

Medium-sized to small commercial producers, when their biosecurity is low, are deemed to represent the highest risk of infection and virus spread, because in many parts of the world most sales from these farms are through live poultry markets. Grazing duck systems

are believed to have played a critical role in the genesis of the H5N1 HPAI panzootic. Small family-owned flocks face lower risks when they are segregated from the commercial sector. It may be possible to further reduce risk by applying biosecurity measures at the level of the village flock as well as good hygiene practices in the management of individual flocks.

Biosecurity is, in principle, more a matter of management than of system and scale, although the costs of biosecurity measures and certification tend to favour large-scale production, slaughter and retail operations. Sector development policy needs to support and guide moves towards higher levels of biosecurity. Much more needs to be done to raise awareness at all relevant levels through effective animal health risk communication and to foster public–private partnerships. Risk assessment needs to be made a routine part of animal health and food-safety planning, as in many farms there is still a mismatch between the biosecurity measures implemented and the risk routes and level of infection pressure with which they have to contend. Increasing the resistance of poultry through vaccination, and other biosecurity measures applied at farm level need to be appropriate to the production system.

Legislation, financial incentives and capacity for biosecurity planning are important considerations for policy-makers. High-income countries have guidelines related to the biosecurity of farms and markets, regulations to be applied in the event notifiable disease outbreaks, and financial incentives in the form of price penalties on the final product or private–public financing of emergency control including compensation. However, such provisions are not always present in countries with newly developed poultry industries. If farmers are to be given help to carry out risk assessment and develop appropriate biosecurity plans, trained personnel (often in short supply) or clear and widely applicable guidelines need to be available. There is a need for incentives that promote the development of safe marketing channels for processed poultry products, as these usually lag behind structural changes in production.

Countries are implementing various measures to regulate the type and location of poultry production and sales. Examples include specifying production zones, banning production and sales within city limits, restricting certain types of production, and specifying "farm standards". The private sector is effecting its own structural adjustments. Interest in compartmentalization (described above) is mostly driven by large companies. Contract farming, once an attractive option for the contractor and the contractee, may decline as a result of heightened food-safety regulations and compartmentalization (as has happened in Thailand).

As noted above, small family-owned flocks and commercial systems face different types of risk, and require different risk-mitigation strategies. The biggest animal health and food-safety problems occur when the systems are in close contact and adversely affect the risk status of the other. The rapid evolution of mixed, quasi-biosecure systems and of live-bird markets has brought systems that were previously separated into overlapping space. An option for the future may be to try to reverse the process and segregate the different types of production so that both can continue to meet their respective roles without creating risk for the other. One example proposed during the conference was to create clusters of licensed producers, certified HPAI-free, which only supply the live-bird markets allocated to them, and to allow no other access to these markets. This idea could be expanded to

include certification of biosecurity standards on the farm (thus protecting against other food-borne diseases) and of safe feed sources.

HPAI has drawn attention to the lack of resources faced by the veterinary services in many countries, which almost as a rule do not reach out to the many small-scale backyard poultry keepers. There is now an opportunity to use the impetus provided by HPAI to improve veterinary services. It was argued that veterinary services need to get better at communicating and that there is need to build private veterinary services. A particular challenge is to identify institutional mechanisms with which to reach out to poor farmers with small poultry flocks. One novel example described at the conference was the involvement of micro-finance organizations and NGOs in delivering such services in Bangladesh. The UN System Senior Coordinator for Avian and Human Influenza made a strong plea for a future unified health system that combines human health and veterinary services.

Feed and water shortages may change the shape of the sector in unexpected ways

As large-scale poultry production expands, so too will demand for feed. Maize (for energy) and soybean meal (chiefly for protein) are the main components of most compound poultry feeds. However, this picture may change.

While over the past few decades the poultry sector has benefited from a long-term decline in world market prices for feed grains, it is now facing rising prices as a result of competition from direct grain consumption by a still-growing human population and use of grain for biofuel production. Protein sources are also under pressure. Cost and environmental factors may make soybean imports less attractive as a protein source, and lead countries to seek alternatives in the form of other legumes or oilseeds. Fish farming which is a competitor in the lean protein market is also a competitor for feed ingredients.

Alternative energy sources are being evaluated, including sorghum (which is not used in biofuel manufacture), molasses from sugar cane, and by-products such as rice bran, wheat bran and screenings. Alternative protein sources are also being investigated, including sunflower meal, peanut meal and rapeseed residues (including those from biofuel production); utilizing these feeds would, however, bring poultry into competition with dairy cattle. Production of feed from by-products of ethanol production such as dried distillers' grains with solubles (DDGS) has some potential, but there are questions about the cost of production. A wider range of potential feed sources increases the possibility for local sourcing of feeds in low-income countries. However, there is some health risk associated with alternative feed sources, as plant protein sources other than soybean are often more susceptible to mycotoxin contamination.

Future directions for the feed industry and their effects on the poultry sector were the most speculative discussions during the conference, as changes to the underlying drivers are relatively recent and may not be stable (e.g. biofuel produced from maize may be superseded by other renewable fuel sources). Diverse views were expressed regarding the significance of biofuel production as a future competitor for grains. One point of view was that this threat is a myth, as biofuel production is not sustainable. Conversely, it was argued that the expansion of biofuel production needs to be taken seriously as it puts both direct and indirect pressures on the poultry industry – direct when feed ingredients are diverted to

biofuel production, and indirect when land is converted to growing crops for biofuel production, reducing the area available for producing poultry feed ingredients. In both cases the likely scenario is that the prices of poultry feed will rise. Research into alternative crops for feed as well as for biofuel should be encouraged. It seems clear, that the question of the sustainability (environment and health as well as profit) of poultry production systems, including their feed sources, is likely to become increasingly prominent in the legislation of high-income countries and in industry strategy.

Large-scale operations taking advantage of their economies of scale will be at an advantage in researching new feed sources and in scaling-up their production, or in breeding birds adapted to changing nutritional or environmental conditions. They will be better able to feed precisely and reduce feed contamination.

In the future there will be more emphasis on designer diets for different bird types and different conditions. Competition for feed stocks, including demand for fishmeal for aquaculture, may require some new priorities in poultry breeding. There is an urgent need to look at specific efficiencies, particularly nitrogen and phosphorus efficiency and the problems nitrogen compounds pose with respect to global warming. There will be more discussion of productivity in terms of income relative to feed cost rather than in terms of feed efficiency – restructuring will be driven by profitability. Some countries in Africa that use alternative feed resources may become more competitive.

Given that the factors affecting poultry nutrition have a similar impact on other monogastric livestock, poultry as highly efficient feed converters may be at an advantage. Feed manufacturing capacity and expertise is increasing in countries with rising consumption of poultry products, such as China and India, suggesting the possibility that much feed production and processing could be shifted to these areas. However, most Asian countries are currently net importers of feed grain. For countries to be self-sufficient in poultry feed they not only need production capacity, but also storage capacity, which may be a limiting factor in African countries. Large-scale poultry meat suppliers have the option to relocate their production internationally or within a country to be close to the sources of feed or to take advantage of more favourable climates. However, these benefits have to be balanced against the advantages of being closer to consumers if feed production and final-product consumption are in different locations.

Widening the acceptable portfolio of feed ingredients will encourage the use of alternative feed sources at national and local levels, and may promote stronger efforts to improve storage and reduce contamination of locally available feeds used for family poultry and small-scale commercial flocks. There is also the potential to breed for birds that can perform well on lower planes of nutrition. This approach would also be relevant for village conditions in developing countries (even if the birds could not be reproduced in the villages) – some such examples already exist. A niche market with high product prices for birds kept under "natural, ethical, ecological" conditions could be envisaged, although this might be hard to achieve and certify under village conditions in developing countries.

CONCLUSIONS

With such a diverse participant list and range of topics, the conference did not aim to come to a consensus or firm recommendations on every issue. However, it was possible to arrive at some broad conclusions, which were presented by the Director of FAO's Animal Production and Health Division, Dr Samuel Jutzi, in his closing remarks as follows:

The conference noted the very strong poultry sector dynamics at the global scale (growth, consolidation, structural change, trade flows); this confirms the sector as possibly the most dynamic and most globalized agricultural subsector. Sector growth is primarily demand-driven. The sector is likely to look very different in the future. It faces considerable and multiple challenges which concern public health (e.g. HPAI H5N1), social objectives such as poverty alleviation and gender equity, and environmental threats. The task ahead is multifactorial and requires inputs from a diversity of disciplines and the engagement of all relevant stakeholders

While the evidence from research shows that smallholders are not always less efficient than large-scale enterprises in market production, they tend to be at a disadvantage in the context of traceability and quality/safety compliance as well as in government-led disease prevention measures. More detailed studies of the competitiveness of smallholder poultry production and its determinants are required, so as to assess the viability of these units and pathways for possible upgrading and up-scaling.

The assessment of the enormously dynamic growth and structural change of the commercial poultry sector in many countries needs to take into account the large differences that exist both between and within countries, with non-commercial or informally commercial systems often persisting and co-existing with large and medium-scale operations. The determinants and dynamics of system changes deserve more analysis for risk management, particularly in terms of public health and social objectives.

Three core messages related to the further development of the global poultry sector were identified by Dr Jutzi:

1 The poultry sector is growing and industrializing in many parts of the world, but continues to be very diverse in structural terms. Traditional small-scale, rural, family-based poultry systems continue to play a crucial role in sustaining livelihoods and, importantly, supporting women farmers. As long as there is rural poverty, poultry will be there to offer opportunities for income generation and quality human nutrition. The assumption that modern, commercial industrial poultry production will lead to the disappearance of smallholder poultry production everywhere is probably erroneous. Under many conditions, twin-track or even multitrack poultry development is the likely pathway for the foreseeable future.

2 The poultry sector is associated with considerable public-health risks as exemplified by the HPAI H5N1 crisis. Adjustments in the way poultry is produced and marketed are required and feasible across the entire spectrum of the commercial poultry sector – from small to large. Biosecurity is, in principle, more a matter of management than of system and scale, although the costs of biosecurity measures and certification tend to favour large-scale production, slaughter and retail operations. Sector development policy needs to support and guide moves towards higher levels of biosecurity. For this to happen, much more needs to be done to raise awareness at all relevant

levels through effective animal health risk communication and to foster public–private partnerships.

3 While over the past few decades the poultry sector has benefited from long-term declines in world market prices for feed grain, it is now facing rising prices as a result of competition from direct grain consumption by a still-growing human population and use of grain for biofuel production. This development is likely to be to the advantage of large-scale operations which can take advantage of their economies of scale; on the other hand, it will encourage the use of alternative feed sources at national and local levels.

PART 1

Sector trends and impacts

Global poultry sector trends and external drivers of structural change

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SUMMARY

The poultry sector has undergone major structural changes during the past two decades due to the introduction of modern intensive production methods, genetic improvements, improved preventive disease control and biosecurity measures, increasing income and human population, and urbanization. These changes offer tremendous opportunities for poultry producers, particularly smallholders, to improve their farm income. Evidence from case studies shows that it is difficult to see a bright future for smallholder poultry production in a rapidly changing industry structure; however, smallholders can still compete with larger producers because of savings that smaller units can achieve because of foregone or cheaper overheads, lower labour costs per unit and, possibly, more intensive supervision, leading to relatively high profit efficiencies. Smallholders also have problems in meeting high demands for food safety, traceability and compliance, because of high coordination costs and high transaction and marketing costs. Increasingly it appears that smallholders' ability to maintain their competitiveness in these types of markets is dictated by their ability to establish market trust and reputation along the marketing and distribution channels. This will require smallholders to be linked to the supply chain and to obtain certain supply chain management necessities, combining both productivity-enhancing technologies at the farm level and improved coordination in the marketing system.

Keywords: poultry sector structural changes, smallholder competitiveness, supply chain, transaction costs.

1 INTRODUCTION: CHANGES IN THE STRUCTURE OF THE POULTRY SECTOR IN DEVELOPING COUNTRIES

Over the last four decades there has been rapid growth in livestock production and a rapid change in how animal products are produced, processed, consumed and marketed. Growth in livestock production in both developed and developing countries has been led by poultry. From the 1990s to 2005, consumption of poultry meat in developing countries

increased by 35 million tonnes – almost double the increase that occurred in developed countries (Table 1).

The increase in poultry meat consumption has been most evident in East and Southeast Asia and in Latin America, particularly in China and Brazil (Table 1). The share of the world's poultry meat consumed in developing countries rose from 43 to 54 percent between 1990 and 2005, which accounted for 36 percent of the large net increase in meat consumption in developing countries over this period. Further, the proportion of the world's poultry meat produced in developing countries rose from 42 to 57 percent. It is estimated that production and consumption of poultry meat in developing countries will increase by 3.6 percent and 3.5 percent, respectively, *per annum* from 2005 to 2030 because of rising incomes, diversification of diets and expanding markets, particularly in Brazil, China and India.[1]

The trends described above, and our current knowledge of smallholder involvement, raise a critical issue: for once, a sector in which the poor are heavily involved is growing. Table 2 shows that in fact pork and poultry are the prominent growth sectors of developing-country agriculture. If the poor fail to remain active in this sector, they will have missed a tremendous opportunity to improve their livelihoods. If they participate, farm income could rise dramatically; however, the conditions under which this could occur are unclear.

Although the above-mentioned issues are real, it has also been suggested that the principal reason for the exit of smallholders from livestock production in developed countries is that they are not competitive with the larger operations that benefit from both technical and allocative economies of scale embodied in genetic improvement of animals and feeds or improved organization – especially in the case of poultry and pig production where profitable adoption simply requires larger farm sizes (Narrod, 1997; Martinez, 2002; Morrison Paul *et al.*, 2004). This is a particularly difficult issue for smallholders, as it conveys a sense of inevitable economic doom propelled by irreversible technological progress. Anecdotal experience suggests that many livestock production experts do not look much beyond this explanation when assuming the inevitability of livestock industrialization in developing countries. In this paper, we try to disentangle the issues and provide empirical evidence drawing on case studies, involving household surveys, which capture various factors affecting profitability, including transaction costs and efforts to mitigate environmental externalities, for different sized producers in a number of countries.

2 GLOBAL TRENDS AFFECTING THE POULTRY SECTOR

2.1 Demand-side factors affecting the global poultry sector

Growth of the poultry industry has been both demand and supply driven. The factors that can cause the demand curve to shift outward are: (1) increases in income; (2) increases in the price of poultry substitutes such as pork or beef; (3) increases in the preference for poultry; and (4) decreases in the price of poultry complements. Factors influencing this shift are growth in population, increases in real per capita incomes, income elasticity of demand, urbanization and variations in real prices. Additionally, in many countries the population's

[1] Projections to 2030 are from the International Food Policy Research Institute's (IFPRI) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model projections, October 2007. The IMPACT model, developed by Rosegrant *et al.* (2002), offers a methodology for projecting global and regional food demand, supply, trade, prices, income and population to 2020 and 2030.

TABLE 1
Production and per capita consumption of poultry meat by region, 1990-1992 and 2003-2005

Region	POULTRY MEAT PRODUCTION					POULTRY MEAT CONSUMPTION				
	1990-1992		2003-2005		2030 projected	1990-1992		2003-2005		2030 (projected)
	(million tonnes)	(% of world production)	(million) tonnes)	(% of world production)	(% of world production)	(million tonnes)	(% of world consumption)	(million tonnes)	(% of world consumption)	(% of world consumption)
China	4.5	10	14.2	18	23	3.3	10	10.3	16	26
India	0.4	1	1.8	2	4	0.4	1	1.7	3	3
Other East Asia	1.8	4	1.9	2	0	0.4	1	0.5	1	1
Other South Asia	0.8	2	1.8	2	1	0.3	1	0.6	1	2
Southeast Asia	1.2	3	5.2	6	7	2.1	6	4.2	6	7
Latin America	5.9	14	15.9	20	21	5.4	16	13.3	20	17
of which Brazil	2.7	6	8.5	11	10	2.3	7	6.1	9	7
West Asia and North Africa	1.5	3	2.9	4	6	2.2	7	4.4	7	7
Sub-Saharan Africa	1.3	3	1.8	2	2	0.7	2	1.2	2	4
Developing World	18.2	42	45.8	57	65	14.3	43	35.4	54	67
Developed World	25.2	58	35.1	43	35	18.8	57	29.9	46	33
World	43.5	100	80.9	100	100	33.1	100	65.3	100	100

Source: FAOSTAT accessed on October 2007. Projections to 2030 are from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model projections, October 2007.

TABLE 2
Production growth rates in developing countries, 1975–2005

	% *per annum* (by volume)
Cereals	2.2
Fruit	3.9
Vegetables	5.1
Fish	1.6
Milk	4.0
Pork	6.0
Poultry	7.0

Note: "Fish" includes marine and freshwater fishes; "Poultry" includes chicken, duck and turkey meat.

Source: calculated from data obtained from FAOSTAT, accessed March 2007.

tastes and preferences for food products are changing, resulting in a shift away from "inferior" goods towards those considered "superior". The regions where annual income growth rates are highest, such as Africa (4.2 percent), Asia (3.5 percent) and Latin America (2.3 percent), are also those where the population growth rates are highest (between 1.2 percent and 2.2 percent) (OECD-FAO, 2007). As income increases, meat consumption tends to increase. High expenditure elasticity in poultry indicates its dominance in the diet both in the developed and the developing world (Table 3).

There is generally a positive relationship between per capita consumption of poultry products and per capita incomes. This positive relationship supports general economic theory which suggests that as incomes increase, particularly in developing countries, people will increase their consumption of high income-elastic foods. Throughout the world, this shift has traditionally involved the substitution of meat for starches. This additional meat can be produced either domestically by the reallocation of resources or imported. Figures 1a and 1b illustrate the relationship between per capita income and per capita consumption for South Asia and Latin America. The upward trends in these regions have been increasing over time.

2.2 Supply-side factors affecting the global trends of the poultry sector

Technology change in the poultry industry has been very rapid. The move from free-ranging to confined poultry operations dramatically increased the number of birds that one farmer could manage. This shift facilitated the substitution of capital for labour in animal production, and led to a significant increase in labour productivity (Narrod and Pray, 2001). Technology change in the poultry industry, led by advances in breeding that improved animal size, fecundity, growth rate and uniformity, has enabled farmers to increase output per unit of feed, produce more birds per year, improve animal disease control and decrease mortality (Narrod and Fuglie, 2000).

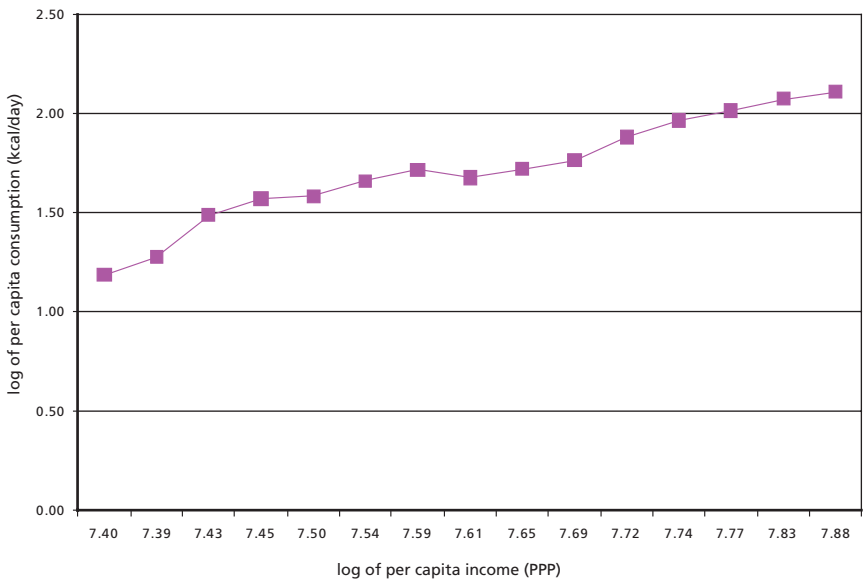
In terms of management techniques, the move to enclosed production systems in which animals of different ages are segregated and raised apart has had a positive impact

TABLE 3
Expenditure elasticities for major livestock products in developing and developed countries, 1970–1995, 2000, 2005 and projections for 2025

Region/product	Expenditure elasticities 1970–1995	Expenditure elasticities 2000	Expenditure elasticities 2005	Expenditure elasticities 2025
Developed countries				
Beef		0.18	0.10	0.01
Pork		0.24	0.14	0.02
Poultry		0.66	0.56	0.45
Milk		0.25	0.20	0.08
Eggs		0.02	-0.08	-0.19
Developing countries				
Beef	0.65	0.69	0.62	0.50
Pork	1.10	0.52	0.46	0.35
Poultry	0.27	0.72	0.77	0.66
Milk	1.36	0.60	0.48	0.37
Eggs		0.44	0.39	0.28

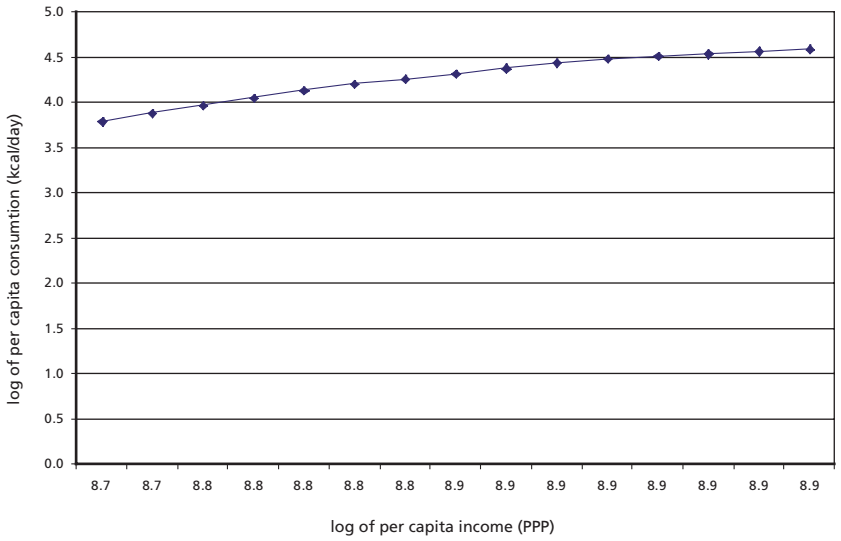
Source: Delgado *et al.* (1999) Table 8. Projections to 2005 and 2025 are from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model projections, November 2006.

FIGURE 1A
Chicken meat consumption and income (constant 2000) for South Asia, 1990–2004



Note: PPP = Purchase price parity.

FIGURE 1B
Chicken meat consumption and income (constant 2000) for Latin America, 1990–2004



Note: PPP = Purchase price parity.

on disease control. The ability to use vaccines and pharmaceuticals to control the spread of poultry diseases helped expand the large-scale operations, allowing farmers to achieve significant economies of scale and unit-cost reductions. Further, the introduction of evaporation shed cooling in hot climates (e.g. in Thailand) has had a tremendous impact on the industrialization of the sector (Poapongsakorn *et al.*, 2003). Improvements in feed technology ensured that the improved breeds were using the ideal combination of ingredients at the least cost because of shorter production cycles and lower feed conversion ratios (from 2.0 to 1.75). The move towards increased processing of birds into a variety of convenience foods has further accelerated the growth of the poultry industry.

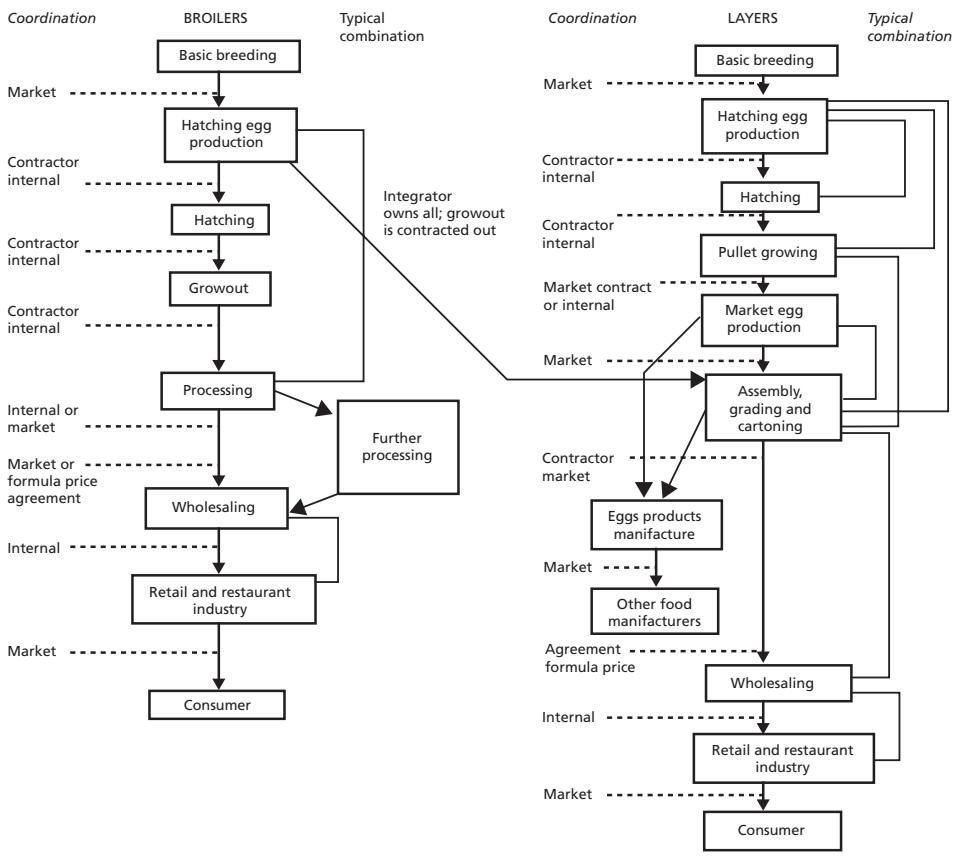
Concurrently, there has been a major structural change in the poultry industry throughout much of the world (Narrod, 1997; Narrod and Pray, 2001; Delgado *et al.*, 2008). Specifically, the commercial poultry industry in the developed world and in many developing countries has moved towards large-scale vertically integrated broiler operations that contract grow-out operations to smaller farmers. Today, the commercial poultry industries in most countries are moving towards such large-scale vertically integrated operations. These operations are characterized by a high level of vertical control (ownership) or coordination among suppliers of production inputs, poultry growers, poultry processors and marketers (Figure 2).

The specific degree of integration, however, varies among countries and firms. For the most part, integrated poultry operations involve most or all of the following segments: breeding flocks, hatchery, feed mill, production units, assembly of live birds or eggs, poultry slaughtering or packing plants, further processing units, delivery vehicles and distribution

centres. Feed mills and further-processing segments are not always included in the integration, although they are an essential part of the production system (Henry and Rothwell, 1995). In some countries, it was the feed industry which was responsible for the initial integration of the poultry industry. In other countries, it was either the breeding company or the hatcheries which were responsible for the integration. In still other countries, integration was based on the potential market for further processing and fast food, as processors sought to add value to their business and become closer to the final customer.

The move towards vertical integration appears to mirror the stabilization of the economy and the growth of the urban market. The expansion of these large integrated operations has tended to occur in countries with developing or existing urban markets that supply the major cities. However, in some countries, integrated operations are moving closer to the

FIGURE 2
Typical integrated poultry operation



Source: adapted from Marion (1985).

source of inputs; Brazil is an example – see Camargo Barros *et al.* (2003) and Delgado *et al.* (2008). In countries where live chickens are still sold mostly in informal markets, such as India, Indonesia and Viet Nam, forward linkages are also becoming evident, particularly as these countries are faced with the highly pathogenic avian influenza (HPAI) situation and concern is growing about the poultry-to-human spread of the virus (Indonesia and Viet Nam).

Although there is a move to integrated operations in a number of developed and developing countries, for many developing countries, production practices are such that the majority of producers still maintain small flocks which are kept outdoors and are exposed to outside influences. At the same time, these small backyard producers may be interspersed with large-scale commercial operations, giving rise to highly concentrated regions of production near urban areas. Poultry products are among the most perishable, so they have to be produced in close proximity to the demand. Figures 3, 4 and 5 illustrate that in Asia, Latin America and Africa the geographical concentration of poultry operations tends to be around major cities. As can clearly be seen in Figure 3, poultry distribution patterns can be explained by the distribution of human population, i.e. where there is a dense human population then there is likely to be a dense poultry population. Growing concentrations of animals in large units near cities are associated with greater pollution and increased risk of transmission of both zoonotic and other diseases. Notably, HPAI began in areas with high poultry population density, such as China, Indonesia, Thailand and Viet Nam (Figure 3). Increasing concerns over environmental and health externalities associated with concentrated and intensive poultry production near urban areas are causing countries to rethink zoning issues.

2.3 Declining poultry prices

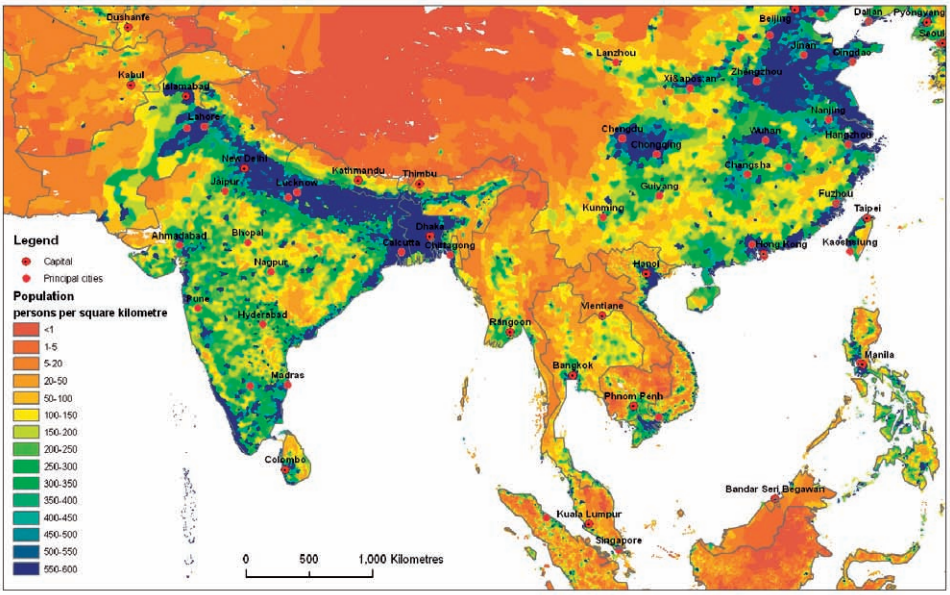
Collectively, the changes outlined above have led to a decline in world meat prices over time, particularly for poultry, as shown in Table 4. However, prices are expected to rise as a result of the rising price of maize. Between the 1980s and the 1990s, real prices of poultry declined at a rate of 3 percent per year. This decline continued, but at a slower rate. The downward trend in prices was brought about by a number of factors, such as improvements in the efficiency of production of large-scale poultry operations (Delgado *et al.*, 2003) and rapid technological progress, as in the case of the United States of America (Narrod, 1997). It is important to note that there was an increase in poultry prices between 2003 and 2004, which could be attributed to a reduction in export supplies caused by several outbreaks of H5N1 HPAI. In 2004/2005, as HPAI outbreaks were reported in some 40 countries previously not infected by the virus, poultry prices noticeably dropped – by 11 percent. Poultry prices are expected to increase over the period 2005 to 2030 at 0.2 percent per year, reflecting increasing demand in China and sub-Saharan Africa, and increasing prices of feed grains such as maize (projected to increase by 0.8 percent per year over the period 2005–2030 (Table 4), supported by the exceptional demand for maize coming from increasing biofuel production).

Consumers as a whole have benefited from the livestock industrialization process, as a result of reduction in meat prices. It is known that poultry meat and eggs contain protein and micronutrients, such as vitamins from group B, iron and zinc, which could provide an

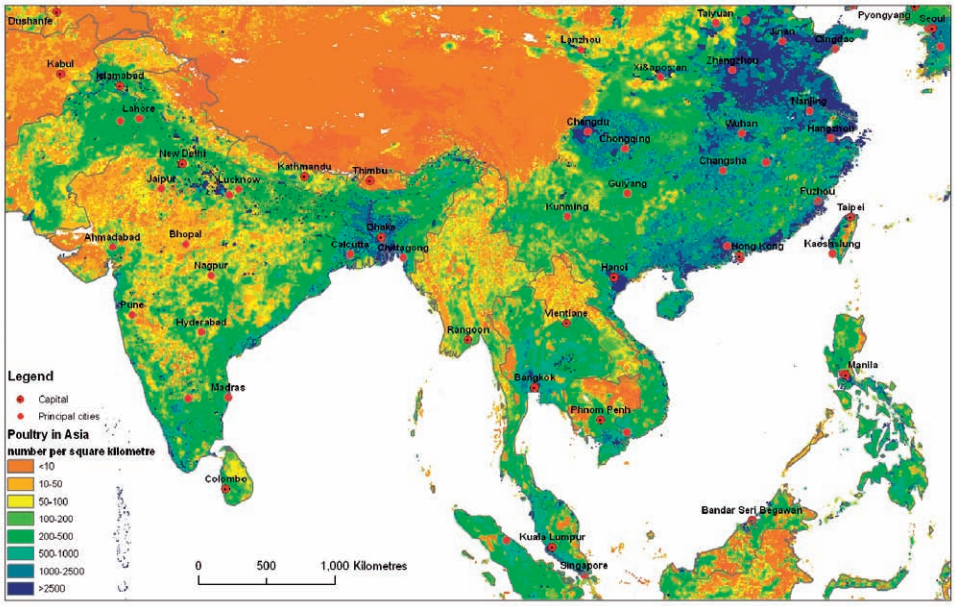
FIGURE 3

Geographical concentration of poultry operations tends to be around major cities in Asia

Human population



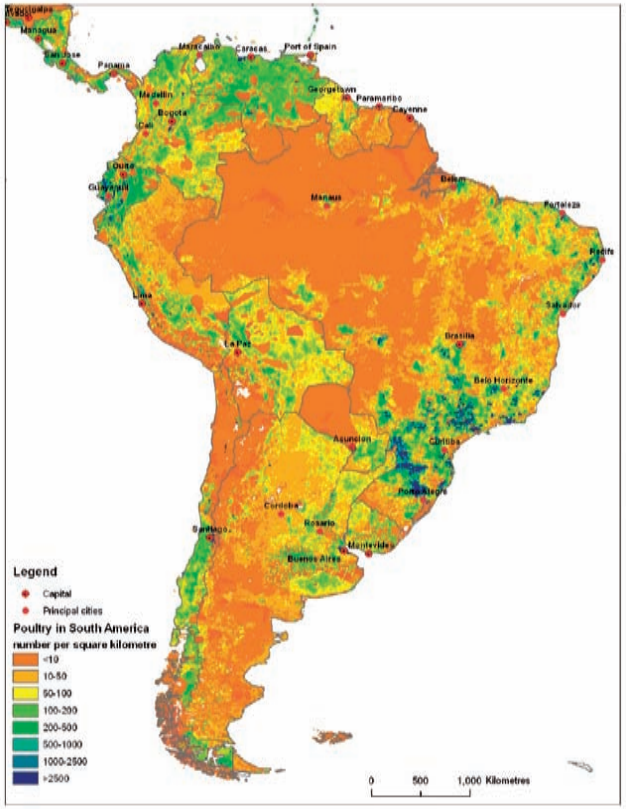
Poultry population



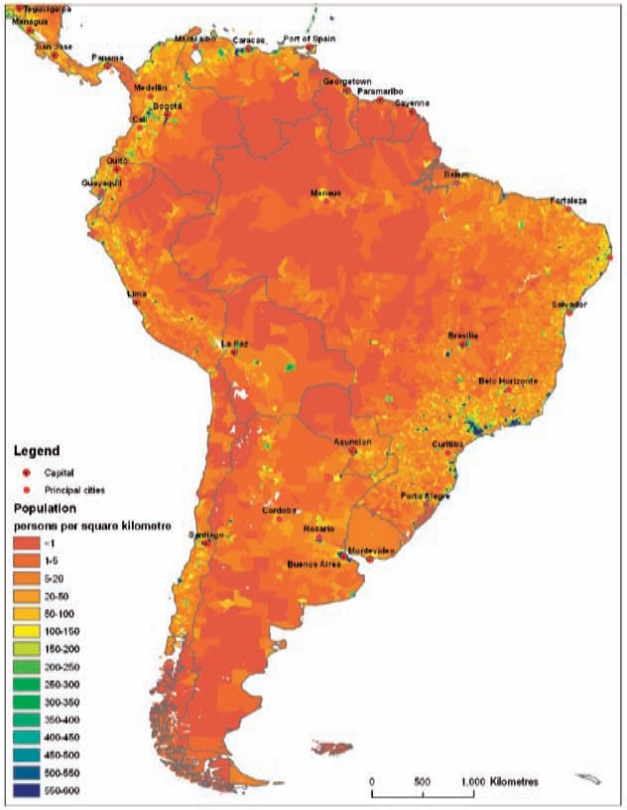
Source for human population maps: Center for International Earth Science Information Network (CIESIN), Columbia University; FAO; and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded Population of the World: Future Estimates, 2015 (GPW2015): Population Density Grids. Palisades, NY: Socioeconomic Data and Applications Center (SEDAC), Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw. (accessed on October 17, 2007). *Source for poultry population maps:* FAO Animal Production and Health Division. Gridded Livestock of the World. Available at http://www.fao.org/ag/againfo/resources/en/glw/home.html. (accessed on October 17, 2007)

FIGURE 4
Geographical concentration of poultry operations tends to be around major cities in Latin America

Human population



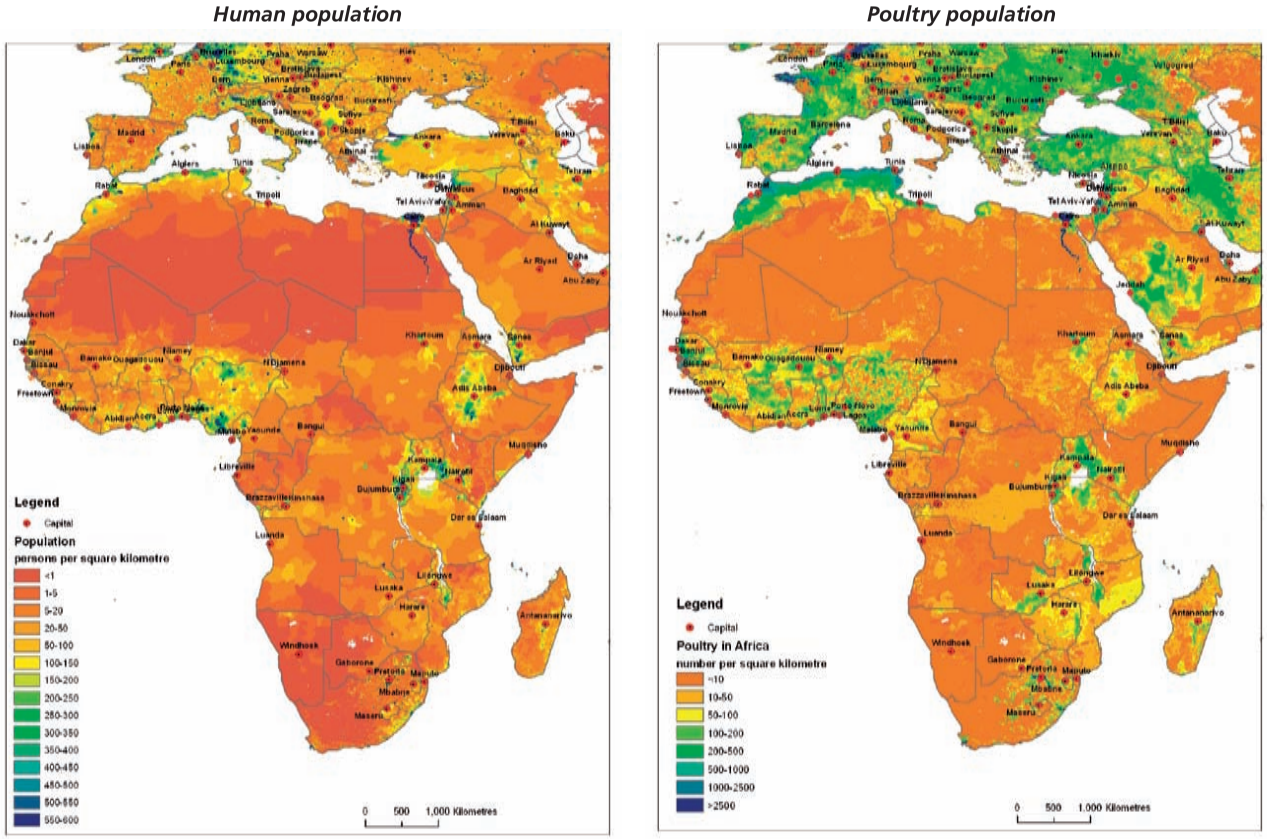
Poultry population



Source: See figure 3.

FIGURE 5

Geographical concentration of poultry operations tends to be around major cities in Africa



Source: See figure 3.

TABLE 4
Past trends in real prices of selected livestock products and maize

	Maize	Beef	Pork	Poultry	Milk
	Constant 2000 US$/tonne				
1980	232	5 092	3 338	1 995	2 442
1981	221	4 182	3 663	1 815	2 535
1982	172	3 805	5 056	1 629	2 259
1983	209	3 742	3 933	1 704	1 541
1984	201	3 363	3 689	1 812	1 346
1985	161	3 085	3 551	1 605	1 175
1986	123	2 937	3 820	1 759	1 282
1987	103	3 254	3 559	1 425	1 427
1988	141	3 325	2 258	1 640	2 228
1989	142	3 271	1 795	1 657	2 306
1990	134	3 145	2 720	1 482	1 587
1991	127	3 156	2 325	1 359	1 762
1992	121	2 841	1 441	1 341	1 979
1993	115	2 961	1 609	1 376	1 719
1994	119	2 583	1 377	1 360	1 707
1995	134	2 071	1 503	1 349	2 356
1996	175	1 901	2 171	1 438	2 154
1997	123	1 943	1 682	1 358	1 853
1998	105	1 789	1 042	1 440	1 799
1999	92	1 874	1 001	1 309	1 562
2000	88	1 935	1 307	1 238	1 850
2001	88	2 078	1 323	1 273	1 902
2002	95	2 018	1 000	1 175	1 349
2003	99	1 866	1 111	1 289	1 692
2004	103	2 321	1 447	1 510	2 002
2005	87	2 317	1 321	1 387	2 006
Growth rates (%)					
1980–1990	-5.3	-4.7	-2.0	-2.9	-4.2
1990–2000	-4.1	-4.7	-7.1	-1.8	1.5
1990–2005	-2.8	-2.0	-4.7	-0.4	1.6
1980–2005	-3.8	-3.1	-3.6	-1.4	-0.8
2005–2030 (projected)	0.8	0.6	0.5	0.2	-0.6

Nominal prices in US$ are deflated by the US Consumer Price Index.
Maize: US$/tonne, US #2 yellow, fob Gulf of Mexico. Source: IMF, accessed October 2007 (http://www.imf.org/external/np/res/commod/index.asp).
Beef: US$/tonne, Australia/New Zealand frozen, U.S. import price. Source: IMF, as above.
Pork: US$/tonne, USDA 5-market average hog prices. Source: IMF, as above.
Poultry: US$/tonne, USDA Avg. 12-City Broiler Price, Broiler Composite and Georgia Dock Price. Source: http://www.cattle-fax.com/data/files/poultry/prices.xls
Milk: US$/tonne, whole milk powder, fob Western Europe. After 1994, midpoint of prices reported by New Zealand Dairy Board. Sources: FAO Commodity Review and Outlook 1982-1991, FAO Commodity Market Review 1995-2000, http://future.aae.wisc.edu/data/weekly_values/by_area/1705, accessed October 2007.
Note: Projections to 2030 are from the IMPACT model projections October 2007.

important contribution to the health and nutrition of consumers. For the urban poor, the fall in prices meant an increase in their purchasing power, leading to greater economic access to poultry and other meat. Moreover, especially in the case of poor households engaged in small-scale backyard poultry raising (which is likely to be their main source of animal protein), responding to increased demand probably also leads to higher levels of home consumption (Neumann *et al.*, 2002; Barroeta, 2007).

2.4 Increased trade in poultry products further increases demand

Broiler products dominate the international poultry trade (Moore and Morgan, 2006). Table 5 shows the top five broiler importing and exporting countries or regions for 2005, along with imports and exports as a share of production. The Russian Federation dominates in terms of broiler imports, followed by Japan and the European Union. Brazil and the United States of America dominate in terms of broiler exports. China is emerging as an active broiler exporter.

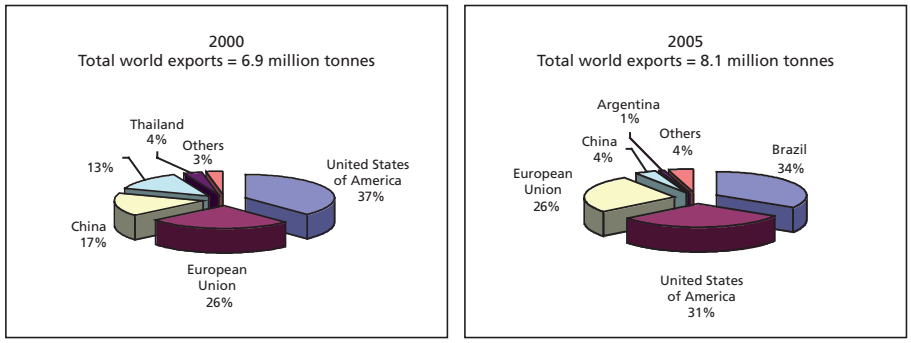
Brazil has overtaken the United States of America in terms of chicken-meat exports, expanding by 21 percent from 2000 to 2005, largely due to increases in production and in demand from foreign markets (Figure 6). The United States of America's market share of chicken meat exports decreased by 7 percent over the same period, because of lower import needs in the Russian Federation. The United States Department of Agriculture predicts that there will be continued higher demand for Brazilian products because of their competitiveness and aggressive market promotion efforts by Brazilian poultry exporters in new markets (USDA/ERS, 2007). Trade in poultry meat is projected to increase at a faster rate than production and consumption (OECD–FAO 2007).

TABLE 5
Broiler imports and exports: top five countries or regions in 2005

Country/region	Imports	Exports	Production	Share of Production
	(1 000 tonnes)			(%)
Russian Federation	1 204		1 346	89
China	907		10 102	9
Saudi Arabia	451		545	83
Japan	419		1 339	31
Mexico	357		2 437	15
Brazil		2 762	8 507	32
United States of America		2 480	15 945	16
European Union		2 123	9319	23
China		296	10 102	3
Argentina		111	1 010	11

Source: FAOSTAT accessed 23 October 2007.

FIGURE 6
Changes in market share for chicken meat exports, top five exporters



Source: FAOSTAT accessed 23 October 2007.

2.5 Rise of large-scale retail outlets

The emergence of large-scale retail outlets, including supermarkets and hypermarkets, in developing countries reflects a structural change that alters the way in which meat and dairy products are assembled, inspected, processed, packaged and supplied to consumers (Costales *et al.*, in FAO, 2006). As a result, livestock markets tend to be divided between the "wet" markets for fresh and warm meat and supermarket outlets for processed, frozen, packaged and branded meat. The relative significance of each market segment is closely linked to the purchasing power of households and individuals, their demand for leisure, their preferences with respect to the form and texture of meat upon purchase, and the relative value or price premium they are willing to pay for a safer product. Wet markets are still the main output market for live broilers produced by smallholders and independent commercial producers. There are, however, no guarantees that these markets will continue to offer economic opportunities for smallholders over the longer term, even if they are relatively efficient producers, because of large fluctuations in live broiler prices, changing consumption patterns and habits, and the rapid expansion of the large-scale retail sector with its demands for product consistency and known safety.

2.6 Increased concerns over sanitary and phytosanitary (SPS) issues and food safety

Increasing international trade and globalization are also important drivers of change in the poultry sector. More precisely, they influence the relative competitiveness of producers and production systems in supplying the rising demand for poultry products, particularly in international markets (Costales *et al.*, in FAO, 2006). Increased and long-distance trade requires compliance with standards and regulations and SPS requirements to ensure food quality and safety, as well as public intervention and investment and private costs. Food control and certification systems must be of a high standard. In addition to the health and safety standards and regulations agreed by international bodies (such as the World Organisation for Animal Health, (OIE) for animal and human health measures, the Codex Ali-

mentarius Commission for human health measures, and the International Plant Protection Convention for plant health measures), technical requirements may be imposed by retailers. These may include demands for particular meat cuts, carcass size and weight, leanness of meat, egg colour or labelling with particular information or in specified languages. Large retailers require a reliable supply of agricultural products from their suppliers (producers) with consistency in volume and in quality; hence, they vertically integrate to reduce production risk and transaction costs. Producers who become part of this integrated chain may face a change in contractual arrangements (e.g. becoming dedicated contract farmers) with increased levels of assistance and higher prices for quality products, but with increased risk if contracts are not met or the retailer closes down. This applies particularly where the farmer must specialize to satisfy volume, safety and quality requirements (see Table 6).

TABLE 6
Standards in the livestock market and implications for small-scale producers

Standards	Positive factors	Negative factors
Process standard		
Ultra-high-temperature (UHT) treatment of milk: government requirement.	Clearly specified process.	Administration costs of inspection. Investment in equipment and training may exclude smallholders.
Hazard Analysis and Critical Control Point (HACCP) systems in abattoirs: required by importers and supermarkets.	Clearly specified process.	Probably neutral for small producers.
Organic produce: standards set by certifying bodies.	Premium price. Can be carried out on a small scale (e.g. honey production in Chile). Favours labour-intensive systems	Several certifying bodies, harder to achieve in developing countries. Costs of certification. Difficult to achieve by unorganized smallholders (achievable by smallholders working in cooperatives).
Performance standards		
Salmonella levels in meat: with financial penalty for poor performance.		Standards usually set to stringent developed-country consumer requirements. No guaranteed method to meet required standards. Cost of tests may be prohibitive unless subsidized by government.
Combined standard		
Contract farming requirements for timing of activities and quality of product.	Premium price. Some support with investment and cash flow. May be supported to overcome risk, e.g. restocking after HPAI outbreaks. Technical support. Reduced risks related to variations in input and output prices.	Risk of total market loss if there is failure to produce the required quality. Not all producers meet requirements. Social stigma associated with failing to "make the grade".

Source: adapted from Costales *et al.* (in FAO, 2006).

Smallholders can find it increasingly difficult to compete with large-scale producers if they are required to make investments to meet the needs of a retailer. For smallholders to stay involved in this fast-growing segment of the market, they need to integrate into high-value chains through contract farming or other forms of institutional arrangements that have process-based food-safety systems in place and can deliver a form of branding. If smallholders choose to operate independently, it will be harder for them to remain involved over time as markets become more demanding in terms of information about the quality of the product at the time of sale and as market chains become complex.

3 CHANGING STRUCTURE OF THE INDUSTRY AND SUPPLY CHAINS ASSOCIATED WITH THE RETAILING/MARKETING OF POULTRY PRODUCTS IN DEVELOPING COUNTRIES

Under conditions of clearly specified quality and safety standards, and high risk and uncertainty in output and input markets, vertical integration is a well-known strategy to resist shocks in input and output prices, especially for small producers operating in a market subject to price instability. It is also an efficient way to provide technical assistance to the producers and to diffuse new technologies. For example, the Charoen Pokphand Group in Thailand has been promoting new housing and manure-management systems over the last six years, resulting in drastic shifts in production among its contract farmers.

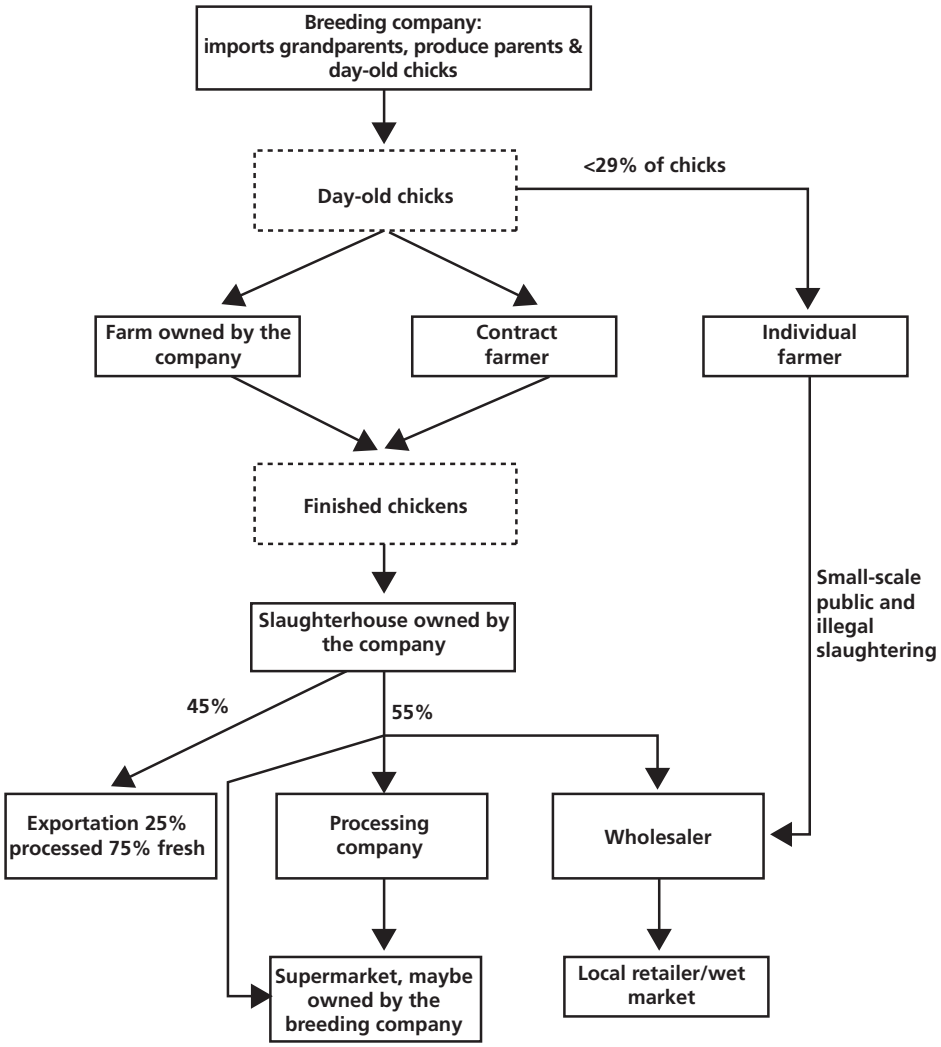
The introduction of contractual production arrangements within a framework of vertical coordination reduces transaction costs associated with information asymmetry and secures benefits from market ownership and control over product quality and safety by controlling technical inputs and processes at all levels. Large retailers and large commercial firms in developing countries are increasingly tending towards vertical coordination, although vertically coordinated chains may interact with informal markets by supplying inputs for poultry production (Figure 7).

Under production contracts, the integrators agree to supply the major inputs, such as day-old chicks (DOCs), feeds, veterinary care and medicines, and technical services. The integrators also arrange for the marketing of live broilers, which are in principle owned by them. Integrators bear all input and output price risks, and share production risks with the broiler growers. However, the growers typically do not have a share in the benefits of increasing output prices (nor do they share in losses resulting from falling output prices). Integrators operate in all aspects of production, including raising grandparent and parent flocks, rearing DOCs and milling/mixing feeds.

Conversely, the broiler producers supply the labour, land, sheds, water, electricity and management skills needed for production. They, in turn, receive a growing fee per bird based on performance indicators such as feed conversion ratio, harvest recovery and average live weight. Compensation, additional to the growing fee, is given to growers who surpass the performance standards. In the case of growers who fall below the standards, corresponding amounts per bird are subtracted from the fee.

The supply chain in Karnataka exemplifies vertically integrated broiler supply chains in India (Figure 8). All or most aspects of production (from parent stock to processing) are owned or controlled by an individual company known as the "integrator". The eggs produced from the parent-breeding farms are supplied to hatcheries, which are usually under

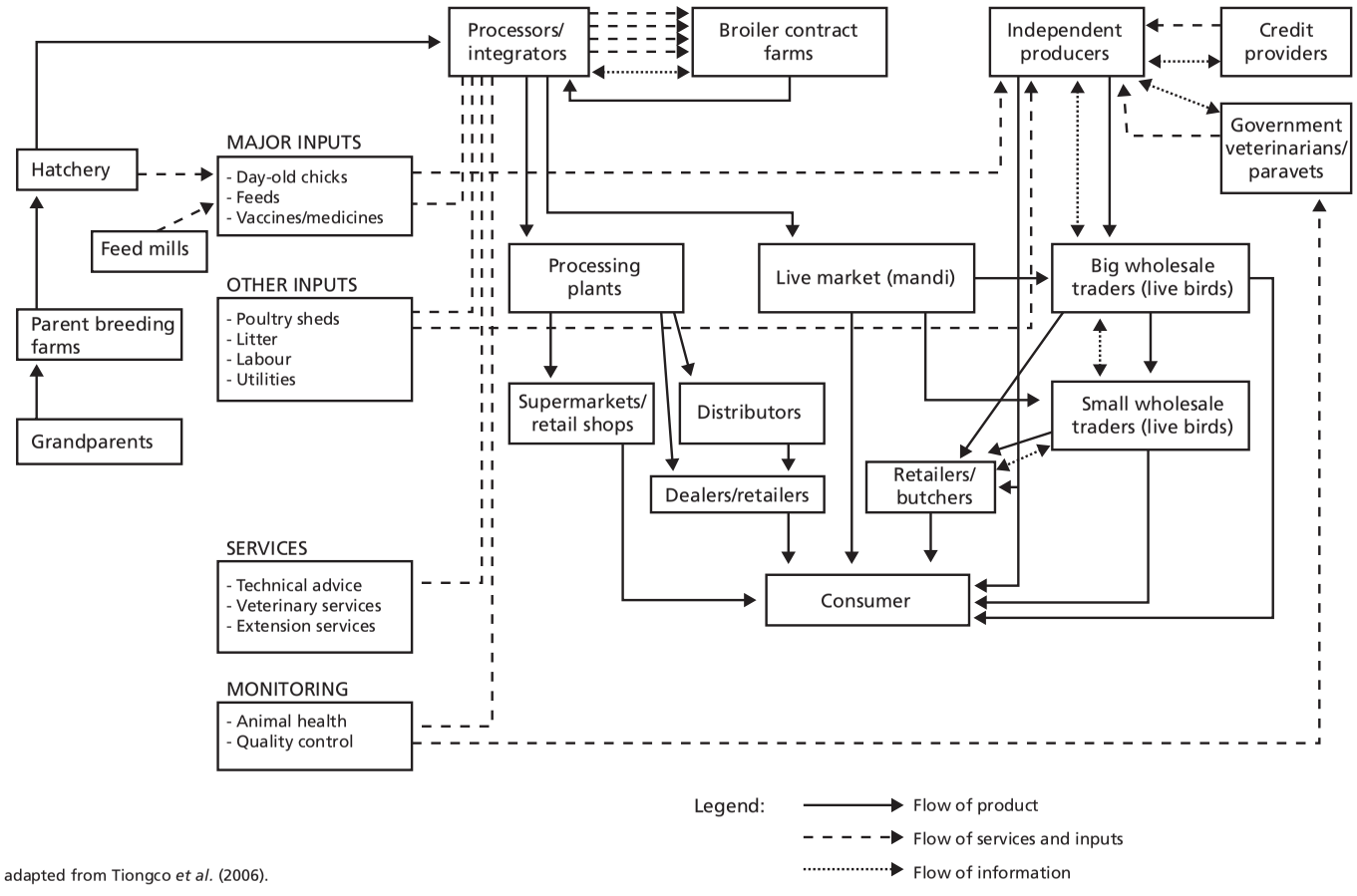
FIGURE 7
Commercial chicken supply chain in Thailand



Source: Costales *et al.* (in FAO, 2006).

contract with these big companies to produce DOCs. The DOCs are then supplied to broiler farms, which are either under contract with integrators or are independent producers of broilers. Along with DOCs, the integrators also provide the contract grower with feed, medication and technical advisors to supervise farm production. Company field representatives are assigned to visit farms on a regular basis to assist producers with their management and help them to achieve maximum performance and efficiency.

FIGURE 8
Poultry supply chain in Karnataka, India



Source: adapted from Tiongco *et al.* (2006).

Contract broiler farmers have virtually no problem marketing live birds, as the integrators arrange for the lifting of live birds from the broiler farms. The integrator, who owns the birds, will either sell the live broilers to big wholesale traders or (if they have their own processing plants) process the birds as chilled chicken to be sold to consumers.

In the case of independent broiler growers, output is sold to traders, wholesalers or retailers, or directly to consumers (if the growers have their own retail shop). Most independent farmers obtain their information on market prices from traders, intermediaries or fellow farmers, and sell broilers at the farm-gate price after negotiating with the buyer. Lack of negotiating power and lack of access to market information contribute to high transaction costs. Further, lack of facilities for collective action or other institutional arrangements makes it more difficult for smallholder producers to reduce transaction costs through economies of scale. However, overcoming these constraints is not impossible for smallholders if they have the ability and incentives to integrate into a more dynamic private-sector business.

4 EFFECT OF CHANGES ON SMALLHOLDERS' COMPETITIVENESS IN FOUR FAST-GROWING DEVELOPING COUNTRIES

4.1 Scaling-up of poultry production in Brazil, India, the Philippines and Thailand

The four country cases chosen – Brazil, India, the Philippines and Thailand – are all fast-changing developing countries where cities, population, urban incomes and consumption of livestock products have been growing rapidly since the early 1980s. Poultry is in fact one of the fastest growing segments of the agricultural sector in these four countries (Table 7). Production of poultry in these four countries has been increasing rapidly for the last 30 years, except in the case of Thailand where production has scaled down in recent years due to the avian influenza outbreaks that have hit the country periodically since 2004. Poultry production in Thailand is expected to recover as a result of improved market conditions and increases in demand for more highly-processed poultry products (overcoming depressed demand for meat in fresh from), reflecting recovery of consumer confidence in consuming poultry meat. Production is expected to increase at an annual growth rate of 2.3 percent to 2030 over the 2005 base.

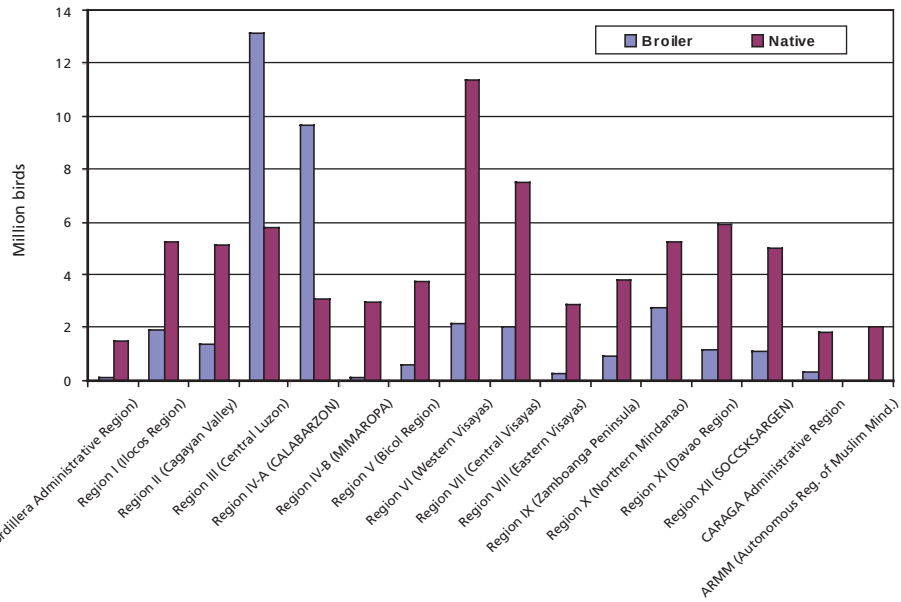
One impact of scaling-up that is occurring in the Philippines is the replacement of traditional varieties of meat animal with a few international breeds. Chicken farms in the Philippines were initially characterized by the use of native breeds. Native breeds continue to be important in the Philippines broiler market, making up about 70 percent of the total chicken population, and continue to grow at a rate of 3 percent per year. However, they are rapidly being displaced in the growing Metro Manila market and nearby cities in Regions III and IV-A (Figure 9). With a wide selection of broiler-based products (such as chicken nuggets, chicken breast sandwiches and fried drumsticks) available in fast-food establishments, an important issue for smallholders is whether they can penetrate these food-service chains. In addition, smallholders, especially those not vertically integrated with large firms, market their produce as live birds to wet markets and small retailers where food safety and quality requirements are not strictly imposed (USDA-FAS, 2006).

TABLE 7
Poultry production growth rates in Brazil, India, the Philippines and Thailand: 1975–2006 and projected to 2030

	1975–1990	1990–2006	1990–2000	2000–2006	1975–2006	2005–2030 (projected)
Brazil	10.3	8.3	9.7	6.1	9.3	2.4
India	9.1	11.3	11.8	10.5	10.2	4.5
Philippines	3.9	6.4	8.7	2.8	5.2	2.8
Thailand	5.7	3.7	6.0	-0.1	4.6	2.3

Sources: FAOSTAT accessed October 2007; rates to 2030 are taken from IFPRI's IMPACT model projections, October 2007.

FIGURE 9
Chicken inventory by region: the Philippines, 2007



Source: adapted from Costales *et al.* (2003) and Delgado *et al.* (2008); Country FAOSTAT-Philippines, accessed 24 October 2007.

As supply chains become more complex, economies of scale (cost reductions realized through expanding the scale of operations) at various stages of the production process trigger the creation of large production units. As a result of this, the number of producers rapidly diminishes even though the sector as a whole may expand. In many rapidly growing economies, the average size of operations is rapidly increasing and the numbers of livestock producers are in sharp decline. In Brazil, the estimated inventory of chickens by flock size grew significantly between 1985 and 1995-1996, as shown in Table 8. It can be observed

TABLE 8
Distribution of poultry farms by size of operation in Brazil, 1985-1996

Year	<10 000 head		>10 000 – head	
	South	Centre west	South	Centre west
1985	25%	57%	75%	42%
1996	32%	21%	68%	78%

Source: adapted from Camargo Barros *et al*. (2003). Brazilian Institute of Geography and Statistics (IBGE), Census, 1995/1996.

TABLE 9
Change in the size distribution of poultry farms in Thailand between 1988 and 2003

Flock size (birds/farm)	Number of farms (×1 000)			(% change)		
	1988	1998	2003	1988–1998	1998–2003	1988–2003
1–19	2 267	1 948	362	-14	-81	-84
20–99	946	1 146	581	21	-49	-39
100–999	27	66	68	144	3	152
1 000–9 999	9	13	14	44	8	56
10 000 and over	0.5	2	4	300	100	700
Total	3 250	3 174	1 028	-2.3	-68	-68

Sources: adapted from Poapongsakorn *et al.* (2003) citing the 1988 and 1998 Inter-censal Survey of Agriculture by the National Statistical Office and the 1993 Agricultural Survey by the National Statistical Office (National Statistics Office, 2003).

that growth in larger farms (more than 10 000 birds) happened in the centre west – states of Mato Grosso, Mato Grosso do Sul and Goiás – and also in the states of São Paulo and Minas Gerais (Camargo Barros *et al.*, 2003). In the south, the share of small farms increased by 7 percent – brought about by expansion of farms in the states of Paraná, Santa Catarina and Rio Grande do Sul (particularly farms with 5 to 10 thousand birds among which there has been significant growth).

Similarly in Thailand, only the largest category of farms grew in number (Poapongsakorn *et al.*, 2003). Table 9 shows changes in the size distribution of poultry farms in Thailand. The table depicts a situation in which smallholder farms (with less than 100 birds) still dominated in terms of numbers, although they had been declining in absolute level between 1988 and 2003. The larger-sized farms registered the largest proportional increases in number over the period covered by the table (in 2003, 43 percent of broilers produced in Thailand came from farms keeping less than 10 000 birds), indicating the increasing scale and commercialization of poultry production.

4.2 Impact of structural changes on profitability of small-scale producers – results from case studies

The main concern with regard to the forces promoting the scaling-up of livestock production in developing countries is that they might drive small-scale producers out of business altogether, and the question of whether the displacement is being accelerated by policy distortions, externalities or structural factors such as transaction costs that disproportionally affect small-scale farms. If true economies of scale resulting from technology, management or transport (for example) are driving the incentives for larger-scale poultry farming, then other things being equal, we would expect larger farms to be more profit efficient and have higher or equal unit profits compared to small farms. In such circumstances, the larger farms could eliminate competition from small farms over time by cutting their profit margins. Small farms can stay in business by using family labour valued below market price; this works well in developing countries where there are limited employment opportunities in other sectors. But as soon as employment opportunities in other sectors rise, many smallholder producers will opt out.

The results of the case studies conducted by Delgado *et al.* (2003), suggest that smallholders typically have higher profits per unit of output than have large-scale producers – as shown in the cases of India and the Philippines in Table 10. In the case of broiler producers in the Philippines, profits per unit obtained by smallholder contract farmers were higher than those obtained by large-scale contract farms. The findings from India are supported by a recent study in Karnataka, which looked at the effect of contract farming on the profitability of broiler production (Fairoze *et al.*, 2006).

In Thailand, large independent broiler farms made higher profits than medium-sized independent farms (Table 10). Fee contract farmers in the Thai broiler sample had similar per unit profits at large and small scales. In Brazil, as in the case of Thailand, small and large broiler farms have similar average profits per kg. This may reflect the fact that in the Brazilian case the majority of small and large-scale farms are contracted to vertically integrated operations. Much of the inputs are supplied by the integrator and in most cases the small and large-scale farms are using similar if not the same technology. Moreover, small-scale farms do not explicitly cost family labour, allowing them to maintain their unit profits close to large farms.

There is, however, a growing concern that smallholders might be excluded from the process of contractual arrangements, as integrators would prefer to contract with large-scale farmers so as to minimize production and transaction costs associated with searching for and screening prospective farms, negotiation of contracts, delivery of inputs and services, monitoring of growers' management on farm, and enforcing contract terms.

Tiongco *et al.* (2006) observed that an integrator's transaction costs are incurred on a per grower basis and do not depend on the size of the farm. Moreover, small farms usually require more technical assistance from the integrator per unit of output. For example, a farm visit may require the same amount of time regardless of the scale of production. It was also observed that there was no significant difference between small and large farms in terms of the growing fees paid by integrators per unit of output. Holding the growing fee per unit constant, integrators would rather contract with larger producers to lower their cost of procurement or to lower the cost of default.

TABLE 10
Average profit per unit of output of broiler live weight across farm sizes by country and by production arrangement, 2002

Country		Farm size			
		Smallholder <10 000 birds		Large/Commercial >=10 000 birds	
		Independent	Contract	Independent	Contract
India					
Average profit without family labour cost	rupees/bird	13.13	1.03	10.93	3.16
	US$/kg*	(0.11)	(0.01)	(0.09)	(0.03)
	rupees/bird	11.36		9.98	
	US$/kg*	(0.10)		(0.09)	
Average profit with family labour cost	rupees/bird	12.40	0.04	10.80	3.01
	US$/kg	(0.11)	(0.003)	(0.09)	(0.03)
	rupees/bird	10.59		9.85	
	US$/kg	(0.09)		(0.08)	
Philippines					
Average profit without family labour cost	pesos/kg	1.59	4.05	1.07	3.96
	US$/kg	(0.03)	(0.08)	(0.02)	(0.08)
Average profit with family labour cost	pesos/kg	1.34	3.98	1.06	3.95
	US$/kg	(0.03)	(0.08)	(0.02)	(0.08)
Thailand		Forward contract and independent	Per-bird wage contract	Forward contract and independent	Per-bird wage contract
Average profit	baht/ kg live weight	0.71	1.35	2.48	1.51
	US$/ kg live weight	(0.02)	(0.03)	(0.06)	(0.04)
Brazil					
Average profit	real/kg live weight	0.05		0.06	
	US$/ kg live weight	(0.02)		(0.02)	

Note: * assuming 1 bird weighs 2.4 kg live weight.
Numbers in parentheses are average profit in US$ per unit of output. The currency conversion rates used are based on 2002 foreign exchange rates: for Thailand, US$1= 42.96 baht; for India, US$1 = 48.61 rupees; and for Brazil, US$1 = 2.92 reals; for the Philippines, US$1 = 51.60 pesos.
Source: Delgado *et al.* (2008).

Smallholders will have at least a chance to compete with larger-scale producers, as they have the ability to produce at a lower per unit cost of production or at least achieve profits per unit of output that are similar to those of large-scale farmers. If smallholders are not able to sustain a rate of productivity growth equal to or greater than that of large farms under these conditions, they will have a hard time remaining in business.

TABLE 11
Mean relative profit efficiency of broiler farms across farm sizes by country, 2002

Country	Farm size (number of birds)			
	Smallholder <10 000 birds		Large/Commercial >=10 000 birds	
	Independent	Contract	Independent	Contract
Philippines	N = 30	N = 34	N = 31	N = 14
Mean efficiency (%)	35	56	45	73
	45		64	
India	N = 93		N = 42	
Mean efficiency (%)	45		85	
Brazil	N = 34		N = 195	
Mean efficiency (%)	76		86	
Thailand	Contract <5 000 N=74	Contract 5–10 000 N=51	Contract 10–20 000 N=27	Contract >20 000 N=18
Mean efficiency (%)	49	71	88	87

Source: Delgado *et al.* (2008).

In terms of relative profit efficiency, the outlook for small broiler producers is not good. Table 11 shows that large-scale producers from the four case-study countries are more profit efficient than small farms, which means that they will be able to drive their costs down and survive on smaller unit profits but bigger volumes of sales. If this is the case, it is possible that smallholders will be driven out of the market because of their small volumes of production. According to Delgado *et al.* (2008), for smallholders to survive the livestock industrialization process, the key issue is for them to have access to output markets.

Smallholders find it increasingly difficult both to meet the food safety and quality standards required in growing urban markets and in export markets and to deliver a regular supply. Small-scale producers are often left out due to their low productive capacity, remoteness and limited competitiveness compared to larger growers. Organizational challenges further impede private-sector inclusion of smallholders. Although the public sector has traditionally provided services such as extension, research, infrastructure and marketing outlets, the movement towards demand-driven agriculture limits the ability of government to fully provide the assistance needed by smallholders to enable them to gain recognition in the marketplace. Rich and Narrod (2005) suggest that close coordination of the supply chain works against the smallholder because of information asymmetry and high transaction costs, organizational constraints and regulatory failure. Smallholders tend to face high transportation costs because of their geographical location and poor infrastructure linking them to markets. Smallholders often have imperfect information regarding the needs of buyers and customers in the high-value markets for which they are producing. Further, their ability to meet public or private standards is limited – there is often a large divergence between public and private standards, and the public sector in the countries in question

often has a low capacity to enforce public standards. In terms of coordination mechanisms, smallholders often have limited ability to enforce contracts and there is often a divergence in market power among the actors in the supply chain.

There are, basically, five elements that are essential to ensure smallholders' access to markets. First, producers need access to extension services or technical assistance so that they stay up to date with the specialized techniques needed to ensure the safety of high-value products. Second, they need access to good infrastructure so as to be able to manage flows between chain links quickly and efficiently so as to meet the rigid deadlines imposed by buyers and reduce transportation and distribution costs. Third, they need access to good sources of information so as to be well informed of changing market demands and to be able to integrate this information rapidly across the supply chain. Fourth, producers need to have the ability to produce products that are certifiably safe and of good quality. Certification systems need to be not only consistent but also credible, to meet buyer and customer demands. Lastly, producers need to have good mechanisms for coordination of their supplies to the markets so as to ensure the timely delivery of high-quality products. If market failures are preventing smallholders' access to these important elements, it is very possible that they will lose much of their current market access unless some sort of institutional arrangement can be made to address the problems.

5 THE FUTURE OF SMALLHOLDER POULTRY PRODUCTION IN A RAPIDLY CHANGING MARKET

Poultry production has undergone rapid changes during the past two decades as a result of the introduction of modern intensive production methods, genetic improvements, improved preventive disease control and biosecurity measures, increasing income and human population, and urbanization. The intensification of segments of the poultry sector, in proximity to areas of ever more dense human population, in conjunction with the increasing ease of transport, has led to growth or scaling-up of poultry production. In all the case-study countries, there has been a rising demand for poultry products with specific food-safety and quality attributes, probably linked to increased urbanization and income levels. The private sector in the case-study countries has taken the lead in delivering products with the desired attributes, at least to wealthier consumers patronizing high-end market outlets. Large producers in all the case-study countries have also sought a form of branding through vertical integration with small-scale retail outlets for poultry meat serving the broader urban populace.

From the findings of the case studies described above, it is difficult to see a bright future for smallholder poultry production. However, results also show that it is unlikely that smallholders will disappear soon. Smallholder producers can still compete with larger producers because of savings achieved as a result of foregone or cheaper overheads, lower labour costs per unit and, possibly, more intensive supervision, leading to relatively high profit efficiencies.

Food-safety concerns and demand for reliable timing and quality drives the concentration of supermarkets. The requirement to meet high demands for food safety, traceability and compliance often disfavours smallholders compared to larger operations in terms of supplying specific supply chains, because of high coordination costs, and high transaction

and marketing costs associated with sourcing from smallholders. Increasingly, it appears that smallholders' ability to maintain their competitiveness in these types of markets is dictated by their ability to establish market trust and reputation along the marketing and distribution channels. This will require them to be linked to the supply chain and obtain certain supply chain management necessities. The fact remains that public policy targeted at achieving widespread impact on poverty by keeping smallholders involved in the growing livestock sector needs to harness the resources of the private sector, typically through the provision of incentives for contract farming. The incentives for such schemes often come in the form of tax breaks to the integrators; it will be important to factor the costs of forgone public revenue when establishing the unit costs of the schemes. The key for poverty alleviation is to ensure that the measures are beneficial to smallholder producers as well as larger farmers and integrators. Investigating the full costs and benefits of different policies aimed at encouraging contracting with smaller-scale farmers is a policy-research priority.

Aside from contract farming, there are other strategies that can facilitate a more competitive link of smallholders to changing markets. Important considerations include appropriate government policies that would provide communication and storage infrastructure facilities and cost-effective disease control methods. The HPAI crisis in East Asia severely threatens the viability of the small-scale poultry sector in the region because of its dramatic spread, and the high mortality and massive depopulation associated with outbreaks. Preventive and control measures must be pro-poor so as not to constrain the participation of smallholders.

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Scale and structures of the poultry sector and factors inducing change: intercountry differences and expected trends

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SUMMARY

Rapid growth in consumer demand for livestock products in the developing countries is being met by corresponding growth in poultry meat and egg production and consumption. Comparison of five case-study countries, India, Egypt, China, Thailand and Brazil, shows a clear association between average per capita incomes and consumption of poultry meat. In India and China only, egg consumption has grown faster. Global meat export trade is dominated by Brazil, with contributions from Thailand and China, although the latter country's imports exceed its exports. Quantities traded by India and Egypt are quite small.

Four main poultry production sectors are identified: 1, industrial and integrated; 2, commercial high biosecurity; 3, commercial low biosecurity; and 4, village or backyard. These are ranked in reverse order of scale of production, concentration of bird density, productivity per bird, contribution to total poultry meat production, market integration and adoption of formal biosecurity measures (the relative effectiveness of this biosecurity has been questioned). Sector 1 and 2 systems and poultry production are concentrated in particular limited areas of each of the case-study countries. Larger numbers of Sector 4, and possibly Sector 3, smaller-scale producers operate in all areas. Sectors 1, 2, and possibly 3, involve separation of the stages of production – breeding, growing, feed-milling, processing and distribution – allowing the benefits of increased scale and specialization. In Sector 1, the separate enterprises are vertically integrated, to reduce transaction costs and improve managerial control. The alternative of contract growing allows participation of small-scale growers and sharing of production and price risks.

Poultry breeding, feed milling and markets are seen as three drivers of change. The introduction of exotic strains and intensive breeding has led to rapid growth in productivity, particularly in India. Concentrate feed is the largest cost item. Global prices of the ingredients maize and soy meal have increased greatly this year (2007). Egypt suffers from high import dependency for both crops. India, China and Thailand, though self-sufficient in maize, are vulnerable to increasing demands and prices for feeds. Only Brazil is already a major exporter of both crops and has large areas of, as yet, underexploited cropland. Increase in poultry production and processing is linked with growth of commercial food and retailing and with globalization. Consumer preference for live-bird retailing, in Egypt and India, constrains growth of the sector.

Case-study countries differ in their comparative costs of poultry production, possibly lowest in Brazil. But prices are affected by trade, exchange-rate policies and producer support. Import duties (tariffs) imposed by importers benefit domestic producers, but raise costs for consumers and depress prices in exporting countries. Thus, tariffs on poultry meat and on feed grains affect producer prices and incentives. Devaluation of an overvalued currency has similar impacts, but (unlike tariffs) increases social welfare. The poultry industry has had relatively little direct government support. Public good and externalities associated with disease control justify government intervention. Outbreaks of highly pathogenic avian influenza (HPAI) in India, Egypt, China, Thailand and other countries (though not Brazil) have affected poultry production, consumption and trade. Policy issues arise in connection with compensation for birds culled, the use of vaccination and regulations some of which may disadvantage smallholder backyard producers.

Commercial production and consumption of poultry meat and eggs are expected to continue to expand. Possible constraints include global economic, environmental and social problems, domestic policy limitations, supplies and prices of feed grains and oilseeds, deficiencies in national infrastructure, and disease such as HPAI. Sector 4 production is likely to continue to serve a different market from that of the expanding commercial sector. The semi-commercial Sector 3 may be a transitional stage in the commercialization process and may eventually contract.

Key words: poultry, comparison, sectors

1 THE CONTRIBUTION OF POULTRY TO THE LIVESTOCK REVOLUTION

1.1 Increased production and consumption in developing countries

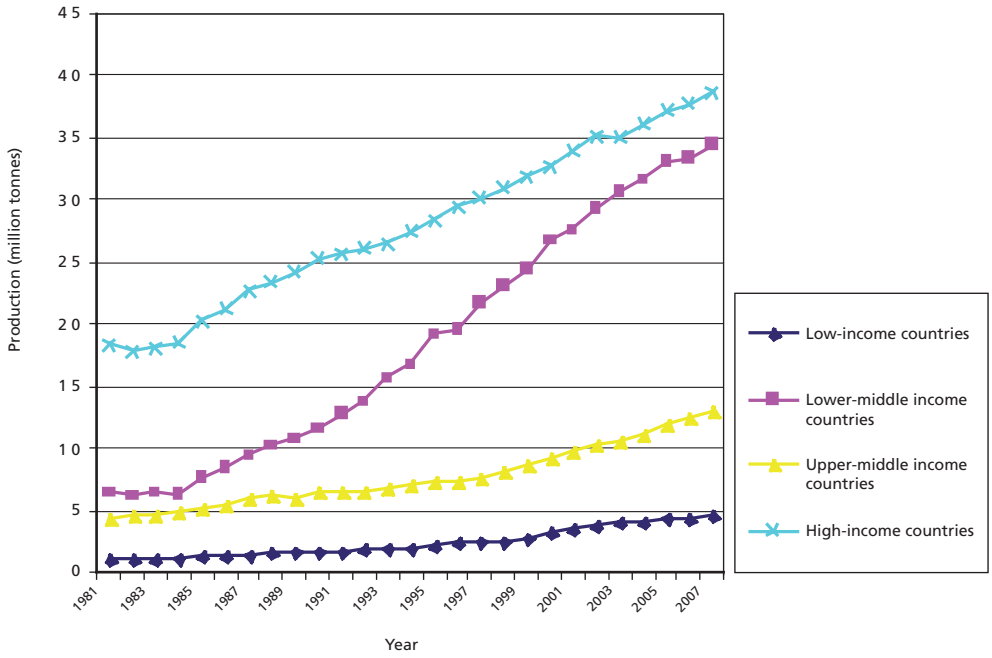
The rapid growth in developing-country demand for livestock products, known as the "livestock revolution", is being satisfied, at least in part, by rapid expansion in poultry meat production (Delgado *et al.*, 1999). The "revolution" has been fuelled by population growth, urbanization and income growth, as have the associated increases in the production and consumption of poultry meat. These changes have occurred at different rates in different countries, depending for instance on the current average per capita income levels. The World Bank classification of developing countries into low-income, lower middle-income and upper middle-income categories may be used for comparative purposes[1] (Figure 1).

The most rapid expansion, in poultry meat production, has occurred in the lower middle-income group of countries, with average annual per capita incomes of between US$876 and US$3 456. In this group, poultry meat production has grown steadily, at an annual rate of over 8 percent, and has more than quadrupled over the last 20 years. Production in the low-income group of countries, and in the upper middle-income group, started from a lower base and has grown more slowly (Figure 1).

Egg production has grown at similar rates. In the lower middle-income countries, the "volume", in tonnes, produced in 2004 was closely similar to the "volume" of poultry meat, but the value of egg production was more than double that of meat. The low-income

[1] The proportion of the total population, dwelling in urban areas, is positively associated with per capita incomes, rising from 30 percent in low-income countries to 77 percent in high-income countries. The proportion of national income derived from agriculture falls from 21.5 percent for low-income countries to 1.9 percent for high-income countries (see Annex A).

FIGURE 1
Poultry meat production 1981 to 2007



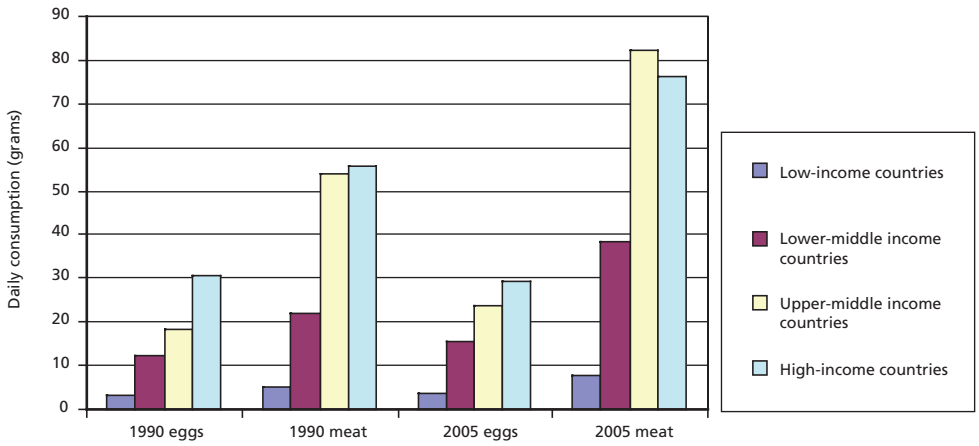
Source: FAOSTAT.

countries, as a group, produce similar quantities of poultry meat and eggs, in both volume and value terms. However, the upper middle-income countries produce a substantially lower volume and value of eggs than of poultry meat.

The impact of average per capita income on demand for poultry products is illustrated by comparing daily consumption of poultry meat and eggs in the different country-income groups, and changes over time (see Figure 2). Consumption levels of both poultry meat and eggs increased between 1990 and 2005 for all income groups except for high-income developed countries, where egg consumption fell. As average per capita incomes rose over the same period for all income groups, these changes give an indication of the impact of income growth on demand for poultry products. The decline in egg consumption in high-income countries suggests that the effect of income growth may have reached a peak and demand may be more strongly influenced by changes in consumer taste.

The contrasts in consumption of poultry meat and eggs between country-income groups in any one year are striking. Data for 2005 are presented in Table 1. These cross-country comparisons illustrate the relationship between individual incomes and consumption levels of poultry meat and eggs. It may be assumed that the average per capita consumption levels of countries with widely different average incomes provide an indication of the likely consumption behaviour of different income strata within countries. The poor, surviving on very low incomes and low levels of nutrition, can only afford to consume very small

FIGURE 2
Average daily consumption of eggs and meat per capita



Source: FAOSTAT.

TABLE 1
Mean per capita incomes and consumption of poultry meat and eggs, by country income categories, 2005

Income group	Mean gross national income per capita (US$)	Mean per capita poultry meat consumption (kg per year)	Mean per capita egg consumption (kg per year)
Low-income	585	2.81	1.30
Lower middle-income	1 923	14.04	5.70
Upper middle-income	5 634	30.06	8.64
High-income	35 264	27.80	10.71

Sources: FAOSTAT and World Bank data.

amounts of poultry meat and eggs. As incomes increase, so too does the consumption of poultry products – rapidly at first, but at a diminishing rate.

A comparison of income and consumption levels in lower middle-income countries with those in low-income countries shows that a 1 percent increase in income is associated with a more than 1 percent increase in consumption of poultry products.[2] A comparison of changes in average income and consumption levels between lower middle-income and

[2] The "income elasticity of demand", estimated as the percentage increase in quantity demanded for a 1 percent increase in income, is greater than unity over this range. The demand is said to be "elastic". It becomes less elastic as incomes rise further.

upper middle-income countries shows a smaller proportionate increase in consumption than in income. The differences in average consumption levels between high-income countries and upper middle-income countries are quite small. Indeed, consumption of poultry meat appears lower in the high-income countries. Consumption of poultry products in the upper middle- and high-income countries may be near to the desired maximum, and more expensive preferred sources of animal protein may be substituted in human diets.

1.2 The poultry industry in five case-study countries

The association between levels of income and consumption of poultry products may be illustrated by comparing the five case-study countries: India, Egypt, China, Thailand and Brazil (see Figure 3). The countries are ranked in increasing order of mean annual per capita income. While India is a low-income country, the other four are all lower middle-income countries (although Brazil is near the top of the income range). For more detailed information on the case-study countries, see Annex B.

The normal positive relationship between per capita income and consumption of poultry meat seems to apply both in the case of a very low level of consumption (India) and a very high level of consumption (Brazil). However, the pattern of egg consumption is rather different, with egg consumption in China much higher than in the other countries and more than twice as high as that of chicken meat. Egg consumption in Brazil, on the other hand, is much lower than might be expected. It appears that cultural differences affect choices regarding consumption of eggs.[3]

The relative importance of chicken and the meat of other bird species is also dependent on cultural differences. The consumption of duck is probably prevalent in irrigated areas of East Asia and Egypt, where duck rearing is a component of local farming systems.

Poultry meat makes up 18.4 percent of total meat consumption in China and 46.9 percent in Brazil. Poultry meat and eggs together contribute a larger percentage of total meat, eggs and fish consumption – 30.9 percent in China and 47.4 percent in Brazil. Although the proportions might differ slightly if measured in terms of units of animal protein, it is clear that poultry make a major contribution to human nutrition in these countries.

Growth in per capita incomes in the case-study countries over the last six years has contributed to the growth in consumer demand for poultry meat. For instance, in India, incomes have grown annually by 10.5 percent while chicken-meat consumption grew by 8.4 percent. The corresponding rates in China were 13.7 percent and 2.0 percent. Thailand is exceptional in that annual income growth of 7 percent was associated with a 4.25 percent fall in poultry meat consumption. In Egypt both income and poultry-meat consumption fell over the last six years.

Three of the case-study countries, India, China and Brazil, are very large in area, human population and poultry production. Statistics for these countries, therefore, dominate those for the respective income groups – India contributing 47 percent of the aggregate production of low-income countries, and China and Brazil together accounting for over 73 percent of total lower middle-income country production.

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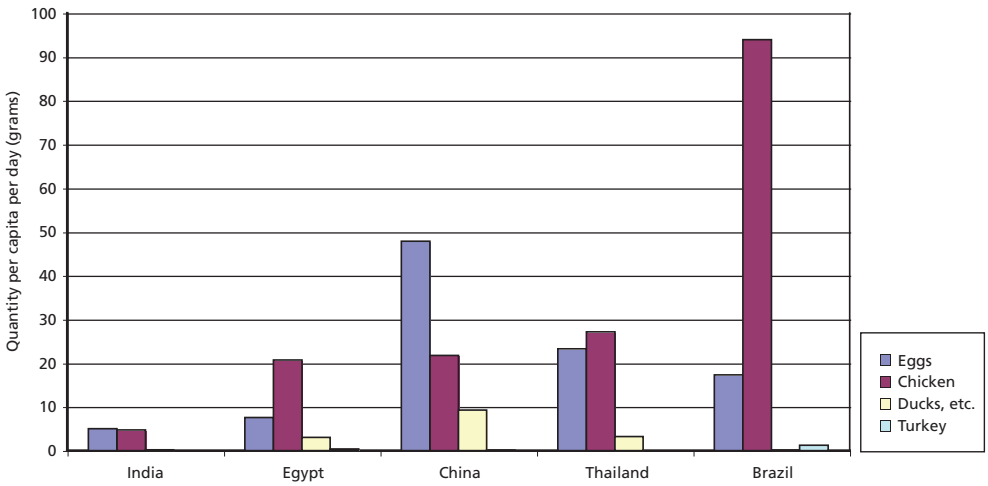
[3] These choices will affect the development of the poultry sector, and the relative emphasis on broilers and layers. These decisions will, in turn, affect the relative availability and, inversely, the relative prices of meat and eggs.

FIGURE 3
Consumption of poultry products in the case-study countries, 2006



Source: FAOSTAT.

1.3 Poultry meat and egg production

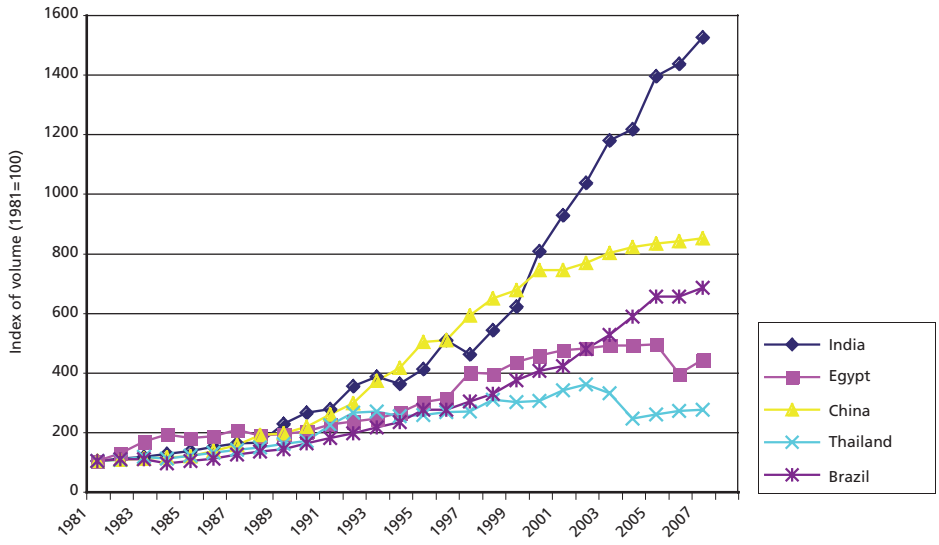
There are large differences between case-study countries in terms of the size of the poultry sector and the contribution made to global poultry-meat production. Listed in diminishing size order, the percentage contributions made to global production are as follows: China 17.5; Brazil 11.9; India 2.4; Thailand 1.3; and Egypt 0.6. A visual comparison of the relative growth rates of poultry meat production, independently from overall size, is obtained by comparing indices of growth, with 1981 as the base year set at 100 (see Figure 4).

Poultry meat production has grown most rapidly in India, at over 11 percent annually over the last quarter century. The pace appears to have accelerated in the last decade. In China production grew even more rapidly up to the mid-1990s, but the rate of growth has slowed since then, giving an overall average rate of about 9 percent. Brazilian poultry-meat production has grown steadily since 1985, at a lower rate of just below 8 percent. The slackening in growth in the last two years may be a consequence of the impact of HPAI on demand.

In Egypt, after quite rapid growth to the mid-1980s, production expanded at a slower rate until the end of the century. Since the year 2000, production appears to have stagnated; it actually fell in 2006 as a result of HPAI. Thai production grew quite rapidly until the early 1990s, then quite slowly over the next ten years. Since 2002, production has fallen as a result of HPAI outbreaks, although recovery has started.

The overall growth in production is the result of changes in three key variables: first, the inventory or number of birds in the national flock; second, "productivity" – here measured as the number of birds produced and slaughtered per head of the national flock; and third, the carcass weight. All these variables have increased over the last quarter century in most

FIGURE 4
Relative growth of poultry meat production: case-study countries



Source: FAOSTAT.

developing countries, and their relative contributions to the growth in poultry meat production may be assessed from published statistics. Results for all five case-study countries are given in Figure 5.

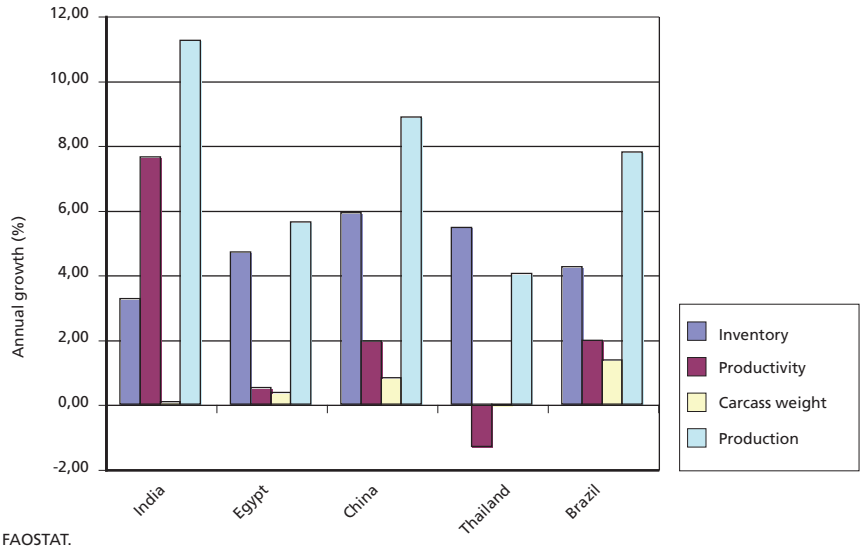
In India, the greatest gains have been made in the "productivity" measure; this is in contrast to the other four case-study countries where inventory change has contributed most to growth. This growth in productivity in India may reflect the technological change that has occurred in poultry breeding, from traditional, "desi" poultry to exotic hybrid chickens. In Thailand, the fall in productivity may be due to the large numbers of birds slaughtered for disease-control purposes and, therefore, removed from the market. The inventory of birds is not affected to the same extent, and has grown faster than total production.

Egg production has increased over the same period in all case-study countries, but less rapidly than meat production. This suggests that the overall growth of the poultry industry, in all cases, has been associated with a switch from egg production to broiler-meat production. However, there are big differences between countries with respect to the relative importance of poultry meat and eggs in volume terms. In India and China the volume of eggs produced exceeds the volume of poultry meat by 23 percent and 97 percent, respectively. In Thailand, Egypt and Brazil, the volume of egg production is less than that of poultry meat, at 65, 45 and 16 percent, respectively. For Thailand and Brazil, this may reflect the greater importance attributed to broiler production for the export market.

1.4 International trade in poultry produce

Trade in poultry products differs substantially between the five case-study countries, with Egypt and China being net importers of poultry meat, India close to self-sufficiency, and

FIGURE 5
Relative contributions to growth of meat production, 1981 to 2006



Source: FAOSTAT.

Brazil and Thailand being net exporters. Changes in poultry meat trade over the last quarter century are shown in Figure 6. However, the situation differs somewhat with respect to trade in eggs and live birds – so each country is considered in a little more detail in the following paragraphs.

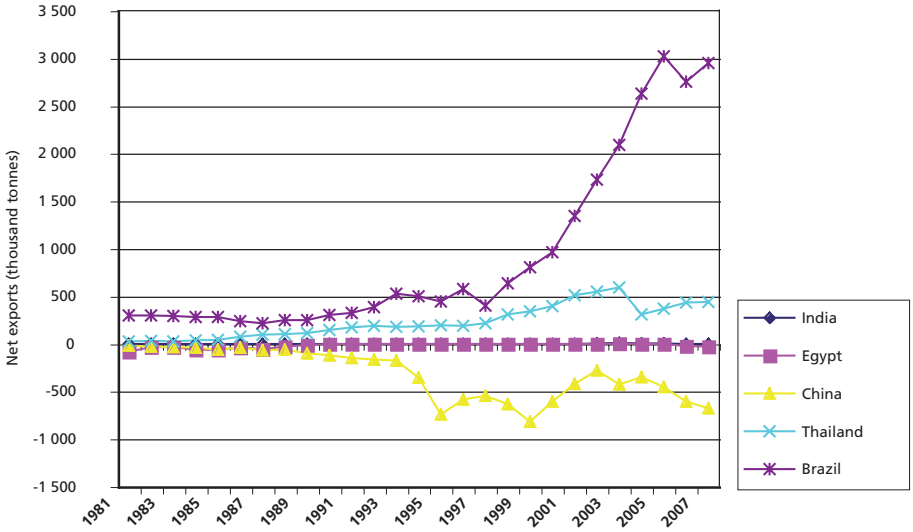
India is a net exporter of a small amount of poultry meat – a fraction of 1 percent of domestic production.[4] In this respect, it differs from the majority of low-income countries, which are net importers of poultry meat. A small amount of export revenue is earned from canned poultry meat exports. Limited costs are incurred in importing live birds. However, eggs constitute a significant net export, earning nearly 80 times the export earnings from poultry meat.

Egypt is a net importer of poultry meat and eggs, but since 2003 has been a net exporter of live birds. Quantities and values are relatively small, and poultry meat imports only represent 4.5 percent of domestic utilization.

China, despite being a significant exporter of unprocessed poultry meat on the world stage, is a net importer, attracting 15 percent of global imports and supplying 8 percent of domestic consumption from imported produce. However, poultry meat is subjected to further processing in China, and some of the products are exported. If the value of canned chicken-meat exports is added to the value of primary chicken-meat exports, then China becomes a major net exporter of poultry-meat products, in value terms. Although China is a net importer of a small number of live poultry, the value of bird exports exceeds the value of bird imports by a small margin. The volume of eggs traded is only a small percentage of total production and consumption, but the balance between imports and exports

[4] The quantity is so small that the net export graph for India cannot be distinguished from the x axis in Figure 6.

FIGURE 6
Growth in net trade for case-study countries



Source: FAOSTAT.

changes from year to year. In 2005, China switched from being a marginal net exporter to a marginal net importer. However, in value terms, exports exceeded imports.

Thailand is a much smaller East Asian country which has encouraged the growth of the poultry meat export industry. Between 1980 and 2003, exports of poultry meat grew at a rate of 15 percent annually. In 2003, Thai exports represented 7 percent of the global total. Since then, exports have fallen as a result of HPAI outbreaks and have not yet recovered to the previous level. Nonetheless, exports currently account for over 40 percent of domestic production. However, like China, Thailand is earning revenue from exports of canned meat, which currently contribute considerably more to export earning than do exports of un-canned poultry meat. This emphasis on processed exports reflects a general switch from raw or frozen poultry exports to pre-cooked and processed exports, to avoid restrictions imposed following the HPAI outbreaks. Thailand is currently a net exporter of live birds, although imports were higher in 2004 after the first HPAI outbreak. Some eggs are also exported.

Brazil has rapidly expanded poultry-meat production and exports, and now supplies around 35 percent of global exports. This places the country ahead of the United States of America, which is the other major world exporter of poultry meat. Exports account for about 28 percent of domestic production. In fact, led by Brazil, the lower middle-income countries have in the twenty-first century become the main global net exporters, while net exports from the high-income countries have dwindled to a very low level. Since the mid-1990s the upper middle-income countries have become the main net importing group.

Canned poultry meat, live birds and eggs are also exported from Brazil, but in much smaller volumes and with much smaller values than the poultry meat exports.

2 THE RELATIVE IMPORTANCE OF DIFFERENT PRODUCTION SYSTEMS

2.1 The FAO four-system classification

The rapid expansion of poultry production, in all the case-study countries and globally, has been associated with technological change and increasing scale of production units. More specifically, the development has involved a switch in emphasis from traditional small-scale production using dual-purpose indigenous breeds to intensive commercial production systems using hybrid birds specially bred either for meat or for egg production. In practice, a range of commercial and semi-commercial systems may develop – so some further categories are needed.

TABLE 2
Characteristics of four different poultry production sectors

Characteristics	Sectors			
	1. Industrial and integrated	2. Commercial: high biosecurity	3. Commercial: low biosecurity	4. Village or backyard
Biosecurity	High	Moderately high	Low	Low
Market outputs	Export and urban	Urban/rural	Live urban/rural	Rural/urban
Dependence on market for inputs	High	High	High	Low
Location	Near capital and major cities	Near capital and major cities	Smaller towns and rural areas	Everywhere: dominates in remote areas
Housing	Indoors: closed	Indoors: closed	Indoors/part-time outdoors: closed/ open	Outdoors most of the day: open
Contact with other poultry, domestic birds and wildlife	None	None	Yes	Yes
Veterinary service	Own veterinarian	Pays for veterinary service	Pays for veterinary service	Irregular, depends on government veterinary service
Source of medicine and vaccine	Market	Market	Market	Government and market
Source of technical information	Company and associates	Sellers of inputs	Sellers of inputs	Government extension service
Source of finance	Banks and company funds	Banks and company funds	Banks and private informal	Private informal and banks
Breed of poultry	Commercial	Commercial	Commercial	Native
Food security of owner	High	OK	OK	From OK to bad

Source: FAO (2004).

A set of characteristics used by FAO to distinguish between four main production sectors is presented in Table 2 (FAO, 2004). In effect, the commercial sector has been subdivided into three main categories, Sector 3 having the lowest levels of: i) scale and concentration of production; ii) intensity; iii) productivity; iv) commercialization; v) specialization; vi). market integration; and vii) formal biosecurity measures; and Sector 1 the highest. Attempts have been made to assess the distributions of poultry producers and birds between the four sectors in the case-study countries.

The four categories are better described as "sectors" than as "systems", as increasing commercialization is associated with increased segmentation of different stages in the value chain from input supply through to retail delivery of the product. The production system is, then, only one stage in the chain.

Levels of biosecurity merit further comment. Although formal biosecurity may be higher in industrial/commercial systems, the greater bird population density may increase the probability of infection and the scale of disease outbreaks that occur in these concentrated production systems (Otte *et al.*, in FAO, 2007a).

Increasing concentration of production is also associated with problems of waste disposal and soil, air and water pollution (Steinfeld *et al.*, in FAO, 2006a). Within each sector there is a great deal of variation between individual types of production system and value chains, so further discussion is needed.

2.2 Sector 4: village or backyard production

The most basic and simple backyard production system involving a few hens and a cockerel is essentially a closed system. Home-produced fertile eggs are hatched to provide replacements, birds feed by scavenging or are provided with household scraps and crop by-products; there are virtually no veterinary inputs and the remaining eggs and meat produced are consumed within the household.

Such very simple subsistence poultry production systems are probably quite rare. Producers with even slightly larger flocks, generate cash income from the sale of eggs and birds within the local community. In the five case-study countries and in most parts of the developing world, live birds and eggs are traded in open-air or "wet" markets and in retail shops, where birds are slaughtered on sale. Transactions may take place directly between producers and consumers, but traders and other market intermediaries may be involved, selling on to other sectors of the poultry industry.

Sector 4 production systems are widely distributed and exist in both rural and urban areas. In most countries, the majority of producers fall into this category, but with development of the industry a growing proportion of both meat and egg production is derived from the commercial sectors. It is estimated that today in India, only 10 to 20 percent of total poultry output is derived from "backyard" production (Landes *et al.*, 2004). Proportions may be higher in Egypt, at 22 percent of chicken meat and 30 percent of eggs, and China at over 60 percent of meat and nearly 70 percent of eggs, but are probably lower in Brazil and Thailand where the commercial sector is most developed. However, in all five case-study countries there is wide inter-regional variation in poultry population density, reflecting the localized concentration of commercial production. In areas that are less densely populated by poultry, "backyard" systems are likely to contribute a larger proportion of total poultry production.

In the village or backyard sector, production is generally based on traditional local, native breeds, producing both eggs and birds for meat. In India they are referred to as "desi" and in Egypt as "balady" poultry. Chickens are the main species kept, but in India, Egypt, China and Thailand significant numbers of ducks and other domesticated birds are kept. In China, ducks and other species make up nearly a fifth of the national poultry flock. Some are kept in mixed flocks, while others are kept separately from chickens.

Productivity of the traditional native breeds, whether measured by annual meat production per bird, feed conversion rate or eggs produced per bird, is comparatively low. For instance, in Egypt the balady chickens take two or three times as long as commercial birds to reach market weight, require almost twice as much feed per unit of weight gain, and the layers produce only two-thirds of the number of eggs per year (Taha, 2003). Nonetheless, village or backyard production can make a useful contribution to dietary protein intake and incomes of resource poor households (Acamovic *et al.*, 2005). Furthermore, given the lower opportunity costs[5] of resources and the higher market prices offered for local poultry, backyard systems are likely to yield a positive economic return, despite increasing competition from the commercial sectors.

2.3 Sector 3: low-biosecurity commercial poultry production

This sector is based on commercial production to generate cash income, but it retains some characteristics of the traditional, backyard systems, particularly in selling live birds in wet markets, to commercial intermediaries or directly to retail shops. Production units are generally intermediate in scale between backyard systems of up to 200 birds and commercial systems of over 2 000 birds. Some economies of scale may be derived in terms of scope for use of specialized equipment such as battery cages or semi-automatic feeders. Levels of biosecurity are thought to be low, in that birds are often not permanently housed, mixed flocks of chickens and waterfowl may be kept, birds are generally marketed live, and a range of different markets, un-monitored for health risks, are used for produce sales and input supplies.

Sector 3 flocks are generally devoted either to broiler meat production or to egg production. Specialized commercial hybrid chicks are generally purchased from external sources. Even where native breeds are used commercially, as in the "balady flocks" of Egypt, chicks are generally purchased from specialized hatcheries. Feeds must generally be purchased, either as premixed rations or as raw materials for home milling and mixing. Hence, the production and marketing process is segmented and the value chain may be analysed. However, for this sector in particular, there are so many alternative sources of chicks and feedstuffs and different potential market outlets, that it is difficult to establish a standard outline value chain applicable in all the case-study countries.

Sector 3 and 4 producers are not always clearly distinguished in national statistics. For instance, in China all flocks with up to 299 birds are classified as "backyard", and these account for nearly all poultry producers and around 70 percent of poultry production. Arguably, some of these should be placed in the Sector 3 category. Similarly in Egypt, Sector

[5] The opportunity cost is the amount that could be earned from the most lucrative alternative use. For many poor households the opportunity cost of labour and other limited resources may be very small.

3 and 4 producers together account for nearly the total number of producers, but account for less than a third of total production. Similar proportions apply in Thailand. In India, the smaller independent commercial producers are of regional importance in the north and east of the country and particularly around Delhi, where integrated contract production has not become established as it has in the south. Even in Brazil, where the poultry sector is heavily industrialized, it is estimated that around 40 percent of poultry meat is produced on relatively small family farms of less than 100 hectares (Camargo-Barros, in FAO, 2003).

Sector 3 poultry production may originate with backyard producers who are able to generate sufficient income and savings to escape from the poverty trap and expand into somewhat larger-scale and more intensive production systems (Otte and Upton, 2005). However, there are many other small-scale investors, retired civil servants and the like, who establish moderate-sized semi-commercial poultry units as a means of generating supplementary income. In either case, Sector 3 production units are generally independently owned, relatively small-scale, enterprises.

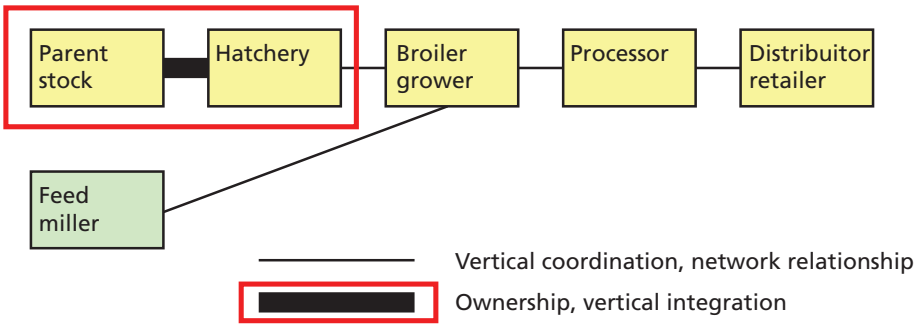
The scale of production units is subject to capital limitations. For these relatively small-scale, independent investors, not only are private investment funds scarce, but so too is access to formal credit. Market limitations arise in countries, like India and Egypt, where there is a marked consumer preference for the purchase of live birds, rather than dressed, chilled or frozen carcasses. The transport of live birds is more difficult and costly, so producers need to be located near their markets. In India, it is suggested that relatively small-scale, Sector 3, producers are at a disadvantage in facing high feed and transport costs, limited access to vaccines and veterinary services, and shortage of credit.

2.4 Sector 2: large-scale commercial, high biosecurity

This sector consists of the generally larger-scale (over 2 000 bird) commercial flocks of broilers, layers or breeding birds. Only relatively wealthy individuals or commercial joint-stock companies have the necessary investment funds or can raise sufficient credit for these larger-scale investments. Biosecurity levels are defined as high, as birds are continuously housed, strictly preventing contact with other flocks or with wildlife. Despite this, many outbreaks of HPAI appear to have started in large-scale commercial flocks (Otte *et al.*, in FAO, 2006b). Inputs are generally supplied and products marketed through formal market agencies. The production and marketing process is clearly segmented, and separate value chains for broilers and layers can be clearly identified (see Figure 7).

Figure 7 illustrates that in the non-integrated Sector 2, production of day-old chicks and feeds, broiler growing, processing and retail distribution of the final product are the responsibility of separate commercial enterprises. They are all "stakeholders" in the value chain, adding value to the product at each stage. The figure is simplified by showing a single enterprise at each stage of the chain. In practice, there may be a range of alternative partner agencies with which to transact business. Furthermore, links which are shown as "vertical coordination" might possibly be based on "arm's length market relationships", although reliance on the latter would be very risky. A similar value chain diagram could be drawn for the layer subsector, although the production cycle is longer and is subdivided into rearing and laying stages. Disposal of spent hens is another necessary activity. Eggs may be marketed without processing, although production from the larger flocks is likely to require egg packing.

FIGURE 7
Schematic diagram of a "non-integrated" broiler value chain



Source: based on Humphrey and Napier (in FAO, 2005) and PBEC (1999).

The scale and intensity of production, reflected in both the level of purchased inputs and the output per bird, is substantially higher in the commercial and industrial sectors than in backyard systems. Advantages are derived from economies of scale, providing scope for specialization and division of labour between the different stages in the production process, leading to automation of operations and labour-cost savings. These advantages add to those derived from the use of highly productive commercial hybrid chicks and improved technologies such as the evaporative cooling or air-conditioning of poultry houses.

The need for vertical coordination of all stages in the production chain, particularly in the regular supply of chicks and the transfer of birds to slaughter or markets when ready, leads to concentration of commercial poultry production in particular areas of the country, generally near major urban markets. The available statistics on poultry production in the case-study countries do not clearly distinguish between commercial (Sector 2) and industrial (Sector 1) production. However, it is clear that these two sectors together produce most of the total national supplies of poultry meat and eggs, particularly in the areas of greatest poultry population density.[6]

In India, particularly around Coimbatore, in the south, large-scale commercial, though mainly Sector 1, producers account for 75 percent of poultry meat production. The four southern states, where poultry densities and flock sizes are high, together contribute 57 percent of the nation's egg production. In the north, particularly around Delhi, non-integrated, Sector 2, producers contribute similarly large proportions of local production and consumption (Landes *et al.*, 2004; Mehta, in FAO, 2007b). In Egypt, the commercial sector is estimated to contribute 87 percent of poultry meat production and 77 percent of eggs. As there are only two major integrators in Egypt, most of this production must come from the non-integrated commercial enterprises of Sector 2 (Otte *et al.* in FAO, 2007a).

[6] For maps showing zonal variation in poultry density within countries, see Gerber (in FAO, 2007g) or GLiPHA (2007).

In China, poultry production is heavily concentrated in the Eastern Region, around Beijing, where commercial holdings with flocks of over 2 000 birds make up just over 5 percent of the total but contribute nearly 88 percent of total broiler meat production. A similar proportion of commercial layer farms, having flocks of over 500 birds, contribute 78 percent of the eggs. The four provinces making up the Eastern Region contribute more than half the national production of eggs. Proportions of large flocks are much lower in the Central and Western Regions, and as a result, their contributions to total production of poultry meat and eggs are much smaller.

The poultry industry in Thailand and Brazil is dominated by commercial and industrial production of broilers for export and for domestic consumption. This intensive production, about half the national total, is concentrated in the Central Region of Thailand, "a small but densely populated region" (Na Ranong, in FAO, 2007c). In Brazil, the main region of intensive production is in the south (50 percent of national broiler production) and south-east (27.5 percent) (OD Consultancy, in FAO, 2007d). Intensive production is now spreading westwards to locations more accessible to the main maize and soybean growing areas. In both Thailand and Brazil, although commercial production from Sector 2 exceeds that from Sectors 3 and 4, most of the poultry production is in the hands of the industrial, integrated production systems of Sector 1.

2.5 Sector 1: industrial and integrated production

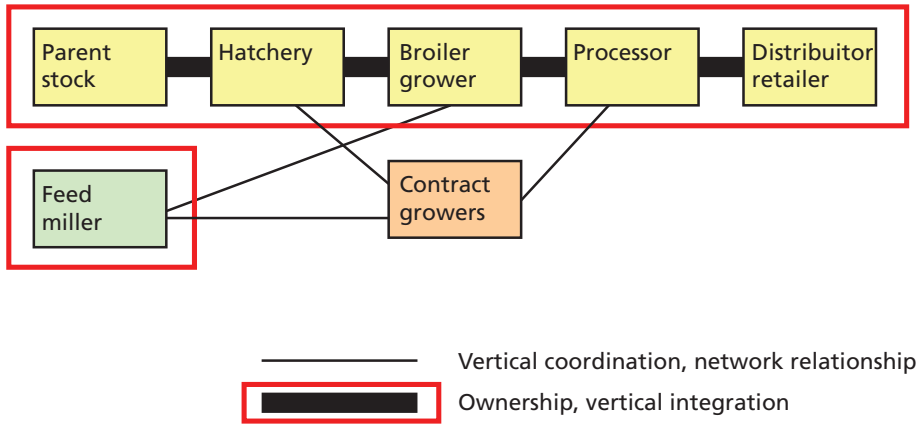
This sector consists of the largest and most industrialized enterprises in the poultry industry. The various stages in the value chain are vertically integrated into a single industrial company. The broiler-growing or egg-laying components are either fully integrated as part of the parent company, or are separate production units operating under contract to the parent company, as shown in Figure 8.

For Figure 8 it has been assumed that although the whole process, from chick breeding and hatching through to distribution and retailing is integrated in a single organization, feed milling remains as a separate business enterprise. In many instances, the feed and poultry production activities are integrated, together with "horizontal" links to other sectors such as pig production. In other cases, vertical integration is partial – from breeder down to broiler grower, or from market distributor up to broiler producer.

Vertical integration yields financial benefits by reducing the "transaction costs"[7] of exchanges at different stages of the value chain. In non-integrated poultry systems, transaction costs are likely to be high because of: first, the frequency and regularity of transactions resulting from the cyclical nature of poultry production; second, the risks of disease and market price fluctuations; and third, the investment in very specific types of assets, or "asset specificity", involved in poultry production, processing and marketing (Williamson and Masten, 1995; Dorward *et al.*, 1998). In these circumstances, the vertical integration of the different stages of the breeding, production, processing and marketing of poultry produce is a rational economic response, which should increase efficiency and reduce unit costs.

[7] These are the costs of obtaining information on the quality of the good being exchanged, negotiating a contract and enforcing the agreement.

FIGURE 8
Schematic diagram of an "integrated" broiler value chain



Source: based on Humphrey and Napier in (FAO, 2005) and PBEC (1999).

In India, substantial numbers of integrated poultry production companies have been established, particularly in the four southern states and in western India around Mumbai (Landes *et al.*, 2004). By contrast, in Egypt only one large-scale broiler farm is completely integrated (Otte *et al.*, in FAO, 2007a). Information is currently lacking on the number of large-scale integrated producers in China, but it is apparent that some operate on a very large scale. The Beijing Dafa Chia Tai Company, which claims to be the third largest in China, raises batches of 2 million broilers from their own farms and 6 million from 2 300 contract farmers.

It is estimated that 70 percent of Thai broiler-meat production is derived from the large-scale integrated poultry sector (Rushton *et al.*, 2005). A decade ago, the broiler sector was controlled by about a dozen large integrated firms (Tisdell *et al.*, 1998). In Brazil, production of broilers for export, or about 30 percent of total broiler production, is in the hands of 20 major integrated production companies associated with the main exporters' association, *Associação Brasileira dos Productores e Exportadores de Frangos* (ABEF).

3 STRUCTURE OF THE VALUE CHAIN

3.1 The introduction of commercial stock

The introduction of improved, exotic, genetic material is an important first step in the growth and development of the commercial poultry sector. Generally, the new strains are less hardy and less resistant to endemic diseases than indigenous birds. The greater productive potential cannot be attained without complementary inputs of specially compounded concentrate feeds, and improved housing, management, and veterinary care. Nonetheless, the introduction of new genetic material is the foundation on which other technological improvements are added.

Despite earlier attempts by field researchers and non-government organizations to improve the genetic potential of poultry, major advances only occurred with the introduction of exotic commercial stock. This was generally the result of private commercial activity, the importer needing sufficient capital to establish and maintain a breeding flock in a carefully controlled environment of the type required by exotic birds.

The Indian broiler industry is said to have been founded in the early 1980s by the Venkateshwara company of India in collaboration with the American poultry breeding company Cobb (now Cobb-Vantress). It is claimed that the Cobb 100 strain owned by Venkateshwara Hatcheries (VH) accounts for 60–70 percent of all broilers in India (Landes *et al.*, 2004).[8] The company distributes breeding stock and day-old chicks nationwide, and provides veterinary services to the growers. Until 1995, imports of grandparent stock were restricted to pure lines only, with the intention of protecting domestic broiler growers. This had the effect of giving VH some monopoly power. Since then, restrictions have been lifted and other integrators have been importing grandparent stock and developing their own strains. This concentration of poultry breeding activity in southern India appears to have resulted in a rapid increase in productivity per bird (Figure 5 above).

In Egypt, there are seven grandparent stock farms, largely originating from imported chicks or hatching eggs and serving over 400 commercial breeding flocks. One of the major integrated producers, the Cairo Poultry Company (CPC), is in partnership with the Hubbard chick company. However, there are a larger number of improved balady chicken type breeding farms. Egypt also exports breeding stock to other Middle Eastern and African countries. The large integrated poultry companies in China generally use improved strains originally bred in the United States of America.

The Thai company Charoen Pokphand (CP), though originally a small feed company, introduced contract broiler production in 1976 as a joint venture with the United States of America-based Arbor Acres/Avigen Company, bringing improved grandparent stock into Thailand. This is seen as the start of the livestock revolution in Thailand. CP has subsequently grown into a vertically and horizontally integrated multinational corporation, with 100 000 employees in the mid-1990s and with interests in the food, poultry and pig meat and shrimp industries. In Brazil, about 95 percent of poultry meat is produced under contract to the large integrator companies. Most of the genetic strains in use originated, or were developed, from North American foundation stock.

Three general conclusions may be reached. First, poultry breeding and chick production is now a specialized activity for large-scale producers. Many intermediate and smaller broiler and egg producers cannot afford to maintain separate flocks of specially bred parent or grandparent birds. They must purchase chicks from the specialist breeders or become contract growers. Second, many of the specialist breeders are vertically integrated with poultry processors and distributors, and commonly with feed millers, together with reliance on contract growers. Finally, there is a continuing need for imports of exotic foundation stock from the United States of America or Europe. The primary breeders in these countries still export grandparent stock to Egypt, China, Thailand and Brazil, and still have partnership arrangements with poultry breeding companies in India. In some cases these links have led to the establishment of joint ventures involving foreign direct investment.

[8] The same large company supplies chicks to 85 percent of layer flocks.

3.2 Links with feed millers

The other key input for commercial and industrial broiler and egg producers is the supply of concentrate feeds. These generally account for about 60 percent of the costs of intensive poultry production, so the feed conversion ratio is an important measure of productive performance. In Figure 8, feed milling is shown as an independent commercial enterprise separate from the integrated poultry production sector, though with contractual arrangements for the supply of feeds to breeding, broiler and laying flocks. In the fully integrated poultry sector, feed milling is generally incorporated within the poultry production company. As concentrate feeds are needed for other (non-poultry) livestock enterprises, the feed milling enterprise readily forms the basis for horizontal integration into other types of productive activity.

Feed millers are, in turn, dependent on supplies of energy- and protein-rich raw materials, particularly cereals and pulses. Costs of feeds and hence of poultry production, are therefore dependent, in part, on the availability and cost of these raw materials. Maize is the main cereal used in livestock feeds in Latin America, and increasingly in Asia and the Middle East (Steinfeld *et al.*, in FAO, 2006a).

Thus, it is reported that the CP Company of Thailand prepared for the expansion of the poultry industry by first developing and persuading farmers to adopt a high-yielding maize variety, in a joint venture with DeKalb. As a result, maize yields quadrupled over the fifteen years from 1970 to 1985, leading to a big reduction in the cost of poultry production (Anon, 1997).

Coordination of feed supplies and broiler or egg production is essential to ensure productive efficiency. Different feed mixes are required at different stages of the life of a flock, and must be delivered regularly at the right time. New technologies, such as pelleting of feeds, may be needed. In these circumstances, transaction costs of feed purchases are likely to be high. Formal delivery contracts are necessary to reduce transaction costs and risks of default. However, vertical integration should bring even greater savings in transaction costs and provide greater assurance of coordinated supplies. These savings help to explain why integration appears to be the preferred option in the highly commercialized large-scale sector, and why average variable costs of production are lower for this sector.

3.3 Production, trade and use of feed crops

Availability and the relative prices of concentrate feeds, particularly maize, vary substantially between countries. Comparisons of the production, trade and feed use of maize in the case-study countries, give an indication of differences in the availability of feed grains. Although there has been a long-term upward trend in maize production in most countries, there is considerable variation from year to year, and even bigger variation in quantities traded. Nonetheless, results for a single year, 2005, illustrate the key differences between the poultry meat exporting countries that are also maize exporters, and Egypt, which is a net importer of both poultry meat and maize (see Table 3).

It may be noted that in India and Egypt feed and seed use accounts for less than half the total domestic utilization, more is used for human consumption. However, in China, Thailand and Brazil, the bulk of the crop is used for feed and seed, while relatively small proportions of the total production are exported.

Soymeal, a by-product of the soybean oil industry, is of increasing importance as a protein-rich ingredient of concentrate feeds for poultry and other intensively produced livestock. Information on production and trade in the raw material – soybeans – gives an indication of the likely availability of soymeal (see Table 4).

Clearly, Brazil has a major advantage as a poultry producer in that it produces exportable surpluses of soybeans as well as maize. Furthermore, it is reported that there are large areas of underexploited potential arable land in the Cerrado Savanna of Central West Brazil. The other four countries import most of the soybean utilized domestically (almost all in the case of Egypt).

Today, countries like India, China, Thailand and Brazil that produce more than enough maize to meet domestic requirements are at an advantage over countries like Egypt that have to import maize to m*eet al*l their needs. The costs of transhipment, freight and insurance associated with imports are avoided. Nevertheless, domestic prices of feed grains and pulses in both importing and exporting countries are influenced by global markets. Over the past 12 months (to November 2007) poor harvests and growth in demand for feeds and biofuel production have led to a large increase – near 50 percent – in the price of maize on world markets (FAO, 2007e). The increase in cereal prices has influenced land allocation to other crops, so shortages and increased prices of soy products have also occurred. Hence, poultry producers in all countries are vulnerable to fluctuations in global feed prices.

Even where the main feed crops are produced domestically, delivery costs are affected by the distance from where the feed crops are produced to where the livestock are con-

TABLE 3
Maize exports, imports and usage as feed in 2005

	India	Egypt	China	Thailand	Brazil
Maize exports as a proportion of home production (%)	2.8	-	6.5	5.8	2.3
Maize imports as proportion of home utilization (%)	-	43.3	-	-	-
Feed and seed use as proportion of total utilization (%)	37	44	85	88	78

Source: FAOSTAT.

TABLE 4
Soybean exports and imports in 2005

	India	Egypt	China	Thailand	Brazil
Soybean exports as a proportion of home production (%)	-	-	-	-	72
Soybean imports as proportion of home utilization (%)	58	98	71	92	-

Source: FAOSTAT.

centrated. Thus, in India, producers in the southern states are concerned to promote local production of maize and soymeal, most of which are currently purchased from producers in central and northern India. In Brazil, integrated poultry producers are expanding into central and western Brazil, where more land is available for maize and soybean production.

3.4 Links with processors and distributors

Vertical integration takes place as a consequence of the growth of firms in the context of the process of development of the food industry and the global economy. However, there are three primary motives for vertical integration in the poultry meat sector: i) increased control of markets and marketing margins; ii) greater biosecurity and quality-control management; and iii) economies of scale in production, processing and distribution (PBEC, 1999). It follows that processing and market distribution are essential elements of the integrated value chain.

Economies of scale and the benefits of automation lead to major cost savings in the slaughter, defeathering and evisceration of broilers. A standard modern abattoir has capacity to process 6 000 to 9 000 birds per hour or up to 20 million per year. Serious losses in efficiency and economic returns can arise where slaughter plants are operated below capacity, as may occur where demand varies on a seasonal basis, when there is a serious disease outbreak, or where regular supplies of birds are too small to justify the establishment of a modern abattoir.

These risks must be set against the cost savings achieved, and the benefits of easy storage and transport for domestic distribution or export of chilled or frozen dressed carcasses. In India and Egypt, consumer preference for the purchase of live birds limits the scope for industrial processing and, because of the higher costs of transporting live birds, restricts broiler markets to the area in which the birds are produced. In the major exporting countries Brazil and Thailand, most birds for both export and domestic use are processed in industrial-type abattoirs.

From the abattoir, poultry carcasses can go for further processing into chicken parts, with or without bones, or for the manufacture of other poultry dishes. Hence, poultry processing readily links into the commercial food industry, which is growing rapidly in all the case-study countries with the spread of supermarkets, fast-food chains and other retail outlets. Exports of canned poultry meat are of increasing importance for China and Thailand, possibly in response to export bans on un-canned products following HPAI outbreaks.

Many of the large-scale integrated poultry meat producers in Thailand and China, and probably Brazil and India, have become multinational agencies in the food industry, some with their own local retail outlets. The links between integrated poultry production and the retail food sector in China are emphasised in the suggestion that local outbreaks of HPAI have accelerated the switch from wet markets to supermarkets (Evans, 2006).

For egg producers, there are fewer economies of scale in processing and marketing. Hence, although there are large enterprises that may be integrated with a feed mill, and in some cases with a hatchery, they are less commonly integrated with the processing and marketing end of the chain. Some independent operators buy day-old chicks or point-of-lay pullets, purchase feeds and sell their own eggs, while egg marketing is sometimes organized on a cooperative basis. In general, the egg industry is less concentrated than the poultry meat sector.

3.5 Contract production

Broiler growing under contract is a common feature of the integrated and semi-integrated industrialized sectors of the global poultry-meat industry. This type of contractual agreement is widely used by large integrated companies in India, China, Thailand and Brazil. Less has been written about broiler growing under contract in Egypt, possibly because there are few large fully integrated poultry producers in the country.

Although there are some local variations, the standard contract adopted usually commits the "integrator" to: i) the supply of chicks, feeds and medicines; ii) the provision of technical, managerial and veterinary support; and iii) transport for the delivery of feeds and the collection of finished broilers. The grower then provides: a) the capital invested in buildings and equipment; b) the day-to-day management; and c) electricity and water services. Under the contract, the integrator agrees, in advance, to make a flat-rate payment of a given sum per kg live weight of harvested birds, plus a bonus for improved performance, usually related to low mortality and good feed conversion ratios. In some cases, a penalty may be incurred for poor performance.

Before a contract can be agreed, the grower must meet required standards for the buildings and other facilities offered, and demonstrate his/her knowledge and experience of poultry production. The payments are based on current market prices and average levels of productivity. Similar arrangements apply in the, less common, case of egg production under contract.

The grower's contract is essentially a means of cost and risk sharing with the integrator. The grower avoids the transaction costs of organizing separate purchases of inputs and sales of products, and reduces the risks of large price fluctuations faced by an independent producer. There may be other benefits associated with the technical advice and support provided by the integrator. At the same time, there is a cost, in that independent producers generally earn larger margins per bird or per kg of meat produced. The integrator avoids the costs of establishing the necessary buildings and equipment and of day-to-day management, while excluding the risks of dealing at arm's length with independent growers. Most studies show that the overall marketing margins are lower for integrated production systems than for independent growers.

Despite the fact that many broiler producers choose to adopt contract growing for large integrator companies, and remain loyal for extended periods, doubts are raised about the fairness of the system by both contract growers and independent growers in competition with the integrated producers. It is claimed that the integrators force producer prices and margins below competitive market levels.

Where, as is often the case, there are a small number of integrators dealing with a large number of potential contract growers, the integrators are in an oligopoly situation and have a measure of market power, which may be exploited, as it is they who generally write the contracts. In India, and probably other countries, there is no formal legal basis for the contractual agreements, which makes enforcement difficult. However, broiler growers always have the option of returning to an independent status if they become dissatisfied with the terms of the current contract. Integrators have an interest in maintaining grower loyalty. The system has functioned effectively in many situations.

4 GOVERNMENT POLICIES FOR THE POULTRY SECTOR

4.1 Comparative advantage

The global distribution of poultry production, and associated patterns of trade in poultry products, is dependent in part on differences in comparative advantage or the opportunity cost of production, and in part on past and present policies affecting trade, exchange rates, markets and prices, technology development and institutions. Comparative advantage depends, in turn, on endowments of natural resources, labour and capital, and the associated productive technology.

Given that India, China and Brazil are among the largest countries in the world, with huge internal, inter-regional differences, comparisons of national average data are of limited value in assessing comparative advantage. However, there are some fairly obvious differences. Brazil, with large areas of still not fully exploited fertile land, has a particularly favourable natural resource base for producing key feed crops (see Tables 3 and 4 above). Egypt appears to be disadvantaged in this respect, and is heavily dependent on imports of feed grains and oilseeds. Relative labour scarcity is reflected in wage rates which are higher in Thailand than in China and India. All these developing countries are constrained by capital limitations, with underdeveloped communications, physical, social and institutional services. However, international movements of capital are increasing in response to economic investment opportunities.

Comparison of average broiler farm-gate prices gives an indication of relative comparative advantage, although market prices may be affected by market distortions. Estimates, of average prices per kg live weight for 2001 are as follows: India US$0.48 to $US0.84; Thailand US$0.68; and Brazil US$0.48 (Landes *et al.*, 2004). In comparison, the estimate for the United States of America is US$0.87. Production costs in China are likely to be lower than those in Thailand, as wages are lower. Market prices of commercial broilers in Egypt between 2004 and 2004 ranged from US$0.9 to US$1.2. Local "balady" chicken prices are 30 to 40 percent higher (Ibrahim *et al.*, in FAO, 2007f).

4.2 Trade policies

Policy objectives, for agriculture and the poultry sector differ among the case-study counties. India and Egypt have historically pursued import substitution policies, with the aim of achieving a measure of self-sufficiency, although both are now opening up to more foreign trade with membership of the World Trade Organization (WTO).

China has undergone major change over the last 20 years, with reductions in government intervention and central planning. There is increased reliance on market forces, which is being accelerated with WTO membership. Large trade surpluses are being earned from manufactures, and there is less concern over the agricultural trade balance. The main goals for agriculture are to achieve food security for the huge population, to improve food safety and quality, to improve farmers' incomes, and to protect the natural environment for sustainable agricultural and rural development. Brazil, as the world's largest exporter of poultry meat, and Thailand, as the fourth largest, are concerned to protect and expand their export markets. Despite these differences, all the countries have imposed quantitative controls on imports in the past and have switched to the use of tariffs under WTO rules. Both kinds of trade barrier, if effective, restrict imports and therefore raise domestic prices – benefiting

domestic producers, but raising costs for consumers. In the case of feed crops, like maize and soybean, costs are increased for feed millers and poultry producers. Generally, the costs of trade barriers exceed the benefits. Tariffs are generally the preferred option, but WTO members are required to reduce tariff levels over time.

In India, quantitative import controls were applied to poultry meat, poultry preparations, eggs and egg products until April 2000, when they were replaced by tariffs of 30 percent on fresh, chilled or frozen chicken and 100 percent on processed products. Controls on imports of breeding stock and poultry feeds were lifted in 1997/98. However, an under-quota tariff on feeds of 15 percent, rising to 70 percent out of quota, was then introduced.

A ban on Egyptian imports of poultry meat introduced in the late 1980s caused domestic price rises and provided incentives for domestic producers. It was lifted in 1997, and replaced by an 80 percent tariff. Imports have remained at low levels. Further production incentives were provided by tariff-free imports of poultry feeds from July 2006.

Chinese tariffs on imports of poultry products were reduced from 20 percent to 10 percent between 2001 and 2004 as part of the trade liberalization process. Imports of poultry products provide materials for the growing processing sector from which some products are exported.

Agricultural exports from Thailand make a significant contribution to foreign-exchange earnings. Exports of agricultural and livestock products account for a large proportion of the total sector contribution to national income. However, Thailand is a net importer of some key agricultural products, including soybean and other oilseeds. In moves to promote trade liberalization, Thailand joined the ASEAN Free Trade Agreement (AFTA) and the Asia-Pacific Economic Cooperation (APEC) Group.

Tariff reforms were launched in 1994, aimed at the simplification of tariff structures and their gradual reduction over time. They were temporarily increased following Thailand's debt crisis of 1997, but now the in-quota tariff on maize and other feed crops is 20 percent. Currently, this has little effect on the maize market, as Thailand is a net exporter. However, imports of soybean are affected. The larger feed millers may benefit in being more-readily allocated low-rated tariff quota allotments. In this way the structures of the milling and poultry industries may be affected by the associated price discrimination.

Prior to the mid-1980s, Brazil like other Latin American countries pursued a policy of industrialization under protective trade barriers. Quite rapid economic growth had occurred, but this was accompanied by rapid inflation and the accumulation of a huge foreign debt. During the 1980s, measures were put in place to reduce the rate of inflation, with cuts in government spending and tighter monetary controls. Brazil joined with neighbouring countries to form MERCOSUR (*Mercado Común del Sur*) in 1991, which led to increased trade between members, but largely in capital intensive industries.

In 1994/5 the Real Economic Stabilization Plan was put in place, with effective currency devaluation and further liberalization, under the guidance of the WTO Agreement on Agriculture. Up to 2003, economic growth was slow and real wages fell under a series of domestic and international economic shocks. However, following a reform plan introduced in 2004/05, the government withdrew from agricultural markets, state enterprises were privatized and minimum support prices were eliminated. As a result, the Brazilian economy has strengthened, producing record current-account trade surpluses to which agricultural expansion has made a significant contribution.

4.3 Macroeconomic and exchange-rate policies

Government policies associated with taxation, spending, borrowing, interest rates, wage rates, the money supply and exchange rates, are together referred to as macroeconomic policies. Although they are applied to the whole economy, they can have a major impact on the development of a particular sector and trade in its products. For example, foreign exchange rates affect prices and quantities of exports and imports, and thus the prices of products and inputs. In the past, many governments have allowed their domestic currencies to become, and remain, overvalued. This situation may arise when the currency is "pegged" at a fixed rate against another currency such as the United States dollar while, as a result of changes in the global economic environment or poor macroeconomic management, rapid domestic inflation and growing foreign indebtedness, the real value of the domestic currency has fallen.

The benefits, of maintaining an overvalued exchange rate are derived in terms of cheap foreign exchange and low prices of imports, and possibly a decline in the prices of domestic produce as export quantities and revenues fall. The distortion may be maintained by the application of foreign exchange controls, together with trade quotas and tariffs, as outlined above. Losses are experienced by potential exporters faced by the artificially low domestic prices of exports. In effect they are taxed.

The main beneficiaries are thought to be urban dwellers for whom imported consumer goods and industrial raw materials are made cheaper. The situation can rarely be sustained, and macroeconomic reform strategies, usually involving currency devaluation, become necessary. Devaluation reverses the effects of an overvalued currency by raising the domestic prices for exports and imports, thereby providing incentives for domestic producers to substitute for imports and/or increase exports.

The development of the poultry sector in Brazil, Thailand and Egypt, has been affected by the international debt crises of the 1980s and 1990s. Brazil and other Latin American countries had borrowed heavily from banks in North America and elsewhere in the 1970s and early 1980s, but by 1982, debt servicing had become impossible and the problem had become a crisis. Thus, Brazil and other debtor countries were required to adopt unpopular reform policies. There followed a decade of cuts in government spending, currency depreciation associated with increasing domestic prices, and slowing economic growth. However, rising interest rates and market liberalization attracted foreign investment and poultry production started to expand.

With the introduction of the Real Economic Stabilization Plan in 1994, the Brazilian currency was changed from the cruzeiro to the real and pegged to the United States dollar. This was accompanied by trade liberalization, as outlined above. These policies stabilized the economy and brought about a consumer boom. Between 1999 and 2001 the real was devalued to about a third of its previous exchange value, leading to a major improvement in export prices, while reducing the profitability of imports. As a result there was a 20 percent expansion in the area planted to soybeans in the 2000/2001 crop year and a 35 percent increase in soybean exports (USDA, 2006). Capital inflows resumed, expansionary policies were adopted and economic growth recovered.

In the late 1990s, Thailand suffered a 40 percent devaluation of the baht which signalled the beginning of the Asian debt crisis, which spread to Malaysia, Indonesia, the

Republic of Korea and, less seriously, the Philippines. Serious capital losses experienced by foreign investors led to massive withdrawals of funds from these and other debtor countries. Interest rates rose and debtor problems were exacerbated in other countries. A further currency devaluation was needed in Brazil in 2001, while the Egyptian pound was devalued in 2002. In each case, the devaluation has raised the domestic prices of poultry products and of feed grains. The increases in poultry prices have benefited and provided incentives for domestic producers and exporters. However, rising prices of feed grains increase costs for feed millers and poultry growers. Serious problems may arise for countries like Egypt that are dependent on feed-grain imports.

4.4 Domestic support policies for the poultry industry

Public-sector investment in the development of the poultry industry has been limited in all the case-study countries. Development has been largely based on private domestic or foreign investment. Some schemes have been established to promote smallholder production and producer cooperatives in India. Poultry production has been subsidized to a limited extent by federal, state and local governments in Brazil and in Thailand. Rather more emphasis has been given to the promotion of crop production in general, and feed-grain producers may have benefited. The price of feed grains in Egypt remained low for a long period as a result of the overvalued currency.

More generally, governments are responsible for the provision of the social infrastructure of roads, telecommunications, water and electricity supplies, and other facilities. There is still much room for improvement in all developing countries. These limitations are seen as constraints to the future development of the poultry industry in all the case-study countries.

4.5 Poultry health and disease control

The maintenance of animal health and the control of livestock disease is an area where some sharing of public and private responsibility is likely to be necessary. Direct costs result from losses due to morbidity and mortality of birds, while indirect costs are incurred in the implementation of control measures.

The case for public-sector intervention in providing for specific disease control measures, such as border controls, surveillance, movement controls, quarantine services, food-safety and drug-quality control, has been argued on the basis that they yield public goods and externalities[9] (Holden, 1999, Umali *et al.*, 1992; Leonard, 1993). It is further generally agreed that where "stamping out" by compulsory slaughter is the chosen method of controlling a disease outbreak, the costs of slaughter and compensation should be met from public funds.[10]

These issues have come to the fore in recent years, with the spread of HPAI. Outbreaks of the disease, associated with a small number of human infections and deaths, have occurred in India, Egypt, China and Thailand. The disease and associated control measures

[9] Public goods are those from which no one can be excluded from the benefits and for which the cost does not depend directly on the number of beneficiaries. Hence, public goods are unlikely to be supplied adequately by private enterprise.

[10] Hitherto, no satisfactory private insurance schemes have been developed to cover these costs.

have incurred major costs, both public and private, in terms of dead or culled birds and the associated financial losses. The impacts have been greater in China and Thailand, as the outbreaks began earlier in these countries, have recurred since, and have resulted in continuing import bans on unprocessed poultry products, thus damaging these countries' major export industries.

In addition, loss of consumer confidence in the safety of eating poultry products caused a fall in demand and hence prices, which affected producers even in countries, like Brazil, where no outbreaks have occurred. However, this impact was largely temporary, as global consumer demand appears in 2007 to have recovered to its former growth path.

Governments have been forced to review their policies for control of the disease. Contingency plans have been prepared to strengthen the response if and when future outbreaks occur. Such plans include compulsory culling, with compensation as a means of "stamping out" the disease. A double "moral hazard" problem arises in determining compensation levels. If they are set too low, producers have little incentive for rapid reporting of an outbreak. If they are set too high, producers have little incentive for maintaining high biosecurity standards.

A vaccine has been developed in China and is distributed free of charge. Presumably it is intended for use in limiting the spread of outbreaks if and when they occur, rather than as a prophylactic. In Thailand, however, vaccination is banned, presumably because of its potential damaging impact on export markets. Both countries have switched most of their poultry export production to pre-cooked and processed products. This not only avoids the problem of import bans on their raw, uncooked poultry products, but also adds value to the commodity.

Other precautionary approaches aimed at limiting the risks of further outbreaks and their spread are being adopted. These include promoting improved surveillance and biosecurity, often by means of regulations that affect the structure of the industry. Regulations, such as the closure of live or wet-markets and the compulsory housing of birds, impose serious costs on smaller-scale, Sector 4 and possibly Sector 3 producers. These costs, together with a smaller capacity to cope with the costs of disease outbreaks, may drive small-scale producers out of the industry, although a small telephone survey in Thailand suggests that the majority have remained in poultry production after the trauma of the main outbreaks. These disproportionate impacts on different sectors of the poultry industry should be carefully considered by policy-makers.

5 EXPECTED TRENDS

5.1 Global expansion of the poultry industry

Commercial production and consumption of poultry meat and eggs are likely to continue to expand globally. This expansion will accompany general economic growth and industrial development, as demand for livestock products increases with growing per capita incomes and urban populations. Growth will continue at the intensive margin with increasing commercialization and industrialization of the poultry sector, and at the extensive margin as commercial poultry production spreads along with other industries.

Analysis of data for the case-study countries has shown large differences in average levels of per capita production and consumption of poultry meat and eggs, between countries

and between regions within countries. These are linked, at least in part, with differences in levels of industrial development and urbanization. Intensive, large-scale commercial production is concentrated in some of the more economically advanced areas. Further intensification and integration will occur in these areas, while concurrently, commercial production may become more widely dispersed.

Expansion of the poultry industry is most rapid in low- and middle-income countries where average incomes are increasing. At low income levels, a given proportionate increase in income results in a relatively large increase in poultry meat and egg consumption.[11] As incomes increase, the impact of further growth on quantities demanded and consumed diminishes. At relatively high income levels the elasticity of demand falls to a very low level, so further increases may have little or no impact on consumption. Ultimately, in the long term, the growth in demand for poultry meat and eggs could slacken as average consumption levels approach the desired maximum. However, in global markets, this stage is quite remote, while if it occurs in individual countries, further expansion of the industry may be based upon opportunities for increasing exports.

5.2 Market and resource constraints on production

a) Constraints on the global economy. Growth in demand for livestock products, poultry meat and eggs is driven by growth in per capita incomes. Hence, threats to the global economy, posed by global warming, energy and mineral resource limitations, and political conflicts, could reduce the growth rate of consumer incomes and their demand for livestock products. Expansion of poultry production would have to slow, to avoid falling prices. The incidence and impacts of these constraints, on the poultry industry, are difficult to predict and depend upon the policy responses of the international community.

b) Macroeconomic, trade, exchange rate and investment policies. As outlined in Sections 4.2, 4.3 and 4.4, above, national economic policies can have significant impacts on income growth and distribution, and on resource and commodity prices. Policy distortions may have an adverse impact on the growth of demand for and supply of poultry products. It is widely recognized that market and trade liberalization and non-discrimination against agriculture, are desirable objectives to promote economic growth and development.

c) Supplies and prices of feed grains and oilseeds. General expansion of cropland is fast approaching the limit of available cultivable land, other than in Latin America. Competition for this resource with other crops and other forms of land use (e.g. for building and urban development) will increase. At the same time, demands for feed crops for other purposes, including human consumption and biofuel production, are increasing. These trends are likely to result in increasing feed prices and reduced margins for livestock producers. However, poultry have a competitive advantage over other species, as their feed conversion rate is better.[12]

[11] The income elasticity of demand is high.

[12] The quantity of feed used per kg of poultry product is lower.

d) Deficiencies in the general transport and market infrastructure. Poor communications, limitations of the road network, lack of marketing facilities and cold chains, inadequate information and other infrastructure deficiencies limit the spread of commercial poultry production in many developing countries. Governments have a role in overcoming some of these marketing constraints, for instance by building roads and disseminating information. However, this public-sector investment is a key component of general economic development, rather than a policy aimed at promoting increased poultry production.

5.3 Disease constraints

Development of the poultry industry may suffer fluctuations due to HPAI, with outbreaks causing loss of production and loss of export markets. Reductions in demand due to human health fears appear to be short lived. However, all this depends upon maintenance of a reasonable level of disease control and the non-occurrence of a human pandemic.

Exporting countries suffer most from epidemics of transboundary diseases like HPAI. Strict SPS (sanitary and phytosanitary) standards are likely to be maintained in future, with export bans being imposed on countries where outbreaks occur. Compartmentalization and regionalization have not been generally accepted. Although freezing, storage and processing allow some flexibility in adjusting to export bans, future outbreaks and the possible endemic state of the disease may cause changes in the main poultry-trading nations.

5.4 The future of Sector 4 production

There is some debate as to whether Sector 4, backyard producers are likely to be displaced in the face of competition from the lower-priced products of the highly productive commercial sectors. However, to some extent traditional and commercial poultry producers operate in different markets for products and key inputs. As commercial production tends to develop in specific regions within each country, often in the vicinity of urban conurbations, the traditional backyard systems may still dominate in remote rural areas.

Even in peri-urban areas, where commercial poultry production is well established, backyard and commercial systems may co-exist, operating in parallel but different markets. It is widely reported, for instance in India and Egypt, that traditional, local breeds of poultry are more highly priced than commercial broilers. The opportunity cost of family labour used in backyard systems is lower than that of hired labour used in commercial systems, while purchases of feed and veterinary inputs are minimal in Sector 4 production systems.

Some form of small-scale "backyard" or "hobby" production is likely to continue in all countries. Many backyard or hobby farmers still exist in Europe, with very little impact on aggregate supplies of poultry meat and eggs, though subject to monitoring and surveillance for disease-control purposes. In poor countries, backyard production maybe supported or promoted as a means of poverty relief. However, there are dangers that disease-control measures such as the closure of open, wet markets, or the requirement that all poultry be permanently housed, impose severe costs on small-scale producers, so that they are particularly disadvantaged in comparison with the commercial sector.

5.5 The role of Sector 3 producers

A question arises as to whether Sector 3 production is a transitory phase in the commercialization of the poultry industry that will largely disappear as Sectors 1 and 2 expand, or whether it will continue to function in filling niche markets for special products, such as duck and goose meat or organic produce. The apparent small size of Sector 3 in Brazil and Thailand suggests that the former outcome is the more likely.

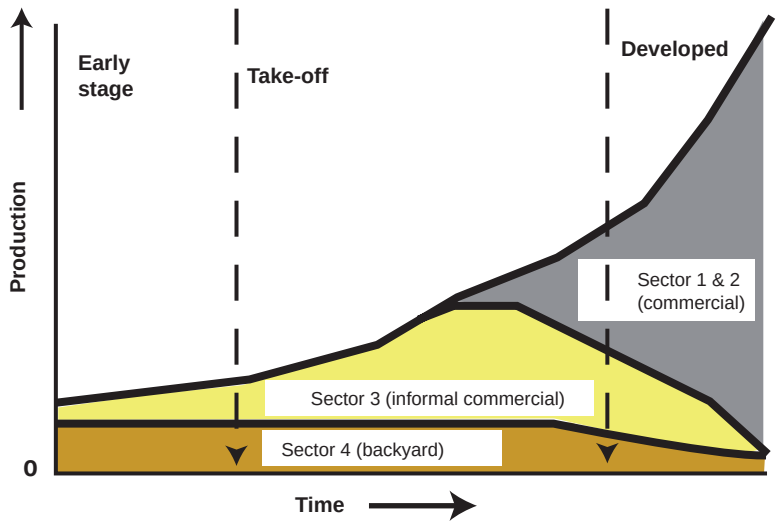
Hence the growth and commercialization of the poultry industry may be illustrated as in Figure 9 which is adapted from Rushton *et al.* (in FAO, 2006c).

Figure 9 is based on the assumption that differences between countries in the structure of the poultry industry reflect different stages in development over time. However, as already noted, development of the industry is concentrated in particular regions within countries. Hence, different regions within countries may be at different stages in the development process. For instance, while northwestern Brazil and western China may be in the "early stage", the south of Brazil and parts of eastern China have a well "developed" poultry sector.

Semi-commercial Sector 3 production may expand in the process of poultry commercialization, but eventually be displaced by larger-scale fully commercial systems. In fact, many Sector 3 producers may become contract farmers or their farms may become part of an integrated chain.

Arguably, this process of integration is required to improve overall biosecurity as contracts through the chain are strong and it is in the interests of all actors to avoid the spread of disease. Integrated systems are more likely to develop where consumer demand has shifted away from live-bird markets to those for mass-produced chilled products.

FIGURE 9
Poultry sector development



Source: adapted from Rushton *et al.* (in FAO, 2006c).

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Annexes

ANNEX A

Characteristics of developing countries, by income group (2006)

Region	Low-income	Lower middle-income	Upper middle-income	High-income developed
Average GNI/capita (US$)	650	2 037	5 913	36 487
GDP growth (%)	8.0	5.7	8.9	4.3
Agriculture, value added (% of total GDP)	21.5	12.3	6.2	1.9
Urban population (% of total)	30	47	75	77
Population/km^2	82.3	79.7	19.5	29.7
Poultry/head rural population	1.2	8.2	11.4	21.7
Poultry meat production (% of world total)	5	38	14	43
Poultry meat/head/year (kg)	1.7	17.1	23.2	33.7
Poultry meat exports (% of world total)	0.1	45.4	8.8	45.7
Poultry meat imports (% of world total)	4	25	30	41

Sources: World Bank data and FAOSTAT.

ANNEX B

Characteristics of case-study countries (2006)

	India	Egypt	China	Thailand	Brazil
GNI/capita (US$)	730	1 260	1 740	2 720	3 550
GDP growth (%)	9.2	4.9	10.2	4.5	2.3
Agriculture, value added (% of total GDP)	18.3	14.9	12.6	9.9	8.1
Urban population (% of total)	29	43	40	32	84
Population/km^2	368	74	140	126	22
Poultry/head rural population	2.9	6.6	6.6	43.1	0.6
Poultry meat production (% of world total)	0.6	17.5	1.3	11.9	2.4
Egg production (% of world total)	0.4	45.0	1.1	2.5	3.9
Poultry meat/head/yr (kg)	1.8	7.3	11.3	10.0	38.7
Eggs/head/year (kg)	1.9	2.8	17.5	8.5	6.3
Poultry meat exports (% of world total)	0	0	7.2	5.4	33.9
Poultry meat imports (% of world total)	0	0.3	14.6	0.1	0
Cereal yield (tonnes/ha)	2.4	7.5	5.1	2.7	2.9
Maize production (% of world total)	2.1	1.1	19.9	0.6	5.0
Soybean production (% of world total)	2.9	0.0	7.8	0.1	23.8

Sources: World Bank data and FAOSTAT.

ANNEX C. PRODUCTIVITY OF POULTRY IN MEAT PRODUCTION

A crude, but useful, measure of productivity in the poultry-meat sector is given by the ratio of the "number of birds produced and slaughtered per year", to the "number of birds in stock, or inventory, at a single point in time". Similar "productivity ratios" may be calculated for other livestock species, as the number produced per head of the national herd or flock. Despite the omission of other valuable products such as eggs, milk and wool, these ratios provide a crude indication of productive efficiency.

Interspecies comparisons, show poultry productivity to be substantially higher than that of other domestic livestock enterprises. For instance, "productivity ratios", based on data averaged over all developing countries in 2005, are 0.2 for cattle, 0.5 for sheep and goats, 1.3 for pigs and 2.4 for poultry. (FAOSTAT, accessed 2006). Similar comparisons, using data for developed countries show higher "productivity ratios" for all species, but with the same inter-specific ranking. The high level of poultry productivity reflects both a higher reproductive rate and a faster rate of growth to maturity than those of other species. These factor together have allowed rapid genetic improvement, rapid growth of the poultry industry in many countries, rapid recovery and restocking after disease outbreaks, as well as the potential for economic gain.

National estimates of the poultry "productivity ratio" differ between countries, and have generally increased over time, as shown in the following table.

Differences between countries, in the productivity of poultry meat, may reflect differences in the relative emphasis given to egg production. In India and China, where in 1981 the ratios were rather low, there is more emphasis on egg production than there is in the other countries. However, in all the countries, except Thailand, the increase in productivity over the following 25 years is largely associated with increasing scale and commercialization of poultry production, and the introduction of specialized fast-growing broiler stock.

Thailand is a special case, in that in 1981, the average productivity ratio was already close to the levels then achieved in developed countries with largely commercial poultry sectors. The apparent decline in productivity by 2006 is largely due to the large numbers of birds lost or culled as a result of HPAI outbreaks from 2003 onwards. The very rapid growth of the productivity ratio for India, of over 7.5 percent annually over 25 years, is remarkable (see text Figure 5 and associated comments).

TABLE C1
Poultry productivity ratios for case-study countries

	India	Egypt	China	Thailand	Brazil
Productivity 1981	0.70	3.48	1.17	3.83	2.73
Productivity 2006	4.42	3.96	1.89	2.76	4.46
Average annual increase (%)	7.64	0.52	1.95	-1.30	1.98

Source: FAOSTAT.

Poultry sector in China: structural changes during the past decade and future trends

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SUMMARY

The poultry sector in China has experienced vigorous growth over the past two decades, both in terms of poultry numbers and level of output per bird. Higher levels of production are associated with the spread of intensive systems in which food conversion ratios are high. Poultry production has increased its share of China's total livestock production – growing much faster than pork production. Growth has been accompanied by great changes in the structure of production. The poultry sector is no longer dominated by hundreds of millions of smallholders keeping birds as a sideline activity. Many small farmers have given up production, especially in the economically more developed eastern provinces of the country.

Drivers of change in the poultry sector include, on the demand side, demographic changes – rising population and increased urbanization; income growth both in urban and rural areas; developments in transportation, the processing industry and retailing; rising per capita consumption; and the requirements of export markets. In rural areas, increased incomes from non-farm activities and better marketing infrastructure have reduced need for smallholders to keep poultry as a cash-generating sideline or for home consumption. On the supply side, drivers of change include technological innovation and its diffusion – feed processing has played a decisive role; and the provision of better public services, such as technical innovation, extension, disease prevention and control, quality standards and information.

For the future, it is expected that demand will continue to rise and that the intensification process will continue. Small-scale and non-commercial farmers will continue their exit from the industry. It is possible that the number of poultry farmers in China could halve by 2020. Nonetheless, poultry keeping remains an important economic option for improving the livelihoods poorer smallholders in the mountainous western parts of the country. Increasingly stringent quality and food-safety standards demanded by importing countries will favour the intensification process. Integrated operations in particular are well placed to implement reliable quality control.

Constraints to poultry sector development in China are likely to include high feed prices, particularly maize and soybean. Avian influenza and other diseases will have a major effect on the development of the sector, and may further promote intensification.

Key policy objectives for the poultry sector in China are: to provide sufficient and safe food to the consumer; to provide income and employment for farmers; and to protect the

environment and promote sustainable economic development. Requirements to promote these objectives include: improved disease control and prevention measures; land-use policies that do not unnecessarily inhibit the establishment of poultry farms; favourable investment policy and provision of loans; promotion of the sustainable use of animal waste; and improved research and extension.

Keywords: poultry, sector, China, structure

1 INTRODUCTION

This paper describes the status of the poultry sector in China. It describes the structural changes that have affected the sector particularly over the past decade. It outlines the main drivers of change both on the demand side and the supply side. It then considers future trends and describes the main challenges facing the sector. Finally, it outlines policy objectives for poultry development and the key actions needed to meet these objectives.

1.1 Case studies

The paper draws on two case studies, a broiler and a layer operation, both of which are situated in Fujian Province in the coastal area of southeastern China. The broiler enterprise, Shengnong Group, is a highly vertically integrated operation. It was set up in the mid-1980s and was the first registered private company in Fujian Province. It has now become a large enterprise with over 4 000 employees and an annual output of about 50 million broilers. Its business operations cover the whole production and marketing chain – feed processing, raising of breeding chicken, hatching, fattening of broilers, slaughtering, cutting, and meat processing. It even runs a dozen fast-food restaurants using its own products. It has an organic fertilizer plant which uses chicken waste as raw material. An electricity generating facility is under construction, which will also use chicken manure (containing rice chaff) as energy input.

The layer enterprise, Wenhua, was established during the mid-1990s. It is a family business, with a co-shareholding by two brothers and one sister. It is much smaller than the broiler enterprise, having an inventory of about 250 000 hens.

2 STRUCTURAL CHANGES IN THE PAST DECADE

2.1 Production growth

The poultry sector in China consists of several subsectors –chickens, ducks, geese, turkeys, etc. Chicken production is the predominant subsector, accounting for 70 percent of poultry meat production and over 85 percent of total egg production. Ducks and geese each account for about 15 percent of poultry meat production (MOA, 2006a).

The poultry sector has experienced vigorous growth in the past two decades, as indicated in Table 1. Poultry inventory has increased by a large margin, from 1.98 billion birds in 1985 to 5.33 billion birds in 2005 – an increase of 169 percent. Poultry output and poultry meat production have shown even greater increases – with a growth of 277 percent and 814 percent, respectively, over the same period. This is an indication of much improved poultry production efficiency. Poultry meat production increased from 1.60 million tonnes in 1985 to 7.24 million tonnes in 1995 and to 14.64 million tonnes in 2005. Egg production has also increased substantially, but at a slower pace than poultry meat

production – from 5.35 million tonnes in 1985 to 16.77 million tonnes in 1995, and 28.8 million tonnes in 2005 (Table 1).

The production growth has been achieved both by expansion of bird numbers and by increased productivity. The improvement in productivity is associated with the intensification of the process of production, as industrialized operations have a better feed:meat or feed:egg conversion ratio and shorter production periods. Most of the large operations have productivity levels that are similar to those of the poultry sector in the most developed countries. This is illustrated by the two case studies described in this paper. The vertically integrated broiler enterprise, Shengnong Group, has improved its feed:meat ratio from 2.2–2.3 (feed to live weight) to 1.97–1.98 over the past decade. The fattening period has

TABLE 1
Growth of the poultry sector in China, 1985 to 2005

	Poultry inventory (billion birds)	Poultry output (billion birds)	Poultry meat production (million tonnes)	Eggs production (million tonnes)
1985	1.98		1.60	5.35
1986	1.97		1.88	5.55
1987	2.19		2.19	5.90
1988	2.49		2.74	6.96
1989	2.24		2.82	7.20
1990	2.26		3.23	7.85
1991	2.45		3.95	9.22
1992	2.60	3.19	4.54	10.20
1993	3.12	3.98	5.74	11.80
1994	3.74	5.13	7.55	14.79
1995	4.11	6.30	9.35	16.77
1996	3.79	5.63	8.33	19.65
1997	4.20	6.39	9.79	18.95
1998	4.50	6.84	10.56	20.19
1999	4.55	7.43	11.16	21.35
2000	4.64	8.10	12.08	22.43
2001	4.89	8.09	12.10	23.37
2002	4.74	8.32	12.50	24.63
2003	5.06	8.89	13.12	26.07
2004	5.16	9.07	13.51	27.24
2005	5.33	9.86	14.64	28.80

Note: Figures in 1996 were adjusted based on the first Agricultural Census conducted in early 1997.
Source: Editing Committee of China Agricultural Yearbook, China Agricultural Yearbook, China Agricultural Press, various years.

been shortened to 45 days, with live broilers weighing 4.2 kg by the time of slaughter. In the case of the layer enterprise, Wenhua, the feed/egg ratio is 2.2–2.3; hens produce about 300 eggs during a lifespan of about 550 days.

2.2 Poultry's share in the livestock sector

The poultry sector has increased its relative importance in the national livestock sector in China over the past two decades. This was especially true for the period 1985 to 1995, when poultry meat production more than quadrupled. Pork production grew much more slowly by comparison. As a result, the share of poultry in total meat production increased from about 8 percent to 18 percent, while that of pork declined from 86 percent to 70 percent (Table 2).

TABLE 2
Poultry meat production and its share in total meat production in China, 1985 to 2005

	Meat total (million tonnes)	Poultry meat (million tonnes)	Poultry meat as a proportion of total meat (%)	Pork (million tonnes)	Beef (million tonnes)	Mutton (million tonnes)
1985	19.27	1.60	8.3	16.55	0.47	0.59
1986	21.12	1.88	8.9	17.96	0.59	0.62
1987	22.16	2.19	9.9	18.35	0.79	0.72
1988	24.80	2.74	11.1	20.18	0.96	0.80
1989	26.29	2.82	10.7	21.23	1.07	0.96
1990	28.57	3.23	11.3	22.81	1.26	1.07
1991	31.45	3.95	12.6	24.52	1.54	1.18
1992	34.31	4.54	13.2	26.35	1.80	1.25
1993	38.43	5.74	14.9	28.54	2.34	1.38
1994	44.99	7.55	16.8	32.05	3.27	1.61
1995	52.60	9.35	17.8	36.48	4.15	2.02
1996	45.84	8.33	18.2	31.58	3.56	1.81
1997	52.69	9.79	18.6	35.96	4.41	2.13
1998	57.24	10.56	18.4	38.84	4.80	2.35
1999	58.21	11.16	19.2	38.91	5.05	2.51
2000	61.25	12.08	19.7	40.31	5.33	2.74
2001	63.34	12.10	19.1	41.85	5.49	2.93
2002	65.87	12.50	19.0	43.27	5.85	3.17
2003	69.33	13.12	18.9	45.19	6.30	3.57
2004	72.45	13.51	18.7	47.02	6.76	3.99
2005	77.40	14.60	18.9	50.10	7.10	4.40

Note: Figures in 1996 were adjusted based on the first Agricultural Census conducted early 1997.
Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 3
Composition of agricultural output value in China

	Total	Cropping	Forestry	Fishery	Livestock	Proportional contribution of livestock (%)
			Billion RMB			
1985	362	251	19	13	80	22
1990	766	495	33	41	197	26
1995	2 034	1 188	71	170	605	30
2000	2 492	1 387	94	271	739	30
2005	3 945	1 964	143	402	1 331	34

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

During the period 1995 to 2005, poultry meat production continued to grow – doubling within this ten year period. The growth rate was slower than that of the previous decade, and only slightly faster than the total growth of meat production. It is generally agreed that had it not been for the outbreak of avian influenza (AI) the poultry sector would have achieved greater growth in recent years.

The share of poultry meat in total meat production increased from about 8 percent in 1995 to 19 percent in 2005. The share of pork fell from 70 percent in 1995 to 65 percent in 2005.

This increased importance of the poultry sector within the livestock sector has been accompanied by a significant increase in the importance of the livestock sector within the agricultural sector. As indicated in Table 3, the share of livestock in the total value of agricultural output in China increased from 22 percent in 1985 to 30 percent in 1995 and to 34 percent in 2005. This implies that the poultry sector's significance in the overall agricultural sector has increased substantially in the last two decades.

2.3 Structural changes in the poultry sector

The overall growth of the poultry sector in China has been accompanied by great changes in the structure of production. Two decades ago, China's poultry sector was very much dominated by hundreds of millions smallholders, each with a few, or at most several dozen, chickens or ducks. Poultry raising was only a minor sideline activity for farm households. Poultry meat and eggs were luxury goods which were mostly consumed on special occasions, such as birthdays or holidays. Apart from a very few state farms around big cities, there were no large-scale commercial poultry farms.

Rapid intensification of the livestock sector has been ongoing in China since the mid-1980s. This intensification comprises two dimensions: agglomeration – the establishment of large-scale intensive industrialized operations (either integrated or not integrated); and spatial concentration. Definitions of intensive and extensive systems vary; the definitions generally applied in China for major livestock species are listed in Table 4.

The intensification process has not been the same for all animal species. Generally speaking, the poultry sector, including both broilers and layers, has experienced the fast-

TABLE 4
Criteria for defining intensive farms in China

Farm type	Criterion defining intensive farms ("scale of raising")
Pigs	Annual production of 50 or more head of pigs
Beef cattle	Annual production of 50 ore more head of cattle
Dairy cattle	With a stock of 20 or more dairy cattle
Broilers	Annual production of 2 000 or more birds
Layers	With a stock of 500 or more birds
Sheep and goats	Annual production of 30 or more sheep/goats

Source: MOA, Yearbook of Animal Husbandry, China Agriculture Press, 2006.

est intensification, followed by the pig sector. The cattle sector, including beef and dairy, intensified more slowly.

The 1996 national agricultural census provides the earliest detailed information on the production structure of poultry production in China. According to the census data, among 234 million small farmers, 104 million households (44 percent) had poultry operations in 1996 (Table 5). Of those farmers who raised poultry, 99.7 percent were small producers with a yearly production of 1 000 birds or less. Poultry produced from this huge number of small farmers accounted for about 43 percent of total poultry production. Considering the figures in more detail, 96.8 percent of the farms raising poultry operated at a scale below 50 birds; such farms provided only 27 percent of total poultry production in 1996. Large producers, with an annual output of 1 000 birds or more, accounted for only 0.3 percent of operations, but accounted for 57 percent of poultry production.

The 1996 census made no distinction between broilers and layers. This may be a reflection of the fact that the traditional system of small producers still prevailed. As a result, no separate data on the size and structure of layer production are available for 1996.

Significant changes in poultry production took place during the last decade. An increas-

TABLE 5
Structure of poultry production in China in 1996 (by size of farms)

Size of farm (number of birds)	Farms with poultry (million)	Poultry output (million birds)	Farms with poultry (%)	Poultry production (%)
<50	100.76	835.46	96.82	27.00
50–200	2.40	219.82	2.30	7.10
200–1 000	0.59	282.52	0.57	9.13
1 001–10 000	0.29	968.07	0.28	31.28
>10 000	0.03	788.55	0.03	25.48
Total	104.07	3 094.43	100	100

Source: MOA: Internal data from the 1996 national agricultural census.

TABLE 6
Changes in number of poultry farms by province in China

	1996	2005	2005 figures as proportion of 1996 (%)	Proportion of rural households (%)
China	104.068	34.612	33.3	13.7
Beijing	0.021	0.008	39.5	0.6
Tianjin	0.034	0.005	13.6	0.4
Hebei	2.893	0.361	12.5	2.5
Shanxi	1.153	0.066	5.7	1.0
Inner Mongolia	0.668	0.789	118.0	22.4
Liaoning	1.571	0.228	14.5	3.3
Jilin	1.462	0.346	23.7	9.0
Heilongjiang	1.889	0.399	21.1	8.1
Shanghai	0.267	0.003	1.0	0.3
Jiangsu	6.272	1.036	16.5	6.5
Zhejiang	2.781	0.702	25.3	5.7
Anhui	8.273	2.006	24.2	14.9
Fujian	3.740	0.738	19.7	10.8
Jiangxi	5.051	3.836	75.9	48.2
Shandong	6.596	0.443	6.7	2.2
Henan	8.371	1.194	14.3	5.9
Hubei	5.350	1.364	25.5	13.4
Hunan	8.549	4.693	54.9	31.4
Guangsong	6.636	1.330	20.0	8.6
Guangxi	5.809	3.604	62.0	36.5
Hainan	0.666	0.525	78.8	46.6
Chongqing	3.431	0.031	0.9	0.4
Sichuan	11.930	6.995	58.6	35.3
Guizhou	3.368	1.251	37.1	15.8
Yunnan	4.196	1.952	46.5	22.2
Tibet	0.009	0.027	314.5	6.6
Shaanxi	1.034	0.214	20.7	3.0
Gansu	1.357	0.086	6.3	1.9
Qinghai	0.078	0.000	0.0	0.0
Ningxia	0.214	0.084	39.1	8.9
Xinjiang	0.397	0.298	75.1	13.3

Source: calculated by the authors based on data from MOA (2006a; 2006b and, NSB (2006).

ing number of small farmers have given up their sideline poultry production. This is especially the case in the economically more developed eastern parts of the country and in the suburbs of large cities. According to data from the Ministry of Agriculture (MOA, 2006b), the total number of poultry farms had declined to 34.6 million – a fall of 67 percent from the figure in 1996. The trend was downwards in all provinces except for Inner Mongolia and Tibet. The more-developed eastern provinces and municipalities showed larger decreases in the number of poultry farms. For example, only 1 percent of the poultry farms operating in 1996 in Shanghai Municipality are still in operation in 2005. The national average is that farm households keeping poultry account for only 13.7 percent of all rural households (Table 6).

During the same period, the number of large producers and their share in poultry production increased substantially. In 1996, large-scale producers with an annual output of 10 000 birds or more had a 25 percent share of the total. In 2005, the share of large producers was over 49 percent (Table 7). The picture is similar in the layer sector. In 2005, producers with 500 layers or more accounted for only 1.9 percent of operations, but nearly 70 percent of egg production (Table 8).

The poultry sector in China is characterized by a dichotomy: large-scale integrated industrialized operations, comparable to those found in the most-developed poultry sector in North America, coexist with very small traditional backyard systems. Generally

TABLE 7
Structure of broiler production in China in 2005 (by size of farms)

Size of farm (annual output of birds)	Number of farms (million)	Broiler production (million birds)	Share of farms (%)	Share of broiler production (%)
1–2 000	34.15	1 483	98.6	23.3
2 000–10 000	0.36	1 751	1	27.5
>10 000	0.11	3 137	0.3	49.2
Total	34.62	6 371	100	100

Source: same as for Table 6.

TABLE 8
Structure of layer production in China in 2005 (by size of farms)

Size of farm (number of birds)	Number of farms (million)	Layer inventory (million birds)	Egg production (million tonnes)	Share of farms (%)	Share of layer inventory (%)	Share of egg production (%)
1–500	40.4	804.4	7.1	98.1	33.8	30.3
500–2 000	0.6	643.4	6.5	1.4	27.1	27.9
2 000–10 000	0.2	694.3	7.2	0.5	29.2	30.8
>10 000	0	236.4	2.6	0	9.9	11
Total	41.2	2 378.5	23.3	100	100	100

Source: same as for Table 6.

speaking, the market demand is mainly covered by large operations, while the backyard operations meet the consumption needs of the raisers themselves. There are practically no state-owned livestock enterprises in China nowadays. The large-scale poultry farms are all private owned.

2.4 Spatial concentration

There is very marked spatial concentration of poultry production in China. The eastern region of the country has a much higher poultry density than the central and western regions, whether compared in terms of total population density or in terms of farm numbers.

As shown in Table 8, in 1996, the 11 provinces in the eastern region of China accounted for 30 percent of farms with poultry production. The eastern region produced about 65 percent of poultry meat; it accounted for 77 percent of large poultry farms (those with an annual output of more than 1 000 birds) and 80 percent of poultry output from large farms. In contrast, the western region, with 31 percent of China's poultry farms, produced only 13 percent of poultry output. Its share of large poultry farms was even lower – only 5 percent of large poultry farms and 6 percent of poultry output produced by large farms.

TABLE 9
Spatial (by regions) structure of poultry production in China in 1996 and 2005

		Percentage of total		
		East	Central	West
1996	Farms with poultry	30.3	38.6	31.2
	Poultry output	64.6	22.6	12.9
	Farms >1 000 birds	77.0	17.6	5.3
	Output >1 000 birds	80.2	13.6	6.2
2005	Total population	38.7	31.9	27.5
	Total farm number	38.5	32.5	29.0
	Farms with broilers	15.5	40.2	44.3
	Broiler output	56.7	28.8	14.5
	Broiler farms >2 000 birds	60.1	29.8	10.1
	Broiler output >2 000 birds	66.3	24.4	9.4
	Farms with layers	19.6	31.4	49.0
	Layer farms >500 birds	60.8	30.6	8.6
	Layer inventory >500 birds	63.1	29.0	7.9
	Egg production >500 birds	60.0	31.6	8.4
	Broiler density, birds/km^2	3 707	1 675	126
	Layer density, birds/km^2	1 412	771	43

Note: the available data for 1996 are not as detailed as those for 2005, and there were no separate data on layer production for 1996.
Sources: NBS (National Bureau of Statistics of China), Statistical Yearbook of China, various years; MOA, Yearbook of Animal Husbandry in China 2006.

TABLE 10
Human and poultry population density in China by province, 2005

	Human population (million)	Poultry population (million)	Human density (persons/km²)	Poultry density (birds/km²)
China	1 308	5 985	136	623
Beijing	15	116	915	6 880
Tianjin	10	89	876	7 448
Hebei	69	289	365	1 542
Shanxi	34	14	214	90
Inner Mongolia	24	33	20	28
Liaoning	42	497	289	3 410
Jilin	27	350	145	1 868
Heilongjiang	38	179	84	395
Shanghai	18	53	2 822	8 342
Jiangsu	75	274	729	2 674
Zhejiang	49	148	481	1452
Anhui	61	335	439	2403
Fujian	35	104	291	856
Jiangxi	43	131	258	787
Shandong	92	1231	589	7 836
Henan	94	387	562	2 315
Hubei	57	107	307	577
Hunan	63	218	299	1 029
Guangsong	92	546	517	3 068
Guangxi	47	388	196	1 633
Hainan	8	49	234	1 382
Chongqing	28	43	340	527
Sichuan	82	256	168	524
Guizhou	37	26	212	151
Yunnan	45	36	116	94
Tibet	3	1	2	1
Shaanxi	37	15	181	72
Gansu	26	12	57	27
Qinghai	5	0	8	0
Ningxia	6	8	90	114
Xinjiang	20	49	12	29

Source: Calculation by authors based on data of MOA (2006b) and NSB (2006).

TABLE 11
Poultry raising size structure by inventory group (size of farm) and province in China, 2005

Inventory group	1–2 000	2 000–10 000	10 000–40 000	50 000–100 000	100 000–500 000	500 000–1 000 000	>100 000	>50 000
China	24.8	29.3	28.2	6.5	5.4	2.0	3.9	17.8
Beijing	1.0	17.8	47.5	10.2	4.1	18.2	1.2	33.7
Tianjin	0.7	11.5	61.1	16.9	7.9	1.9	0.0	26.7
Hebei	28.4	35.5	27.7	3.8	1.0	0.2	3.4	8.4
Shanxi	38.0	31.0	27.8	2.5	0.7	0.0	0.0	3.3
Inner Mongolia	46.3	40.4	13.3	0.0	0.0	0.0	0.0	0.0
Liaoning	11.0	43.3	33.7	5.5	5.2	0.7	0.5	11.9
Jilin	15.4	29.7	36.7	4.5	0.7	1.0	12.0	18.2
Heilongjiang	40.8	36.0	15.7	5.4	0.5	0.0	1.5	7.4
Shanghai	0.0	29.7	28.1	10.9	10.3	6.5	14.4	42.2
Jiangsu	13.6	38.2	25.7	5.3	3.2	0.9	13.0	22.4
Zhejiang	14.2	16.5	42.3	11.4	9.3	1.5	4.7	26.9
Anhui	43.1	18.8	25.4	6.4	4.7	0.5	1.2	12.7
Fujian	22.4	17.1	17.2	8.0	5.0	27.9	2.4	43.3
Jiangxi	53.5	28.4	11.4	5.8	0.4	0.5	0.0	6.7
Shandong	5.4	42.6	36.8	5.2	5.3	1.5	3.3	15.3
Henan	21.7	38.3	15.2	3.8	20.2	0.2	0.8	24.9
Hubei	45.5	19.2	19.9	6.0	4.0	4.2	1.2	15.3
Hunan	66.5	16.4	9.2	4.6	1.8	1.5	0.0	7.9
Guangsong	19.1	10.6	39.8	16.1	9.8	3.0	1.8	30.5
Guangxi	38.2	24.7	14.6	3.4	1.8	0.6	16.6	22.4
Hainan	43.5	17.1	13.3	8.3	10.0	5.6	2.0	26.0
Chongqing	31.8	17.3	38.5	7.5	2.4	0.0	2.5	12.5
Sichuan	70.2	10.8	11.1	4.4	3.3	0.3	0.0	8.0
Guizhou	71.0	17.9	5.5	1.6	4.0	0.0	0.0	5.6
Yunnan	50.8	14.4	17.5	12.1	5.1	0.0	0.0	17.2
Tibet	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shaanxi	65.7	17.9	14.8	0.8	0.7	0.0	0.0	1.5
Gansu	68.2	12.9	12.7	5.0	1.2	0.0	0.0	6.2
Ningxia	5.4	50.3	40.2	4.1	0.0	0.0	0.0	4.1
Xinjiang	65.7	19.4	12.8	2.1	0.0	0.0	0.0	2.1

Source: calculation by the authors based on data of MOA (2006a and 2006b).

For 2005, data are available separately for broilers and layers. The geographical patterns are similar for both types of poultry. About 39 percent of China's total population and farms (farm households) are located in the eastern region; this region accounts for a much lower proportion (15 to 20 percent) of the number of farms with poultry, but a much higher proportion (over 60 percent) of poultry output, for both broilers and layers. Measured in relation to geographical area, the poultry density in the eastern region is about 30 times as high as that in the western region, for both broilers and layers (Table 9). The central region has a density half as high as that of the eastern region.

As clearly shown in Table 10, the human and poultry population densities differ greatly among the provinces of China. Several features can be noted:

- both the human density and poultry density vary greatly across the country;
- there is a close co-relationship between human population density and poultry population density – the higher the human population density, the higher the poultry population density; and
- most of the provinces with higher poultry population density are located in economic hubs of the coastal areas, such as Beijing, Tianjin, Shanghai, Liaoning, Fujian, Shandong and Guangdong.

There is also a clear difference in the size structure of poultry production (see Table 11). Poultry production in the coastal provinces is highly concentrated in a small percentage of large operation units. For example, for the country as a whole, poultry enterprises with more than 50 000 birds account for 17.8 percent of the poultry inventory. The corresponding figures of the coastal municipalities of Beijing, Tianjin, Shanghai and the provinces of Fujian and Guangdong are much higher. The figure in Fujian Province is 43.3 percent – the highest figure for any region. This is one of the main reasons why the case studies were conducted in this province.

2.5 Marketing channels for poultry products

Due to the complexity of the various operation systems and the huge size of the country, it is not possible to prepare quantitative and valued flow charts for the whole production and marketing chain for broilers and layers in China. It is even not possible to draw charts for a single province with reasonable precision. Generally speaking, the structure of the sector is a blend of very small traditional operations, some middle-sized commercial operations, and very large and highly integrated operations. There is great variety at each level of the chain – input provision, breeding, hatching, fattening, feeding, slaughter, wholesale, retailing, consumption, and importing and exporting.

Almost all poultry operations, whether large or small, are privately owned. Both poultry enterprises surveyed for this study were established by local private investment. The integrated broiler enterprise, Shengnong Group, obtains its breeding chickens through a United States of America–China joint venture located in Beijing. The chicken variety is Avine. Shengnong gets about 40–50 thousand sets of day-old chicks delivered each month. It processes its own feed, purchasing maize, soybean cakes and other feed ingredients from different regions. It currently has 12 breeding chicken farms and 27 boiler fattening farms, scattered across several valleys within a county. In 2006, the enterprise produced about 50 million broilers, or about 55 000 tonnes of chicken meat products. Its marketing channels are as listed in Table 12.

TABLE 12
Marketing channels of Shengnong Group, 2006

Type of buyers	Type of products	Quantity of products (tonnes)
KFC, McDonald's and other chain food outlets	Cuts	16 000
Wholesale to various provinces in South China	Chickens	32 000
Food processors	Chickens and cuts	2 200
Shengnong's own processing plant	Processed and half-prepared food to supermarkets	3 000
Shengnong's own fast food restaurants	Food to end consumers	2 000
Total	-	55 200

Source: survey data obtained by the authors.

The layer enterprise, Wenhua, obtains chicks via a United States of America–China joint venture located in Shanghai. All the birds are of the Hi-line variety. Almost all the eggs produced by Wenhua are sold within the province. Of the total egg production of 3 100 tonnes, 20 percent are sold to leading supermarkets, including Wal-mart and Carrefour. Sixty percent are provided to the food-processing industry and the remaining 20 percent are sold to the local wholesale and retail markets.

Most large-scale chicken enterprises have adopted contract farming. Normally, an enterprise provides contracted farms with feed, chicks, and other services and guidance; it receives the fattened birds back for slaughtering and sale.

2.6 Product cost structure

It is difficult to compare costs between industrial and backyard operations. For backyard operations that keep a few birds –at most a dozen – it is difficult to calculate the costs for labour and other items. Even the cost for feed is difficult to estimate, as the feed structure varies significantly across the huge number of small farms; the birds are usually fed a mixture of non-commercial and commercial feed at various ratios.

As for the industrial system, it is relatively easy to obtain reliable information. As an example, the cost structure of broiler production, including slaughtering, of Shengnong Group is shown in Table 13. It clearly shows that the predominant share of costs (two-thirds of the total) is accounted for by feed.

3 MAJOR DRIVERS OF CHANGE

Many factors have contributed to changing China's poultry sector. These factors, or drivers, can be divided into two groups: "pulling" forces that affect the total demand for poultry commodities; and "pushing" forces that have direct effects on poultry production from the input side.

TABLE 13
Broiler production costs in Shengnong Group

	Yuan	%
Chicks	1.37	9.3
Feed	10.00	67.7
Animal health	0.50	3.4
Labour	0.25	1.7
Water and electricity	0.10	0.7
Transport	0.16	1.1
Depreciation	0.40	2.7
Air conditioning	0.50	3.4
Slaughtering	1.50	10.1
Total	14.78	100.0

Source: Survey results obtained by the authors.

3.1 Drivers on the demand side

Drivers on the demand side include the expansion of the total human population, changes in the urban–rural composition of the population, income growth among consumers and farmers, improvements to infrastructure, increasing per capita consumption of poultry commodities and increasing trade in poultry products.

Demographic changes

Population expansion has been the primary force driving rising demand for poultry products in China. China's total population has increased from about 1 billion in 1980 to more than 1.3 billion in 2005 (Table 14). As a result of the population-control policy, the growth rate has been reduced from 1.5 percent to 0.6 percent *per annum* over this period. The population growth was at peak in the late 1980s when there were 15 million new-born babies

TABLE 14
Population growth in China

	Total population (million)	Urban population (million)	Rural population (million)
1980	987	191	796
1985	1 059	251	808
1990	1 143	302	841
1995	1 211	352	859
2000	1 267	459	808
2005	1 308	562	745
2030*	1 500	900	600

*Projections by the State Population and Family Planning Commission (SPFP).
Source: National Bureau of Statistics of China(NBS),: Statistical Yearbook of China, various years.

per year. The figure has declined by half in recent years, but is still at nearly 8 million per year. According to authoritative projections, the total population in China will peak at 1.5 billion by 2030 (NPFP, 2007).

The size of the urban population has risen much faster than that of the total population. Urban population (including rural migrant workers) has more than doubled over the past two decades. The growth trend will continue into the future, and the urban share in the total population will reach 60 percent by 2030. This rapid urbanization process has direct implications for poultry production – more demand for livestock commodities including poultry products. This is because in China urban people consume more meat and eggs than do rural people; this can be seen from the results of household surveys. Changing consumption patterns are discussed further in the next section.

Income growth of urban and rural households

As Chinese consumers still have a relatively low level of consumption of poultry products, the effect of income on demand is large. There are a number of research reports on the income elasticity of livestock products in China. The figures produced by different studies vary widely because of differences in data and time coverage. However, all of studies show that the income elasticity of all livestock products, including poultry meat and eggs, is larger than zero. This implies that demand will rise with income growth. Estimates of the income elasticity from various studies are listed in Table 15.

Household surveys are conducted every year by the National Bureau of Statistics (NBS) in China. According to these surveys, there is a clear relationship between income level and the level of poultry consumption. A rough and simple method is used to estimate the income elasticity of poultry meat and egg consumption. Tables 16 and Table 17 show this relationship for urban households and rural households, along with the respective elasticity estimates. For urban residents, income elasticity of poultry meat consumption declines as income rises – from about 0.5 for the lower income groups to about 0.2 for the higher income groups. Income elasticity for egg consumption shows a similar trend as income

TABLE 15
Estimates of income elasticity of livestock products in China

Source	Household type	Pork	Beef and mutton	Poultry	Eggs	Dairy
Jiang (2002)		0.53	1.26	1.46	0.95	1.52
Deng (2005)	Rural	0.25	0.57	0.22	0.36	0.32
	Urban	0.32	0.49	0.48	0.26	0.49
Hsu *et al.* (2002)	Rural	0.67	0.65	0.7	0.41	0.95
	Urban	1.68	-	3.12	0.55	3.41
Hongbo *et al.* (2007)		0.77	1.34–1.38	0.9		
Gale and Kuo (2007)	Rural			0.63–0.74	0.38–0.72	
	Urban			0.25–0.78	-0.3–0.5	

TABLE 16
Income elasticity estimates for poultry meat and eggs for urban households in China, 2005

Income group	Lowest	Low	Lower middle	Middle	Upper middle	High	Highest
	10%	10%	20%	20%	20%	10%	10%
	First decile	Second decile	Second quintile	Third quintile	Fourth quintile	Ninth decile	Tenth decile
Disposable income (yuan)	3 135	4 885	6 711	9 190	12 603	17 203	28 773
Poultry meat consumption (kg)	5.5	7	8.3	9.3	10.4	11.3	11.6
Egg consumption (kg)	8.3	10.2	11	11.6	11.9	12.5	11.5
Elasticity for poultry meat		0.489	0.497	0.326	0.318	0.237	0.039
Elasticity for eggs		0.469	0.158	0.167	0.081	0.213	-2.027

Source: Calculated based on survey data of the National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 17
Income elasticity estimates for poultry meat and eggs for rural households in China, 2004

Income group	Low	Lower middle	Middle	Upper middle	High
	20%	20%	20%	20%	20%
	First quintile	Second quintile	Third quintile	Fourth quintile	Fifth quintile
Disposable income (yuan)	1 007	1 842	2 579	3 608	6 931
Poultry meat consumption (kg)	1.7	2.4	3.0	3.7	5.4
Egg consumption (kg)	2.6	3.7	4.6	5.6	7.3
Elasticity for poultry meat		0.497	0.625	0.585	0.499
Elasticity for eggs		0.852	0.389	0.372	0.609

Source: Calculated based on survey data of the National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

rises, but at a lower level; it even becomes negative for the highest income group, implying declining egg consumption with further increases in income. In fact, apart for the two lowest groups, egg consumption is almost constant across income groups. This leads to the conclusion that among urban households the low income groups will continue to demand more eggs as their incomes rise, while the higher income groups will broadly maintain their egg consumption levels as their incomes rise.

The situation for rural households is rather different. Income elasticity is in the range of 0.5 to 0.6 for both poultry meat and egg consumption, and for all income groups. This means that all the farming population will increase their demand for poultry meat and eggs significantly as income rises. The average income elasticity of urban households for poultry meat is smaller than that of rural households. However, in recent years, the income growth rate of urban residents has been much higher than that of their rural counterparts. Thus, the overall income effects on poultry consumption have been, and will continue to be, large in both urban and rural populations.

Income of urban residents has been rising at a rapid pace over the past three decades. Measured in 1978 yuan, the per capita income of urban households in 2005 is over six times higher than that of 1978 (Table 18). In other words, per capita urban incomes have doubled every ten years.

The improvement of Chinese consumers' purchasing power can also be seen from the changes in the share of food costs in total household expenditure – the so-called Engel's Coefficient. For the urban population, this coefficient declined from 58 percent in 1978 to 37 percent in 2005, which implies that Chinese consumers now have more flexibility in their consumption. If they wish, they are more able to increase expenditure on poultry products. With further improvement in income, they will consume more meat, milk and other livestock commodities, especially the low-income sections of the population whose current meat consumption level is relatively low and has more scope to increase.

Increase in income has a much greater impact on poultry meat and egg consumption than on other meats. This is because Chinese consumers generally prefer poultry products to other livestock products. As a result, given an increased income, growth in consumption of poultry meat and eggs is much larger than that of other meat, both in percentage and absolute terms.

As in the case of urban residents, the per capita income of China's rural population has also improved dramatically in the past three decades. The growth path and pace is largely the same as that for urban households (Table 19).

The impact of income growth among the agricultural population on the poultry sector is more complex than that of urban residents. The similarity is the income effect on the

TABLE 18
Changes in per capita income for urban households in China, 1978 to 2005

	Yuan per capita	Deflated index	Food share in expenditure (%)
1978	343	100	58
1980	478	127	57
1985	739	160	53
1990	1 510	198	54
1995	4 283	290	50
2000	6 280	384	39
2005	10 493	607	37

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 19
Changes in per capita income for rural households in China, 1978 to 2005

	Yuan per capita	Deflated index	Food share on expenditure (%)
1978	134	100	68
1980	191	139	62
1985	398	269	58
1990	686	311	59
1995	1 578	384	59
2000	2 253	484	49
2005	3 255	625	46

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

demand for poultry products: rapid income growth among rural households has stimulated demand for poultry products in rural households, just as has happened in urban households. However, rural households are not just consumers of poultry products. They are also producers. Increased income not only drives demand, it also directly affects the production structures of poultry sector in several ways.

First, the significance of the livestock sector for the income of farmers has declined, as the income-share earned from livestock has fallen as a proportion of farmers' total household income from 14 percent in 1990 to 9 percent in 2005 (Table 20). These figures represent the average for the whole country; in the eastern regions, the share is even lower. One important reason for traditional farmers to raise a couple of animals in the yard was that they could obtain cash income by selling the animals or their products – usually pigs, chickens or eggs. The importance of this cash-income provision has greatly declined as non-farm salary has risen dramatically. The rural population has two ways to earn non-farm salaries: either to work in township and village enterprises, or go to cities as migrant workers. According to estimations provided by different sources, the total number of rural migrants working in cities is in the range of 120 to 140 million. In this context, backyard poultry raising has lost its traditional importance as a source of cash income.

Second, rising rural income also implies higher agricultural labour costs. Raising livestock is a relatively labour intensive activity in China. Rising labour costs makes small-scale livestock raising less attractive. It needs a lot of work to raise a couple of pigs or chickens, and earnings have become ever less competitive compared to non-farm activities. Most young people in the eastern part of the country have left agriculture and found jobs in non-farm sectors in the cities.

Last but not least, as incomes have improved the rural population has become less tolerant of the environmental problems associated with in-yard livestock raising, especially the odours and flies. As a result, small backyard livestock raising has disappeared in many villages in the coastal provinces, such as Zhejiang, Jiangsu, Shandong and Guangdong. Most farmers in those regions have significantly improved their living conditions. There is still livestock raising in these provinces, but it is now more concentrated in large-scale intensive farms.

TABLE 20
Per capita net income of farmers' households in China

	Total	Non-farm salary		Livestock	
	Yuan	Yuan	%	Yuan	%
1985	398	72	18	52	13
1990	686	139	20	97	14
1995	1578	354	22	128	8
2000	2253	702	31	207	9
2005	3255	1175	36	284	9

Source: National Bureau of Statistics of China (NBS): Statistical Yearbook of China, various years.

Public infrastructure development

Dramatic improvements have taken place in China's transportation systems over the past two decades. The railway system is the major means for long distance transportation such as inter-provincial movement of goods. Not only was the length of the railway network extended by one-third between 1985 and 2005, but the quality and efficiency of the sector has been much improved. With improvement in the rail system, including increased speed and expansion of double-tracking rails, transportation capacity has been increased significantly. The railway is very important for the transportation of feed.

The improvement of the highway transportation system is even greater than that of the railway system, and it is more important for the transportation of poultry products. The road length has doubled in the last two decades. More importantly, the construction of expressways in China has shown spectacular development. China's first expressway came into operation as recently as 1990. China now boasts over 41 000 km of expressway, second only to the United States of America. The number of trucks has more than quadrupled – from 2.2 million in 1985 to 9.6 million in 2005.

At the same time, processing industries have been rapidly developed. Large-scale integrated meat processing companies have been set up nationwide, especially in the eastern part of the country. The Shennong Group Co. located in Fujian Province, for example, is the largest broiler producer and processor in South China. It is a highly integrated enterprise, which includes the whole chain of broiler production and processing – breed egg production, hatching, feed processing, fattening, slaughtering, cutting, processing, export and selling. The whole business process is equipped with modern facilities and techniques. With the most advanced facilities imported from abroad, it has an annual slaughtering capacity of 120 million birds. It provides chicken cuts to fast food restaurants such as KFC (with a share of 13 percent in KFC's total demand in China) and McDonald's; it even owns two dozen chicken meat-based fast-food restaurants. KFC opened its first restaurant in China in Beijing in 1987. Since then, it has expanded very rapidly, and now boasts over 1 400 restaurants in more than 200 large cities across the country, including Tibet. McDonald's first restaurant opened in Shencheng in southern China in 1990; it now has about 800 restaurants across the country.

Retailing facilities in China have also improved significantly during the past two decades, in particular in recent years, as supermarkets and chain stores have been booming across the country, first in the large and medium-sized cities, and now also in towns and even in villages in the economically more developed regions. One major reason for many farmers to keep backyard poultry in the past was to meet their own consumption needs. This has also lost its importance over time, as shops, weekly markets, supermarkets and other marketing facilities selling poultry products are widely developed; farmers now have easy access to a great variety of poultry commodities, from fresh meat to processed products.

Growth of per capita consumption

Per capita consumption of poultry commodities is a reflection of the combined effects of income, price, preference, physical accessibility to the commodities and other factors. The consumption of poultry products has increased continuously over the past two decades. Annual sample household surveys are conducted separately for urban and rural areas in China. Results of these surveys of poultry product consumption are shown in Table 21 and Table 22. Some important points can be noted from the tables. First, the consumption of poultry products in both urban and rural areas has risen significantly in the last two decades. Second, consumption of poultry meat has grown faster than that of any other meat for both urban and rural households. During the past decade poultry meat consumption has doubled in both sections of the population.

Comparing Table 21 and Table 22 reveals that the urban population consumes 140 percent more poultry meat and 120 percent more eggs than the rural population. This can be attributed to a number of factors, including differences in dietary preference. However, the principal and most decisive reason is the income disparity between the urban and rural populations. The average income level in urban areas is over three times of that in rural areas.

Trade in poultry products

Trade in poultry has developed in line with the general trend of agricultural trade in China (Table 23). There are several features to be noted. First, import of poultry products has increased significantly in the past decade, though there have been some variations, while export has more or less stagnated. Second, in most years, poultry export accounted for a

TABLE 21
Consumption of livestock products in urban households in China

	Pork	Beef and mutton	Poultry	Eggs	Milk
	kg per capita per year				
1985	16.7	2.0	3.2	6.8	
1990	18.5	3.3	3.4	7.3	4.6
1995	17.2	2.4	4.0	9.7	4.6
2000	15.7	3.3	5.4	11.2	9.9
2005	20.2	3.7	9.0	10.4	20.0

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 22
Consumption of livestock products in rural households in China

	Pork	Beef and mutton	Poultry	Eggs	Milk
	kg per capita per year				
1985	10.3	0.7	1.0	2.1	
1990	10.5	0.8	1.3	2.4	
1995	10.6	0.7	1.8	3.2	0.6
2000	13.3	1.1	2.8	4.8	1.1
2005	15.7	1.4	3.7	4.7	2.1

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

relatively high percentage of China's total agricultural and food export, while poultry import made a much smaller contribution to total agricultural import. Third, China has been a net exporter of poultry products in the past decade, with an annual net surplus of some US$400 to 800 million. The poultry export is closely linked to the intensification process, as only the large-scale operations can meet the high standards required by overseas consumers, including physical and hygiene criteria. Most of the exporters are large-scale integrated enterprises with fattening, slaughtering and processing operations. China's entry into the

TABLE 23
Trade of poultry and agricultural products in China

	Agriculture total		Livestock		Poultry		Share of poultry in total	
	million US$						%	
	Import	Export	Import	Export	Import	Export	Import	Export
1995	11 207	11 324	1 479	2 831	96	781	0.85	6.90
1996	9 622	11 211	1 414	2 858	156	933	1.62	8.32
1997	8 753	11 840	1 376	2 741	145	846	1.65	7.15
1998	7 320	11 074	1 332	2 459	118	748	1.61	6.76
1999	6 940	10 479	1 859	2 247	421	820	6.07	7.82
2000	9 411	11 863	2 656	2 590	492	986	5.23	8.31
2001	9 962	11 904	2 786	2 669	453	1 064	4.55	8.93
2002	10 177	13 463	2 885	2 570	439	948	4.31	7.04
2003	16 451	15 884	3 357	2 709	478	852	2.91	5.36
2004	24 756	16 419	4 029	3 190	167	651	0.67	3.96
2005	24 576	19 689	4 227	3 604	355	915	1.44	4.65
2006	27 777	22 051	4 554	3 726	481	933	1.73	4.23

Source: MOA, complied data based on unpublished custom statistics.

World Trade Organization, which brought the import tariff for most poultry products from 20 percent in 2001 down to 10 percent in 2004 (WTO, 2001), has had no significant effect on imports.

The most important destination of poultry exports from China is Japan, which accounts for nearly 70 percent of the total export of poultry commodities. The second major destination is Hong Kong SAR, accounting for 20 percent of the total. On the import side, the United States of America used to be by far the dominant provider of poultry products to China. However, in recent years import from Brazil has grown very rapidly. Currently, the United States of America has a share of around 68 percent and Brazil has 25 percent (Table 24).

Most of the imported poultry products in China are chicken wings, other cuts and offal, which are preferred and command much higher prices than abroad. Most exports are processed poultry products, which require a lot of manual labour. This trade structure reflects the difference in consumption preferences between China and its trade partners which are usually developed economies. The average unit value for export and import of poultry products is shown in Table 24. The per-unit value of exports is almost three times of that of imports. This implies that China exports high-value processed products and imports low-priced cuts.

Most of the export of poultry products involves the coastal provinces. Shandong Province is the leading exporter of poultry commodities, accounting for about 40 percent of the national total. Guangdong Province ranks second, with a share of about 20 percent. The 11 coastal provinces, taken together as the eastern region, account for nearly 90 percent of China's total poultry export.

Overall, the poultry trade is not very significant, as both imports and exports correspond to less than five percent of domestic production. However, trade has some significance for the domestic poultry sector in some coastal areas, in particular in Shandong and Guangdong.

TABLE 24
Poultry trade in China in 2006

	Quantity (1000 tonnes)		Value (million US$)		Unit value (US$/tonne)	
	Import	Export	Import	Export	Import	Export
Total	591	392	481	933	814	2 382
United States of America	409	3	325	18	794	5 982
Brazil	143	0	119	0	834	
Argentina	28	0	25	0	915	
Chile	9	0	7	0	792	
Japan	0	206	0	645		3 129
Hong Kong SAR	0	146	0	195		1 336
Macao SAR	0	7	0	13		1 933

Source: MOA, complied data based on unpublished custom statistics.

3.2 Drivers on the input side

Drivers on the input side include those that have "pushing" effects on poultry sector development.

Technology innovation and application

Of all the factors affecting the input side of poultry production, technology is by far the most important. New breeds with higher productivity, new feeding systems, new raising facilities and new methods of poultry production management have all contributed to the improvement of poultry production efficiency, and have pushed the sector towards intensification.

Feed industry and feed production

The inception and development of the feed processing industry has played a very special and decisive role in shaping the structure of the poultry sector in China. With its virtual inception in the late 1970s, the feed industry has developed from the very ground during recent decades. Industrial feed production soared from a mere 2 million tonnes in 1980 to 103 million tonnes in 2005, including complete feeds, concentrated and premixed feeds (Table 25). The quality and the creditability of industrial feed have also gradually improved. Many poultry producers, including those in the traditional sectors, are no longer reluctant to use processed feed and have become accustomed to it. The robust development of the industrial feed sector has been the decisive factor contributing to the rising prominence of intensive poultry systems.

Geographically, the feed industry is mostly concentrated in the eastern parts of the country, in a pattern reflecting the scale structure of the poultry sector. Large poultry farms are concentrated in the coastal provinces, as discussed in the previous sections. Of the total processed feed produced in 2005, 52 percent came from the eastern zone, 30 percent from the central zone and 18 percent from the western zone. About 50 percent of the feed is produced specially for broilers or layers (MOA, 2006a).

Foreign investment and foreign ventures have played an important role in the development of the Chinese feed industry. By the end of 2005, there were 460 overseas-funded feed companies in China, mostly located in the east coast of the country (MOA, 2006a).

TABLE 25
Processed feed production in China

	Total	Complete	Concentrate	Premix
	million tonnes			
1980	2.0	2.0		
1985	15.0	15.0		
1990	31.9	31.2	0.5	0.2
1995	52.7	48.6	3.5	0.6
2000	74.1	59.1	12.5	2.5
2005	107.0	77.6	24.5	4.7

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

Foreign investment in the Chinese feed industry has made a great contribution to the development of the industry. The foreign companies introduced the concept of animal nutrition, which was completely new in China in the early 1980s. The foreign companies have played a key role as pioneers and catalysts. Following their examples, domestic feed companies have been set up, including many private companies. By the end of 2005, there were 15 519 registered feed mills, of which only 1 114 are owned by the government or collectives. China's feed industry is still dominated by a great number of relatively small companies. In 2005, there were 128 feed companies with a production exceeding 100 000 tonnes, which together accounted for about 16 percent of the total feed production in the country. A consolidation of the sector has been underway for years, with the competition becoming increasingly fierce in recent years.

Price development

Prices of poultry products have undergone some changes over the past decades. Broiler price per kilogram has varied between 9.5 and 12.5 yuan, and that of eggs between 5.5 and 8.6 yuan (Table 26). Three major conclusions can be drawn from Table 26.

First, the price ratio between poultry products and feeds has been rather stable. The price of feed relative to that of broilers (taking the price of broilers to be 1.0) is about 0.12 in the case of maize and 0.20 in the case of chicken feed. Second, the price ratio between broilers and eggs is also very stable – close to 0.6 for most of the last decade. Third, the price ratio between chicken meat and pork has developed in a direction favouring pork. Chicken meat was more expensive than pork in 1996, but had become much cheaper than pork by 2005. The relative price of pork has increased from 0.97 in 1995 to over 1.2 in recent years. This is largely the result of changing feed efficiency. Under the traditional system, feed efficiency in chickens is lower than that in pigs, while under the intensive system, chickens are more efficient converters of feed to meat.

From the view point of production costs, the long-term price trend is more or less neutral for poultry production in China.

Public services

Public services have also played a very important role in the changing landscape of the poultry sector in China. The most important are technical innovation, technical extension, animal disease prevention and control measures, quality standards and information, marketing information, and other facilitating measures. Although the precise figures are not available, the public financial inputs for these services have probably increased by a large margin. Not only does the central government provide financial inputs, but the provincial, prefecture and county governments also make large contributions to the public service system for the poultry sector. The central government budget for agricultural support and services has almost quadrupled in the past decade, from RMB 77 billion yuan in 1995 to RMB 300 billion yuan in 2005.

One particular important area of public service for the poultry sector is AI prevention and control. Since the outbreak and public report of AI cases in early 2005, much public funding has been devoted to research work, production and free distribution of vaccine, monitoring, and compensation for farmers in the epidemic areas.

TABLE 26
Prices of products and feeds in China (1996 to 2005)

	Broiler meat	Pork	Eggs	Maize	Chicken feed
			Yuan/kg		
1996	12.65	12.28	8.60	1.57	2.32
1997	11.91	13.72	7.02	1.25	2.27
1998	11.30	11.52	6.85	1.33	2.25
1999	10.62	9.97	6.22	1.08	2.04
2000	9.97	10.10	5.26	0.96	1.84
2001	9.62	10.66	5.38	1.17	1.88
2002	9.37	10.14	5.57	1.08	1.83
2003	9.27	10.71	5.43	1.14	1.85
2004	10.38	13.76	6.53	1.36	2.14
2005	10.78	13.13	6.69	1.30	2.15
			Price ratio (broiler meat = 1)		
1996	1.00	0.97	0.68	0.12	0.18
1997	1.00	1.15	0.59	0.10	0.19
1998	1.00	1.02	0.61	0.12	0.20
1999	1.00	0.94	0.59	0.10	0.19
2000	1.00	1.01	0.53	0.10	0.18
2001	1.00	1.11	0.56	0.12	0.20
2002	1.00	1.08	0.59	0.12	0.19
2003	1.00	1.15	0.59	0.12	0.20
2004	1.00	1.33	0.63	0.13	0.21
2005	1.00	1.22	0.62	0.12	0.20

Source: MOA, unpublished survey data.

4 FUTURE TRENDS AND POLICY OPTIONS

The direction of the future development of the poultry sector in China will be decided by a number of factors. Generally speaking, all the drivers discussed above will continue to play their role more or less in the same manner and direction as in the past decade.

4.1 Demand will continue to rise

Population will continue to grow and is projected to reach 1.45 billion by 2020. This will be increase of 11 percent compared to 2005. More importantly, the population structure will continue to change as rural–urban migration continues and even speeds up. It is estimated that the urban population will reach 800–900 million, accounting for about 55–60 percent of the total population. The urban share in the total population was 43 percent in 2005. If the newly urbanized population raise their levels of poultry consumption to the average level of current urban households, this structural change alone will result in an additional 11 percent increase in poultry meat consumption and an additional 10 percent increase in egg consumption.

Income for both urban and rural residents is expected to grow at an annual rate above 5 percent. During the 28 years following the introduction of the reform policy in 1978, per capita rural income rose by 5.7 times in real terms, or at an annual growth rate of 7.0 percent. The corresponding figures for urban residents are the same. For the period 1995 to 2005, the average annual growth rate of per capita income was 5.0 percent for rural households and 7.7 percent for urban households. The projected 5 percent increase in incomes for the future seems to be realistic. This will further drive the demand for poultry commodities. Given an annual rise of 5 percent, per capita income will double in the next 15 years.

Consumption of poultry meat has doubled during the past decade. Taking all factors into consideration, it seems reasonable to expect that total poultry meat consumption will at least double in the period 2005 to 2020. Egg consumption will increase by at least 50 percent over the same period. This growth in demand implies that China should produce at least 30 million tonnes of poultry meat and 42 million tonnes of eggs in the year 2020.

4.2 Intensification process will continue

To meet the increased demand, the poultry sector in China will further expand. The growth in production will be achieved mostly within the intensive system. Further intensification of the poultry sector is inevitable.

The intensification process will continue in all three major regions in China. So far, the degree of intensification of the poultry sector in the central and western regions is lower than in the eastern region as shown in Table 27. In the eastern region, 5.2 percent of the broiler farms are large (have an output of over 2 000 birds per year); the corresponding figure in the western region is only 0.3 percent. For egg production, the situation is similar. In the coming years, more large poultry farms will be established in the western and central regions, while the existing large farms in the eastern region will further consolidate and integrate. In the mean time, an increasing number of small and non-commercial farms will

TABLE 27
Share of large operations on the total in 2005

	China	East	Central	West
	Broilers: farms with over 2 000 birds			
Share of broiler farms (%)	1.3	5.2	1.0	0.3
Share of broiler output (%)	75.2	87.8	63.7	48.6
Layers: farms with over 500 birds				
Share of layer farms (%)	1.9	4.7	1.5	0.5
Share of layer inventory (%)	66.2	76.8	57.6	42.3
Share of egg production (%)	69.7	77.9	62.4	52.8

Source: MOA, complied data based on unpublished livestock surveys.

give up their backyard poultry production. It is possible that the number of poultry farms in China will be halved by the year 2020. This trend will be particularly marked for farmers in the eastern region.

4.3 Income and trade implications

The contribution of poultry production as a proportion of total income has declined for most farmers in China. This is particularly the case for the eastern region. As shown in Table 28, only 6 percent of rural households in the eastern region still keep broilers; 10 percent keep layers. A closer look at the individual provinces within the eastern region reveals that for parts of the region only very few rural households still have poultry operations. For example, in the suburbs of Shanghai, Beijing and Tianjin, less than 1 percent of rural households are still engaged in poultry raising.

In other parts of the country, in particular in the western region, farms with poultry operations still account for a relatively high percentage of all farm households. On average, about one-fifth of the farmers in western China have broiler and layer operations (Table 28). Considering that a large number of small farmers in the western provinces of the country are still living at an income level close to poverty line, poultry production should have something to offer them. In fact, in some of the poorest areas, one of the key options to help poverty-stricken farmers is to encourage and assist them to raise poultry. This is a relatively quick and easy approach to increasing cash earnings. For farmers in remote inland areas, the intensification process in the eastern parts of the country does not pose a threat, as the local market is highly isolated by topographical barriers to inter-regional transportation.

The intensification process is favourable for international trade. As indicated in Table 29, the leading poultry exporting provinces are also those with the highest share of large poultry operations. For example, Shandong Province is by far the most important poultry exporting province in China. It accounted for over 40 percent of China's total poultry export in 2005. It also has by far the most intensified poultry production sector in the country; over one quarter of China's large broiler operations (farms with over 2 000 broilers) are located in this province. Other examples are Guangdong Province and Liaoning Province, both of which have relatively large shares of the poultry export and of large-scale broiler operations.

TABLE 28
Rural income and farmers' households with poultry production 2005, by region

	East	Central	West	China
Income (yuan/per capita)	5 123	3 029	2 356	3 255
Households with broilers (%)	6	17	21	14
Households with layers (%)	10	20	20	16

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China 2006; MOA, complied data based on unpublished livestock surveys.

TABLE 29
Poultry export and intensification of production, 2005

Province	Poultry export	Broiler output from large operations
	% of total for China	
Shandong	41.6	25.9
Guangdong	16.0	9.8
Liaoning	9.7	9.8
Jilin	5.2	6.6
Hebei	5.0	4.6
Henan	3.0	6.7
Jiangsu	2.9	5.3
Heilongjiang	2.8	2.4
Subtotal	86.3	71.0

Source: MOA, complied data based on unpublished custom statistics.

China is competitive in the export of poultry commodities, in particular processed poultry products as a result of its cheap skilled labour forces. However, importing countries are imposing ever higher product standards, in particular sanitary standards; these standards can only be met by intensive production systems. Integrated operations, in particular, are well positioned to implement strict and reliable quality control, including proper management of animal disease prevention and eradication. The further intensification of the poultry sector will enable China to have a more favourable position in the world poultry trade. China will continue to import some poultry cuts and parts, such as wings and offal, which are very little valued in Western countries but are highly valued in China.

4.4 Rising feed prices will be a major constraint

One of the most potentially unfavourable factors for the future development of the poultry sector in China is the supply and price of feed, in particular of maize and soybean.

As shown in Table 30, production of maize in China has been steadily growing in the past decade, and reached a historic record of 145.5 million tonnes in 2006. In total, maize production grew by 30 percent between 1995 and 2006. About two-thirds of this production growth was achieved by expansion of the cropping area and one-third by yield improvement. Looking to the future, the potential to further expand the maize cropping area is very limited; the main hope for increasing production is yield improvement, which can only be achieved slowly and gradually.

Demand for maize has been increasing very rapidly in recent years, not only in the expanding livestock sector, but also in other sectors – mostly from the ethanol and other chemical-producing sectors. Rising world petroleum prices have made maize increasingly attractive as a raw material for energy and chemical production. In five whole provinces and in some counties of other provinces in central China, gasoline with 10 percent ethanol content has been available in recent years. Industries using maize as a raw material have

been expanding their capacities, and can consume millions of tonnes of maize a year. One indication of increased domestic demand is that maize export from China has been declining steadily in recent years. An even clearer signal of the demand pressure is that the price of maize reached a historic high in the first half of 2007. For the first time in China's history, the price of maize exceeded the price of wheat in May 2007. Pressure on the price of maize will probably continue in the coming years.

Another important factor is the supply and price of soybean. Domestic soybean production in China has practically stagnated in recent years, in spite of all the attention given to the sector by the central government and by local governments in major producing provinces. As soybean is a low-yield crop, it is not competitive with maize and paddy rice in many production areas. As a result, the soybean sown areas cannot expand, and have in fact shrunk. As domestic production cannot meet demand, China's import of soybean has risen very rapidly. The amount of soybean imported to China has continuously broken historic records, and reached 28.3 million tonnes in 2006. China's import accounts for about 40 percent of the world's total export of soybean and by far exceeds domestic production. In 2006, 65 percent of the soybean consumed in China was imported. The trend seems set to continue into the future.

Trends in the supply and prices of feed are likely have both unfavourable and favourable impacts on the further development of the poultry sector in China. On the unfavourable side, slower growth in the production of maize and soybean, and the resulting price rises, will certainly impose pressure on production costs, increasing the need for efficiency and improved management in poultry operations. On the other hand, the poultry sector will benefit from its advantage in terms of feed conversion efficiency compared to other

TABLE 30
Production, trade and prices of maize and soybean in China

	Maize production	Soybean production	Maize export	Soybean import	Maize price	Soybean price
	million tonnes				Yuan/tonne	
1995	112.0	13.5	0.1	0.3	1 577	2 660
1996	127.5	13.2	0.2	1.1	1 482	3 208
1997	104.3	14.7	6.7	2.9	1 151	3 414
1998	133.0	15.2	4.7	3.2	1 269	3 074
1999	128.1	14.3	4.3	4.3	1 093	2 598
2000	106.0	15.4	10.5	10.4	888	2 485
2001	114.1	15.4	6.0	13.9	1 060	2 406
2002	121.3	16.5	11.7	11.3	1 033	2 418
2003	115.8	15.4	16.4	20.7	1 088	2 856
2004	130.3	17.4	2.3	20.2	1 288	3 683
2005	139.4	17.7	8.6	26.6	1 229	3 352
2006	145.5	15.3	3.1	28.3	1 431	

Source: MOA, complied data based on unpublished custom statistics.

livestock products including pork. Poultry meat and eggs will become more competitive in the consumer market relative to pork. Furthermore, rising feed costs will favour the intensification process, further enhancing the competitive edge of large-scale operations over small producers.

4.5 Avian influenza and other disease will be crucial

The shadow of AI is long on the poultry sector in China, and as such constitutes another crucial factor with far-reaching implications for the future development of the sector. During the period between February 2005 and May 2007, 18 of the 31 provinces in mainland China reported cases of AI. The first human case of H5N1 AI virus surfaced in November 2003. A man died in Beijing, and was initially thought to be a victim of severe acute respiratory system (SARS); later laboratory tests showed that it was in fact a case of AI. So far, China has reported 25 human AI cases with 16 deaths (Tao, 2007).

China has made great efforts in fighting AI. Effective vaccine has been developed, produced and provided free to poultry producers nationwide. Responses to the occurrence of the disease have been greatly improved. Strict measures have been taken to control the affected areas and compensation has been made available for farmers who have suffered losses. These efforts have achieved effective results – the number of reported cases has declined significantly since the second half of 2006. However, AI will remain one of the major challenges to China's poultry sector. The most important reason is that it is not possible to isolate the poultry flocks raised in millions of backyards from contact with migratory birds. Due to the high density of human and poultry populations and the high levels of bird migration in the eastern and central parts of the country, it is a daunting challenge to prevent and control the disease in these regions. This may be another factor favouring the intensification of the poultry sector in the eastern and central regions of China.

4.6 Policy options to promote poultry sector development and to assist farmers to adjust

The goals of agricultural policy in China have changed significantly over time. Currently, the predominant and long-term objectives of agricultural policy in China are to ensure food security for the huge population, to improve food safety and quality, to improve farmers' incomes, and to protect natural resources and the environment for sustainable agricultural and rural development. Foreign-exchange earning from agricultural products used to be an important goal, but has now almost completely lost importance in agricultural discussions given dramatic growth in the total export volume, sharp decline in the share of agricultural exports in the total, consecutive years of trade surpluses and large foreign currency reserves. Even the large agricultural trade deficits that have prevailed in recent years have not caused any noticeable concerns to Chinese policy-makers. Price stability for livestock products, another important policy goal in the past, is now given less attention. A certain degree of price movement is considered to be normal under a market system. Only when prices are abnormally high or low do policy-makers pay some attention.

Given the above-described overall agricultural policy objectives, the most significant goals for policy-makers with respect to the development strategy of the poultry sector in China can be grouped into three categories: to provide sufficient and safe poultry products

to the consumers; to provide income and employment opportunities for farmers; and to protect the environment and promote sustainable economic development.

Food security has long been and still is the top priority in China's agricultural policy-making. Facing ever increasing demand as a result of expanding population, rising income and rapid industrial development on the one hand, and declining arable farmland, scarce irrigation water and worsening environmental and ecological conditions on the other, ensuring food security for the country is a daunting challenge. Grain production is the focus of attention in debates over food security. The pressure of rising demand for grains is mainly driven by the feed needs of the livestock sector. In this regard, the development of the poultry sector should play an important role, given its efficient feed:animal protein conversion ratio. The quality of agricultural products, in particular food-safety issues, has gained increasing attention from both the government and the general public. Feed additives and animal diseases have become major targets of policy measures. The outbreaks of SARS and AI have greatly increased the awareness of policy-makers with regard to animal disease prevention and control.

The issue of farmers' incomes has received increased attention from policy-makers and the general public in China, especially since the early 1990s. This has happened against the background of a rural–urban income gap that has continuously widened over the past two decades. In 2006, the national average per capita income of the rural population was only one-third that of the urban population. The need to put more effort into improving farmers' incomes is not just an economic issue, but has become a social and political issue. The state of farmers' incomes has direct consequences for rural–urban migration, the market for urban manufactured products, and social stability. Livestock production is a potential means to increase farmers' incomes, as there is much scope for expanding demand in this sector. Farmers can improve their income by enlarging the scale of their own livestock operations, but also by working for other large livestock operations. In a county of Fujian Province, the wages paid by a large integrated boiler enterprise to its workers are equivalent to 10 percent of the total income of all rural households in the county. As the intensification process unfolds, more work opportunities are created as a result of the growing market and production volume.

Awareness of the need to protect the environment has become a new element in agricultural policy-making in China. Emphasis is laid on the sustainability of natural resources and preventing environmental pollution. In the livestock sector, pollution of surface water, groundwater and soil by the waste products of pig raising has been widely recognized as a problem; the problems associated with poultry operations are believed to be much less. Efforts by some large integrated poultry enterprises to use birds' waste to produce value-added organic fertilizer, or even to generate electricity, are encouraged and supported by the government.

To promote healthy development of the poultry sector in the future in China, the following policy action areas need to be addressed:

- **Disease prevention and control measures.** This should be the top priority for government intervention in poultry-sector development. While the threat from animal disease, in particular high risk epidemics such as AI, has gained much attention in the past few years, there is a tendency for this attention to fade over time.

The general public is now very calm when faced with reports of AI cases in birds or humans. Reports of new cases no longer seem to have any effect on demand for, and consumption of, poultry products. While the reaction of the general public has become calm and reasonable, the government should not weaken efforts in the field of epidemic prevention and control. The potential danger of AI should not be underestimated. Monitoring, prevention, eradication and compensation measures should be further implemented and enhanced. The weakness in monitoring and identifying cases in the vast small-scale sector should be addressed through more intensive government support.

- **Land policy related to the establishment of new poultry farms.** China has been applying a very strict control policy with respect to changes to the use of farmland. According to the existing regulations, land in China is classified into three categories: farmland, construction land and unused land. Cropland belongs to the farmland category, and 80 percent of arable land is classified as "basic farmland". Changing land use from crop production to other purposes is very strictly controlled and must be approved by the State Council. The land used for livestock operations is not very clearly classified. According to China's Law of Land Administration, any land with buildings on it is classified as construction land. Therefore, in practice, if farmers want to build large and roofed poultry pens on cropland, they usually have to apply for permission. If the cropland is classified as "basic farmland", it is in principle impossible to obtain approval, and it is usually a lengthy and complicated process even if the cropland is not classified as "basic farmland". Policy adjustments should be made to treat the establishment of livestock farms and the associated construction differently from industrial construction. Establishment of livestock production on unused land, which is usually wasteland, should be encouraged with favourable approval procedures and support measures.
- **Investment policy and loan provision.** The establishment of new poultry operations and the enlargement of existing ones should be encouraged through preferential investment policy. Assistance with credit is needed for both large establishments and very small holdings. For smallholders, especially for the poverty-stricken farmers in the mountainous western region, the micro-credit system should be expanded and made available to as many poor farmers as possible. Governments should also adopt supportive measures to enable large private investment in the poultry sector in order to allow the necessary commercial loans to be obtained. Linked to appropriate environmental requirements, governments may provide credit guarantees to such investment.
- **Policy favouring the use of animal waste.** For those enterprises that comply with environmental standards, subsidies or taxation exemption can be made for investments in the utilization of livestock waste to produce fertilizer or energy. Such sideline activities of large livestock farms can reduce environmental pressures from livestock production and processing, and at the same time generate useful resources for other sectors.
- **Research and extension.** China has accomplished world class achievements in some areas of agricultural research, such as in hybrid and super-rice breeding. However,

in the field of livestock, China has been much less successful. One major reason is that much more attention and investment have been devoted to crop research than to livestock research. The agricultural extension system is also rather weak in China. As the educational level of Chinese farmers is still low, at about seven years on the national average, and most of Chinese farmers are small farmers or holders, it is imperative for China to have a public extension system that has wide coverage. There are a number of weaknesses in the existing system, including under-qualified staffing and insufficient funding. The system needs to be reformed and enhanced.

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Structural changes in Thailand's poultry sector and its social implications

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SUMMARY

Over the past two decades, the poultry sector in Thailand has undergone considerable structural change – moving towards greater industrialization and increased vertical integration. Up until 2004, the main driver was technology, especially the introduction of evaporative-cooling housing which can save labour costs and substantially increase poultry's growth and survival rates. One engine of the fast growth of the industry was contract farming – an arrangement which gives large integrators more flexibility in adjusting their volume of production to changes in both domestic and export demand, and which provides the contractors with contracts that are relatively lower risk and provide better returns than most of conventional agricultural activities.

During the last half decade, however, Thailand's poultry industry has been moving away from contract farming and towards vertical integration in order to ensure compliance with European importers' more stringent requirements for food safety and animal welfare. The most significant and decisive driver, however, has been highly pathogenic avian influenza (HPAI), outbreaks of which have resulted in frozen broiler meat from Thailand being banned by most importers since 2004. The ban affected Thailand's broiler export substantially in the first few years. However, most of the large companies have been able to switch their production towards precooked products.

In order to assess structural changes in the wake of HPAI outbreaks, a sample of poultry farmers first surveyed in 2002/2003 was re-surveyed. The results indicate that the great majority of these farmers have managed to stay in the poultry business. However, many contractors are only contracted on a rotating basis as a result of the decreased demand for broilers. Some are offered a duck contract, which is generally less lucrative than were typical broiler contracts in the past.

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Even before the HPAI outbreak, the future of smallholders in the poultry sector looked bleak. After the outbreak they have been forced by the Thai government to upgrade their housing to a closed system, which requires substantial additional investment. Because of many stringent HPAI-combating regulations, some of their prior advantages – such as getting higher prices for chicken manure or using it to feed the fish stock in ponds beneath the chicken houses – no longer exist. While the industry may have found a way to cope with the HPAI via biosecurity and compartmentalization, many smallholders appear to be left out and continue quietly to make their exits from poultry production.

Key words: poultry, sector, Thailand, structure

1 INTRODUCTION

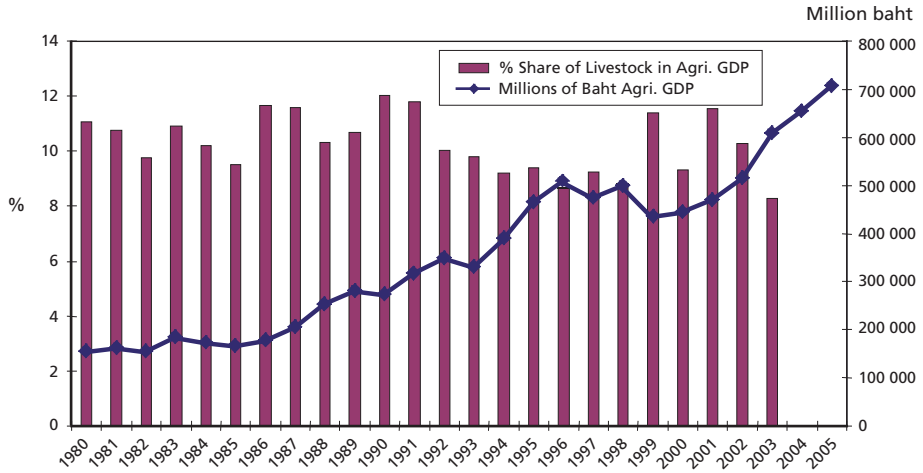
This paper describes the past and present status of the poultry industry in Thailand and the drivers of change in the sector. It then focuses on structural changes in Thailand's poultry sector – mainly resulting from the highly pathogenic avian influenza (HPAI) outbreaks in 2004 and after. The subsequent section considers the future of Thailand's poultry industry. The last section deals with the social implications of these structural changes – especially the impacts on smallholders.

2 THE IMPORTANCE OF THE POULTRY SECTOR IN THE NATIONAL LIVESTOCK SECTOR

Livestock accounts for about 10 percent of agricultural gross domestic product (GDP) in Thailand (Figure 1). The value added by the poultry sector contributes about 3–4 percent of agricultural GDP and more than 40 percent of livestock GDP (Figure 2).

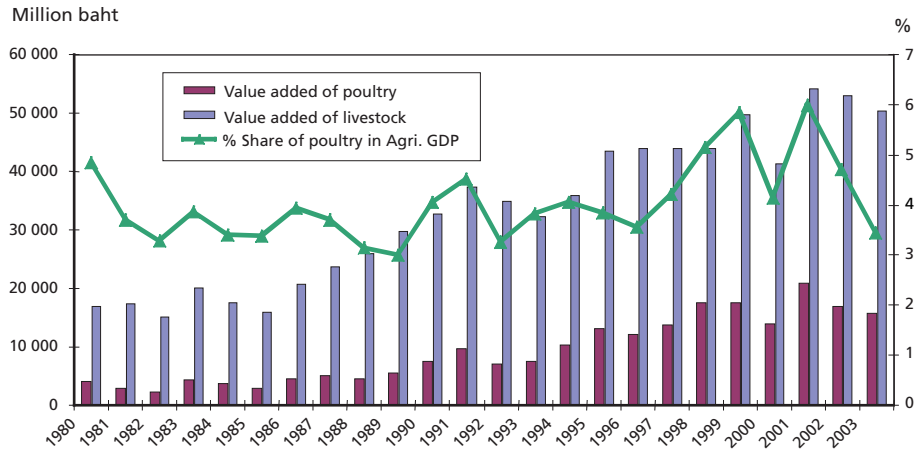
Thailand's poultry meat production in 2005 was estimated to be 950 000 tonnes or

FIGURE 1
Thailand's agricultural GDP and share of livestock in agricultural GDP



Source: National Economic and Social Development Board (NESDB) National Income of Thailand; various years.

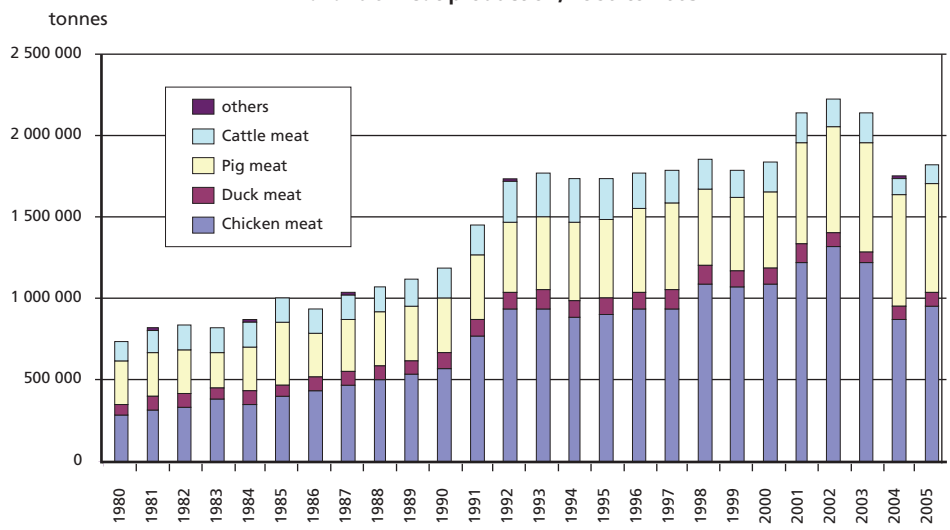
FIGURE 2
Value added by poultry and the livestock sector as a whole, and poultry's share in agricultural GDP



Source: NESDB, National Income of Thailand; various years.

approximately 52 percent of total meat production. Poultry meat ranks first among the major meat types, followed by pork (37 percent) and beef (6 percent) (Figure 3). As indicated in Table 1, during the past two decades the total production of poultry meat has increased at an annual rate of 5–6 percent, the highest growth rate of all livestock prod-

FIGURE 3
Thailand's meat production, 1980 to 2005



Source: FAOSTAT.

TABLE 1
Thailand meat production: annual growth rates

Years	Chicken (%)	Duck (%)	Pig (%)	Cattle (%)
1980–1990	6.69	2.54	3.00	2.70
1990–2000	4.59	1.03	2.52	-2.22
2000–2005	-5.07	-5.24	5.85	-9.28

Source: calculated from FAO data.

ucts. The growth rate fell only in the past few years, mainly because of the impact of HPAI from 2004 onwards.

3 STRUCTURAL CHANGES IN THE POULTRY SECTOR OVER THE PAST DECADE

Although there are a several types of poultry raised and consumed in Thailand, chicken is the most important. There are three main types of chicken in Thailand: broilers, layers and native chickens. From an economic perspective, broiler meat is the most important poultry product, both for domestic consumption and export. As in most countries, egg production from layers is mainly for domestic consumption.[2] Native chickens have been raised for several purposes; they include backyard chickens raised mainly for household consumption and small-scale trade; farm raised birds for sale in specialty markets; and, to a lesser extent, chickens raised for recreation or "sporting" purposes, including fighting cocks. This paper focuses only on broiler and layer farming, which accounts for most of the poultry production in Thailand.

About half of the country's chickens are raised in central Thailand – a relatively small but highly populated region; second in terms of poultry production is the northeastern region, which is physically the largest region of Thailand. Most of the exported chicken comes from farms in the central region.

The number of chickens in Thailand increased substantially between 1992 and 2003 (from 135 to 253 million birds). It then dropped to 180 million in 2004 following the outbreak of HPAI. The chicken stock recovered to 254 million birds in 2005 (Table 2a) but fell again to 184 million birds in 2006 (Table 2a). Total production fell drastically in 2004 and has not yet returned to the pre-HPAI levels (Table 2b).

3.1 Increasing scales of production

The poultry sector in Thailand has undergone considerable structural change in terms of the number and size of holdings over the past two decades. The underlying reason is "economy of scale" – average production cost declines with an expanding scale of production. As a result, the number of producers diminishes even though the sector as a whole may expand. The average size of commercial farms has also been increasing while the

[2] Only when they are in surplus, is a small volume (usually no more than 1–1.5 percent of the eggs produced) exported often below cost, in order to stabilize the domestic price. However, in recent years, there has been a (perhaps temporary) surge in export demand for eggs, primarily from Hong Kong SAR after they detected residuals of illegal red-pigment in Chinese eggs.

TABLE 2a
Chicken population in Thailand (number of birds)

Year	Central	Northeastern	Northern	Southern	Total
1992	82 342 344	26 335 705	15 279 767	11 217 760	135 175 576
1993	83 246 791	25 916 449	19 299 493	10 369 294	138 832 027
1994	72 163 615	24 348 503	21 603 271	11 881 709	129 997 098
1995	62 589 266	24 446 914	15 039 270	9 575 060	111 648 510
1996	69 963 645	37 506 727	23 028 677	14 080 379	144 579 428
1997	79 928 557	42 104 802	24 457 990	18 194 493	164 685 842
1998	77 224 601	38 176 754	23 841 418	16 081 873	155 324 646
1999	78 067 555	47 210 939	27 327 803	17 026 210	169 632 507
2000	98 968 145	44 958 278	27 906 485	17 508 202	189 341 110
2001	111 819 685	54 106 254	30 829 909	18 223 233	214 979 081
2002	127 411 495	56 429 660	28 677 030	16 242 141	228 760 326
2003	153 275 177	51 686 324	32 798 811	14 958 571	252 718 883
2004	89 684 664	49 542 774	28 070 941	12 440 431	179 738 810
2005	135 513 828	62 516 470	38 723 520	17 450 250	254 204 068
2006	90 689 632	59 322 572	23 776 769	10 537 779	184 326 752

Note: figures are for stock on 1 January each year.
Source: Department of Livestock Development.

TABLE 2b
Total broiler production in Thailand (number of birds)

Year	Central Plain	Northern	Northeastern	Southern	Whole country
1995	484 865 421	60 825 080	104 896 077	49 289 349	699 875 927
1996	540 673 299	54 914 702	62 988 977	59 579 799	663 242 075
1997	543 784 870	58 566 142	65 214 205	59 417 792	726 983 009
1998	614 456 148	61 676 927	76 743 327	66 898 521	819 774 923
1999	640 157 348	63 555 931	80 534 944	69 316 043	853 564 266
2000	674 289 629	64 090 285	83 115 970	69 469 091	890 964 975
2001	715 871 830	77 594 194	137 717 119	72 606 563	1 003 789 706
2002	765 954 216	79 633 916	126 315 140	70 870 879	1 042 774 151
2003	824 261 179	81 696 723	138 345 589	72 771 552	1 117 075 043
2004	492 723 422	50 834 395	87 371 052	63 430 263	694 359 132
2005	581 458 924	64 404 895	103 904 377	67 470 907	817 239 103
2006	608 406 705	67 007 326	108 575 719	65 891 723	849 881 473

Source: Department of Livestock Development (DLD) and Office of Agricultural Economics (OAE).

numbers of producers is declining. As shown in Table 3, the number of poultry farm holdings decreased by 60.7 percent between 1993 and 2003. However, the number of large farms (those that raise 10 000 birds or more) almost doubled. The number of chickens kept in farms in this category increased from 60 to 158 million birds – approximately 163 percent. The total number of chickens increased from 109 million birds in 1993 to 217 million birds in 2003.

TABLE 3
Number of holdings and chickens in 1993 and 2003

		1993		
Size of holding (number of chickens per holding)	**Number of holdings**	**Number of chickens**		
		Total	**Layers**	**Broilers**
1–19	1 681 300	373 541	145 222	228 319
20–99	863 809	863 267	368 816	494 451
100–499	53 064	1 798 003	860 693	937 310
500–999	3 861	1 693 940	768 119	925 821
1 000–9 999	13 042	45 028 706	7 343 599	37 685 107
10 000 and over	2 336	59 627 761	14 165 823	45 461 938
Total	2 617 412	109 385 218	23 652 272	85 732 946
		2003		
Size of holding (number of chickens per holding)	**Number of holdings**	**Number of chickens**		
		Total	**Layers**	**Broilers**
1–19	361 600	238 960	66 672	172 288
20–99	580 543	1 190 547	345 646	844 901
100–499	65 943	1 082 718	509 528	573 190
500–999	1 851	713 038	417 733	295 305
1 000–9 999	14 224	56 210 545	11 183 272	45 027 273
10 000 and over	4 028	158 039 328	29 337 908	128 701 420
Total	1 028 189	217 475 136	41 860 759	175 614 377
% change between 1993 and 2003	**Number of holdings**	**Number of chickens**		
		Total	**Layers**	**Broilers**
1–19	-78.5	-36.0	-54.1	-24.5
20–99	-32.8	37.9	-6.3	70.9
100–499	24.3	-39.8	-40.8	-38.8
500–999	-52.1	-57.9	-45.6	-68.1
1 000–9 999	9.1	24.8	52.3	19.5
10 000 and over	72.4	165.0	107.1	183.1
Total	-60.7	98.8	77.0	104.8

Sources: National Statistic Office. Agricultural Census 1993 and 2003.

Up until 2004, economy of scale associated with industrialization was often considered to be the primary factor driving structural change. However, economies of scale/scope are not the only drivers. The major producers (such as CP Corp.) have also adopted advanced technologies. Although smaller farms can take advantage of new technologies via contract farming or by adapting their housing technology and buying inputs that embody technological developments, the export ban imposed in the wake of the HPAI epidemic of 2004 and four further outbreaks in the past few years has drastically impeded their competitiveness.

As a result of technological changes, the broiler raising period has been substantially shortened – to around 40 days. Although this means that broiler chickens sold today are of much smaller size than in the past, the feed conversion ratio has improved substantially to around 1.75:1 or even lower.

One major aspect of broiler raising that has changed markedly during the 1990s is housing. The evaporative cooling house (or "evap house" for short) – a closed semi-automatic housing system which uses large fans and water to cool houses holding more than 10 000 chickens to 28 °C or less during the hot season in tropical countries such as Thailand – has contributed to the industry's cost savings. The evaporative cooling house can save labour and housing costs. More importantly, it increases growth and survival rates substantially.[3]

In the past, broiler development in Thailand was largely undertaken by the private sector, with little intervention or assistance from the Thai government.[4] However, as a result of the increasing importance of international trade in livestock – especially poultry – the Department of Livestock Development (DLD), in 1999, issued farm standards and various regulations on animal welfare to ensure compliance with the European Union's (EU) regulations and requirements. After the onset of the HPAI outbreak, the government has added measures which, in practical terms, require that all broiler farms producing birds for export are transformed into closed farms (i.e. use evaporative cooling houses). As such a transformation is quite capital intensive, the government actions, arguably, favour large-scale modernized farms.

3.2 From contract farming to vertical integration

Even after the onset of poultry industrialization, which resulted in large companies raising more chickens in their own large-scale farms, broiler production during the past two decades (up until the HPAI epidemic of 2004) relied heavily on contract farming. This system usually involves a contract in which a large (usually also vertically integrated) company provides several contractors (contracted farms) with day-old chicks and inputs (such as

[3] The "evap houses" commonly used in Thai broiler industry are modified from those used in the United States of America. However, while the Thai "evap houses" are similar to the close-system houses in the United States of America, the main purpose of keeping the house closed is to keep the inside temperature cooler than the outside atmosphere. Initially, most evap houses in Thailand did not use full automation like those in the United States of America, partly because the labour cost in Thailand is much cheaper than in the United States of America. However, most large companies now employ full automation in order to minimize the risk of disease spread by "unnecessary" human contact.

[4] Most farmers', processors', and exporters´ organizations have been founded and almost fully funded by the companies themselves (many also have offices in the companies' buildings), partly to protect their own interests (e.g. to obtain import quota of soybean and to receive government assistance).

feeds, medicines and some other supplies) at stipulated prices, and agrees to buy the raised chickens (or eggs) usually at the guaranteed prices. Contractors, for their part, provide housing, bedding, equipment, utilities and labour, based on the company's specifications, to raise the day-old-chicks to specified weights.

One of the main reasons that companies used contract farming was that the contract gave them more flexibility in adjusting the volume of production, which sometimes needs to be varied greatly in response to seasonal and irregular changes in domestic and export demand. In such cases, the investment and adjustment costs (including the cost of having idle capacity) were borne substantially by the contractors. Nonetheless, the contractors usually agreed to this type of contract not only because they could take advantage of the embodied technology, but also because, in normal circumstances, the contracts are less risky, and provide better returns, than most other agricultural activities.

During the past decade, however, Thailand's poultry industry has been moving towards vertical integration. The main reason is to meet the ever increasing requirements, especially in the export sector, for food safety and animal welfare. About five years ago, some EU importers detected nitrofurans (a banned group of antibiotics) and dioxin in some lots of broilers imported from Thailand. Some major exporters responded to the problem by switching most of their production to in-house production so that they would have better control over all the inputs used. Animal welfare requirements imposed by most EU importers also drive such changes. The most significant driver, however, was the HPAI outbreak in 2004 along with the four subsequent outbreaks.

Since the first HPAI outbreak, most importing countries have banned frozen broiler meat from Thailand. Such bans were initially of fixed duration (e.g. subject to review after six months). However, as there have been several recurrent outbreaks, the bans have never been lifted and are expected to remain in place for the next few years. Nonetheless, the large companies that have transformed themselves through vertical integration have continued to produce for export, targeting the precooked market. By now, only smaller companies rely significantly on contract farming.

Despite increasing risks, structural change from a horizontally integrated production system to a vertically integrated industry can promote some types of production efficiency. Vertical integration provides economies of scope, ensures reliability of supply, and facilitates quality management and homogeneity of products. Vertical coordination provides an opportunity to keep control of operating and transaction costs while meeting high standards of food safety.

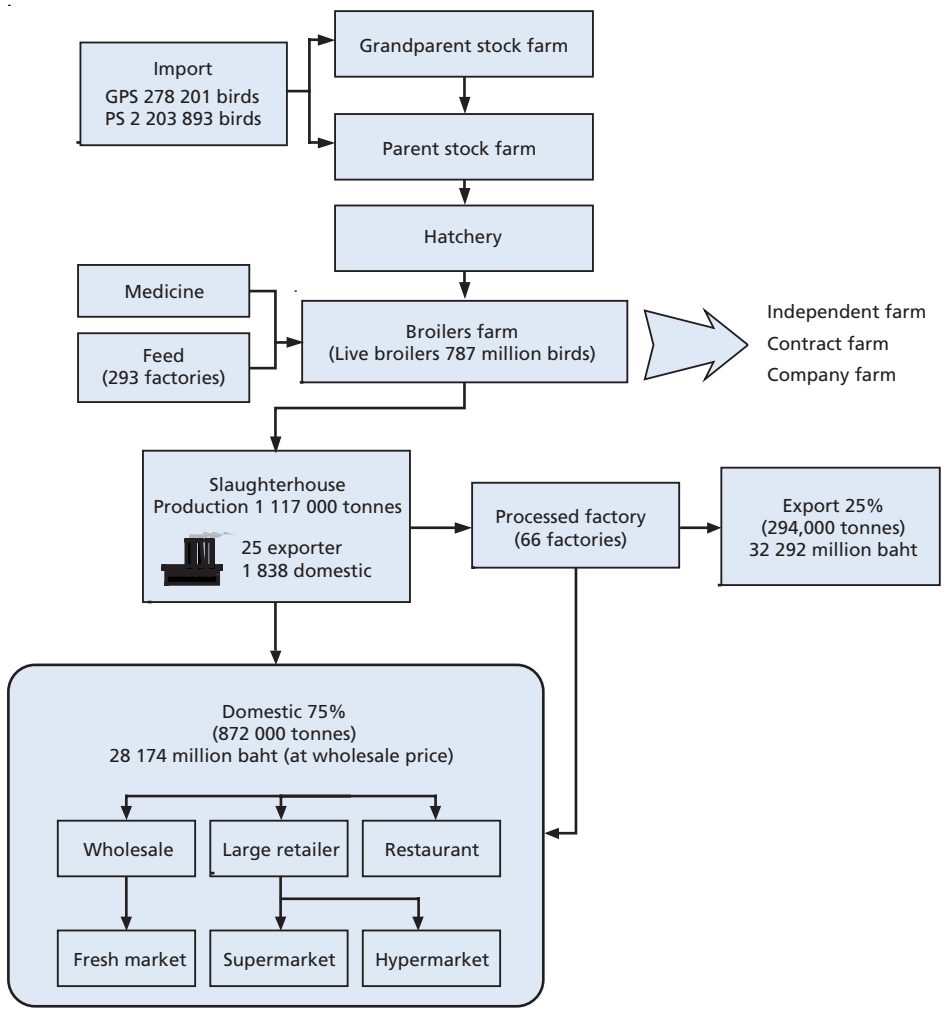
There has been a belief that vertical integration is motivated by tax incentives, especially when value added tax (VAT) is applied – partly because the integrators produce their own inputs and thus do not have to pay VAT on them. This belief is not true, at least in Thailand where VAT is not really collected on the basis of "value added," but as a sales tax accompanied by a tax credit for purchased inputs. In addition, agricultural produce[5] and many inputs (including grains, fishmeal, fertilizer, herbicide and insecticide) are VAT exempted.

[5] Except for processed, canned, and other tight-contained agricultural products. The integrators are also more likely to sell these processed or semi-processed products which are subject to full-value tax at the point of sale (and can claim very little tax credit as most of their "inputs" are raw agricultural produce which are "VAT exempted").

The reverse argument – that the integrators can obtain tax credit on other purchased inputs (such as diesel/gasoline and stationery) but small informal farms that are exempted from, or choose to not participate in, the VAT system cannot do the same – is not very relevant either. This is because those small farms (or firms) do not have to charge (and pay) VAT on their sales, and usually they pay relatively little corporate tax anyway.

At present, broiler production is located primarily in the central region of Thailand, close to the hatcheries, feed mills, and processing plants. At the top of the chain map in Figure 4, most chickens originate from parent and grandparent stock imported from the United

FIGURE 4A
Value chain map – broilers 2005

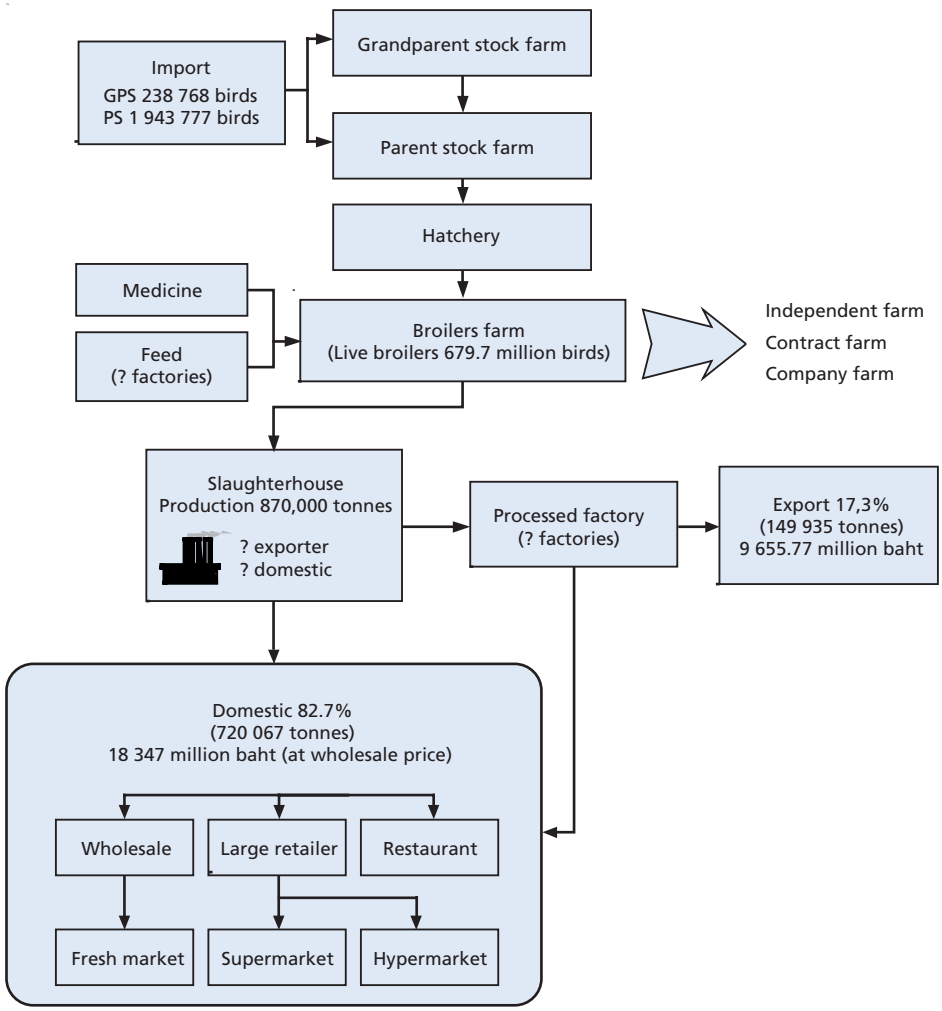


GPS = Grandparent stock, PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

States of America and the United Kingdom. Most integrators have their own hatchery – which also supplies day-old-chicks to their contractors and the independent market. Feed mills have become a part of major integrated poultry companies. Owning a feed mill is an essential part of the production flow (and cost). Some large companies also have their own animal pharmaceutical department. Having their own feed mill and pharmaceutical department can help to enhance the traceability of their inputs.

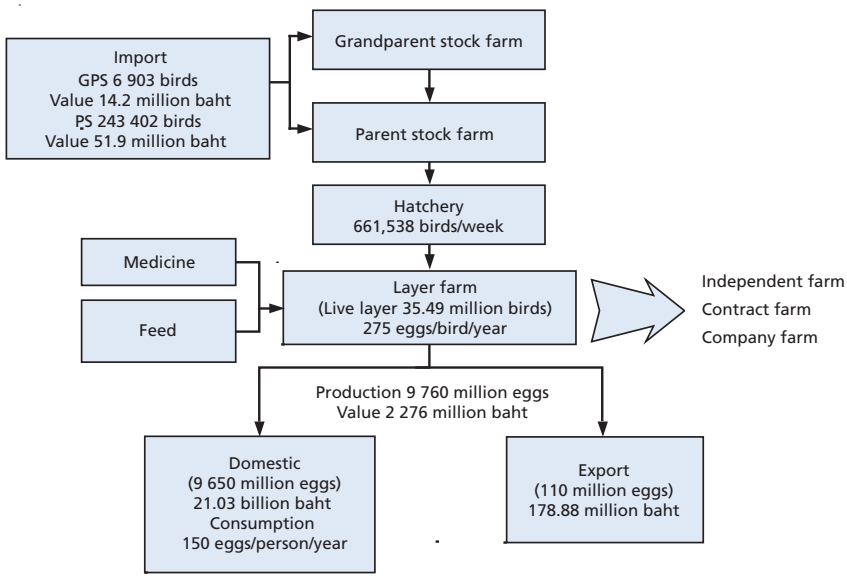
Besides in-house production on the company's farms, many integrators also rely, in part, on contract farming – although its role has lessened in the past decade, especially after the

FIGURE 4B
Value chain map – broilers 1995



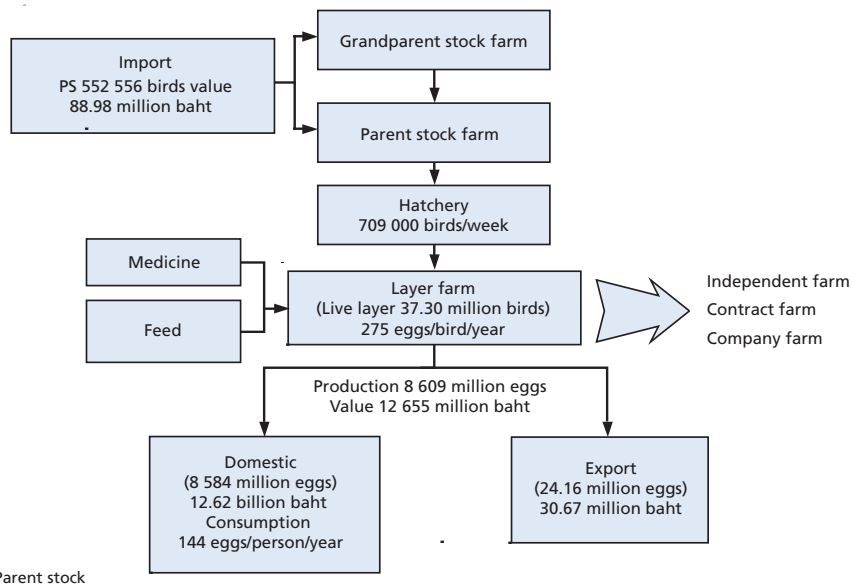
GPS = Grandparent stock, PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

FIGURE 4C
Value chain maps – layers 2005



GPS = Grandparent stock, PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

FIGURE 4D
Value chain map – layers 1995



PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

HPAI outbreak in 2004. Independent broiler farms have also decreased in number during the same period.

Like broiler farms, large integrated layer farms are concentrated mostly in the central region, although layer farms are distributed more evenly across regions. As almost all egg products are sold domestically, the industry was not, in the past, subject to such stringent requirements as the broiler industry. Although the HPAI epidemic has changed this somewhat over the past few years, structural changes are coming much more slowly to the layer industry than to the broiler industry. For example, there have been strong – and apparently quite reliable – rumours that a significant number of layer farms are using the HPAI vaccine, even though the HPAI vaccine has never been approved (in fact it has always been banned) by the Thai government.

3.3 Export

Export has been very significant for the broiler sector. Before the HPAI outbreak in 2004, as much as 40 percent of broiler production was exported annually (37 percent and 39 percent in 2002 and 2003, respectively). As not all chicken parts are exportable, the great majority of broiler chickens were raised for export purposes. The story was very different for eggs, the export of which was negligible (merely 1 to 2 percent of total production) and was mostly undertaken to stabilize the domestic price.

Between 1994 and 2003, the total quantity of broiler export almost tripled (increased by 187 percent, see Table 4). This period also witnessed a significant structural change in export. Prior to 1994, almost all exports were frozen de-boned raw chicken, as Thailand's competitive advantage stemmed from her low wage rates. The export of precooked chicken-meat products began in the early 1990s and accounted for less than 10 percent of the total in 1994. It has been increasing sharply ever since. In 2003, the share of precooked chicken in total export was almost one-third. The growth of precooked-chicken export has been even more dramatic since the HPAI outbreak of 2004. In just three years (from 2003 to 2006) the quantity of precooked chicken exported almost doubled. As Thai raw/frozen broilers are still banned by most importers, precooked chicken accounted for 97 percent of export quantity and about 98 percent of export value in 2006.

Although the structural change in export was accelerated by the HPAI outbreaks (and the possibility that HPAI could return at anytime), such a change had been expected for quite some time. As wages in Thailand are substantially higher than in neighbouring countries, and given that these neighbours include two populous countries, China and Viet Nam, it was clear that once these countries were able to comply with the importers' food-safety and animal-welfare requirements, it would only be a matter of time before Thailand faced keen competition. Therefore, some integrated companies – especially the well-known CP Group – had begun to prepare themselves for such a change for more than a decade. In addition to expanding its production base in China and Viet Nam, its shift of some production lines to precooked products has been part of an overall attempt to move towards higher value-added products in order to overcome the disadvantage of having high production costs (especially high feed prices and labour costs).

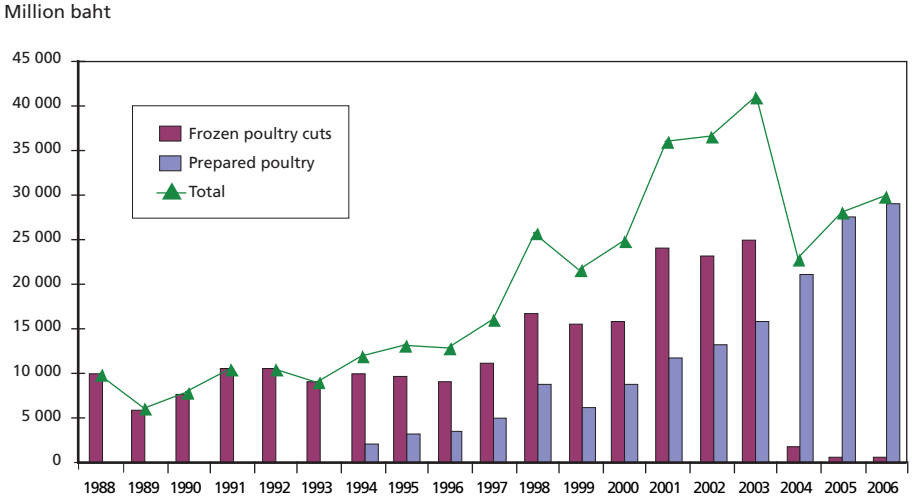
In the past decade or so, factories, processing plants, feed mills and slaughterhouses have developed their operations to meet the standards required by various importing coun-

TABLE 4
Broiler export quantities and prices, 1992 to 2006

Year	Export Quantity (tonnes)		Average export price per tonne (US$)		Price ratio (precooked: frozen)
	Frozen	Precooked	Frozen	Precooked	
1992	174 825		2 351		
1993	157 086		2 244		
1994	153 033	15 996	2 573	4 621	1.80
1995	149 935	22 124	2 598	5 628	2.17
1996	137 176	31 555	2 625	4 236	1.61
1997	150 775	41 114	2 357	3 909	1.66
1998	212 497	60 943	1 906	3 604	1.89
1999	217 720	65 074	1 853	2 403	1.30
2000	240 938	88 575	1 637	2 485	1.52
2001	309 516	116 650	1 745	2 234	1.28
2002	303 966	127 974	1 758	2 396	1.36
2003	331 045	154 464	1 804	2 446	1.36
2004	23 954	193 767	1 854	2 670	1.44
2005	4 534	263 419	3 022	2 592	0.86
2006	8 036	270 345	1 966	2 802	1.43

Source: Ministry of Commerce (the "Menucom" database) except data on precooked chicken export between 1994–1998 which are from NaRanong (in FAO, 1999) (who cited Department of Business Economics, Ministry of Commerce, and Thai Broiler Processing Export Association).

FIGURE 5
Thailand export value of poultry



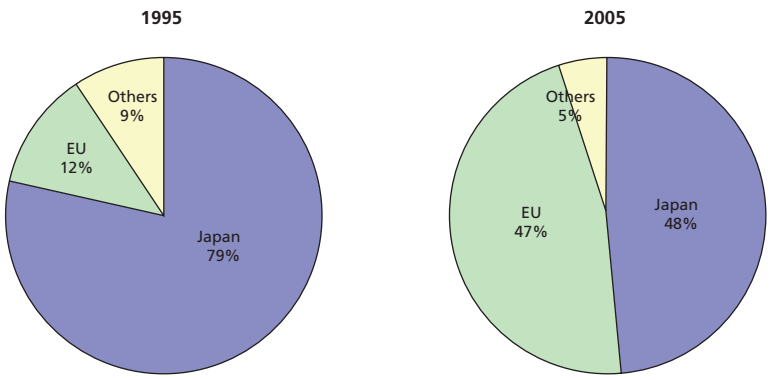
Source: The Ministry of Commerce.

tries. Some exporters have transformed their broiler export from frozen/raw to precooked/prepared products, as they realize that customers will continue to demand inexpensive, high-quality finished products. This also means products that are healthy – free from food-borne pathogens and containing minimal amounts of carcass fat – and that are tender, tasty and palatable to the consumer. Value-added marketing of such products is also an avenue for exporting companies to differentiate their most prized product offerings, while continuing to create processed products that add value and target the changing needs of the consumers, who now usually look for products that can be quickly and easily prepared in 15–30 minutes or less. The sharp growth in precooked products reflects the thinking of the industry's leaders long before the HPAI outbreak; although it was the outbreak that finally forced exporters to change their products in order to survive.

It should be noted that while the prices of precooked chicken products are usually higher than those of raw/frozen products, they are not spectacularly so. At present, the average export price of precooked chicken products is approximately 40 percent above the average export price of raw/frozen broiler, substantially lower than the price premium in the past (e.g. between 1994 and 1998 when the price premiums were as high as 60 to 120 percent, see Table 4). This premium should nonetheless suffice to keep the industry growing and provide a viable escape route in the wake of the HPAI epidemics.

Thailand's major broiler export markets in the past decade were Japan and the EU (Figure 6). In 1995, Japan accounted for 79 percent and the EU accounted for only 12 percent of total broiler meat exports. However, in the past decade Thailand's export to the EU increased substantially, partly because Thailand's export prices were more competitive. In 2005, exports to Japan and the EU accounted for 48 and 47 percent of total broiler meat exports, respectively (see details in Table 5). In the past, Japan usually bought uncooked meat in the form of boneless leg meat, boneless breast meat, and special cut-meat in sticks (Yakitori) and other made-to-order chicken meat products. Now almost all exported meat is in the form of made-to-order products, which are processed or prepared by heat (grilling,

FIGURE 6
Importing countries' shares of Thailand's broiler export



Source: The Ministry of Commerce.

TABLE 5a
Major export markets for frozen poultry (tonnes)

Countries	2001	2002	2003	2004	2005	2006 (p)	Share 2006
				tonnes			
EU	98 686	79 370	98 231	11 027	-	-	-
Germany	49 110	49 110	59 308	5 496	-	-	-
Netherlands	25 632	25 632	21 784	2 978	-	-	-
United Kingdom	20 648	20 648	15 890	1 494	-	-	-
Others							
Japan	162 131	193 919	188 101	9 706	-	-	-
Republic of Korea	26 777	32 945	41 720	2 897	-	-	-
China	12 172	10 642	21 487	603	-	-	-
Malaysia	6 612	8 176	14 082	637	-	-	-
Singapore	8 951	7 308	10 670	576	-	-	-
Hong Kong SAR	4 288	2 967	5 695	234	-	-	-
Others		3 718	8 927	457	96	2 662	100
Total	320 779	339 045	388 913	26 137	96	2 662	100
% change	30.40	5.69	14.71	-93.28	99.63	2 673	

Note: p = preliminary.
Source: Department of Customs.

steaming, boiling, etc.). Some of these products are breaded or seasoned (with salt, Japanese sauce, etc.). The EU used to import Thailand's broiler meat in the form of uncooked skinless boneless breast meat, but also switched to semi-cooked and cooked meat in made-to-order styles in the wake of HPAI outbreaks.

While Thailand is a major broiler exporter where export has been carried out without any price support or export subsidy programmes, the broiler industry is still protected by substantial import tariffs (30 percent for chilled or frozen uncooked meat and 40 percent for cooked chicken meat in 2006). This is partly because Thailand's comparative advantage has always been in processing rather than in broiler production. Without such a protection measure, it would be possible for some countries (e.g. the United States of America) to export low-value chicken parts – especially the wings and leg-quarters – to Thailand. The industry's justification for the import protection has been that export prices of wings and legs from the United States of America could be so low as to be equivalent to dumping. Moreover, as much of Thai broiler meat export consists of white breast meat for the EU market, there is potential for Thailand to have surplus of wings and legs, especially if export soars again. To date, the Thai government and the industry have tried to avoid this issue when negotiating with the United States of America.

TABLE 5b
Major export markets for prepared poultry

Countries	2001	2002	2003	2004	2005	2006 (p)	Share 2006
				tonnes			
EU	49 840	49 840	61 628	76 050	113 096	127 601	43.74
United Kingdom	20 713	28 723	32 132	42 222	69 707	82 883	28.41
Netherlands	24 450	14 956	17 676	19 093	23 818	23 680	8.12
Germany	3 908	2 995	5 862	8 915	9 751	10 806	3.70
Belgium	400	1 331	876	666	1 415	1 175	0.40
France	224	1 424	2 076	604	587	266	0.09
Others							
Japan	52 489	66 162	84 066	102 610	149 079	148 559	50.92
Singapore	7 403	4 380	4 698	5 185	5 398	7 017	2.41
Republic of Korea	3 307	2 311	1 832	5 510	3 553	2 821	0.97
Hong Kong SAR	3 495	2 672	3 484	3 329	3 493	3 380	1.16
Malaysia	7	-	34	-	-	-	-
Others	477	2 233	1 332	1 130	1 819	2 348	0.80
Total	117 018	127 598	157 074	193 814	276 438	291 726	100.00
% change	34.81	9.04	23.10	23.39	42.63	5.53	

Note: p = preliminary.
Source: Department of Customs.

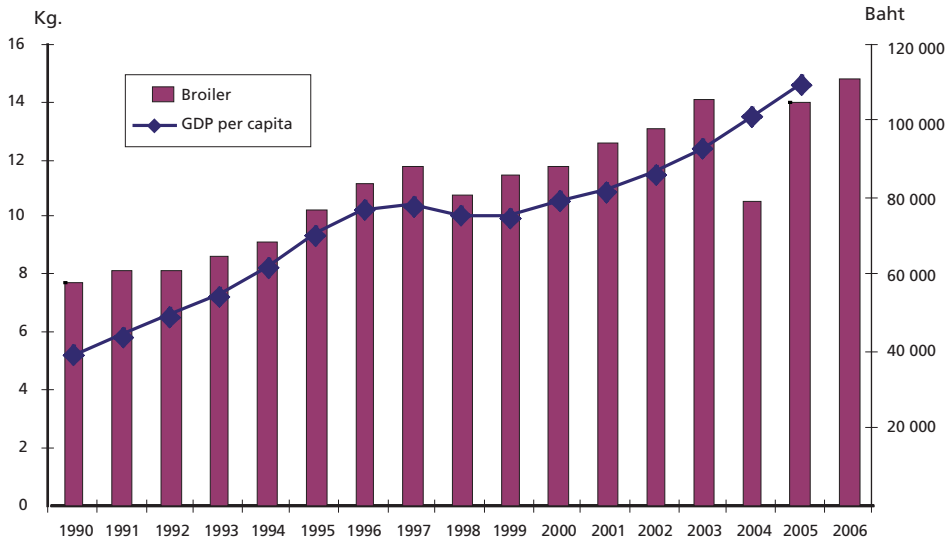
3.4 Domestic market and urbanization

Per capita broiler consumption in Thailand has grown considerably in the past decade, from 10.3 kg to 14.8 kg per year. The growth pattern is closely related to Thailand's GDP per capita (Figure 7).

Although it is natural to see an increase in protein consumption as a developing country becomes richer, one factor that makes the broiler chicken a success is that prices can be kept low. Three or four decades ago, the price of chicken meat was on par with, or sometimes even higher than, pork and fish prices. At present, chicken has become the least expensive source of animal protein in Thailand. As indicated in Figure 8, the retail price of broiler meat has been consistently lower than those of pork and beef for the past decade and a half. As a result, per capita consumption of broiler meat has continued to increase in the past decade (with a sharp drop in 2004 as a result of the HPAI epidemic) while the beef consumption has continued to decrease (Figure 9).

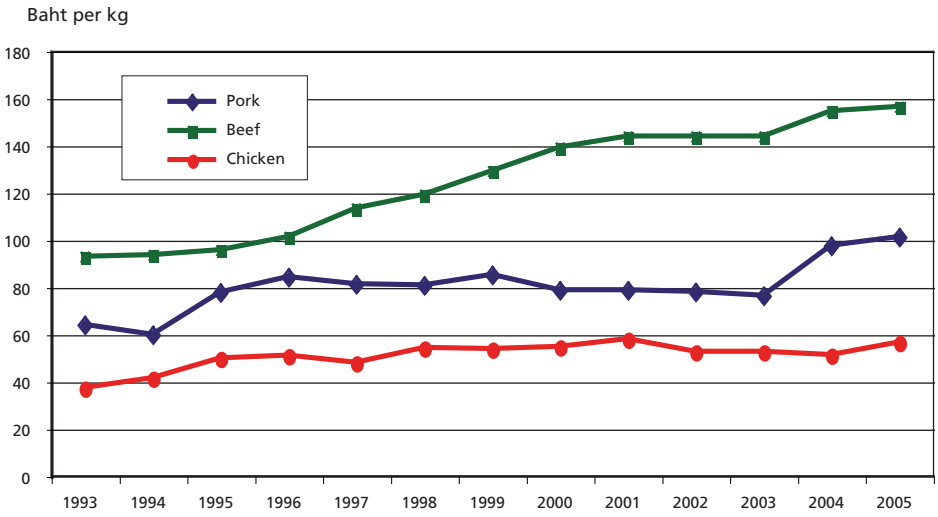
Urbanization is another factor that may have had a positive impact on poultry consumption. The increasing number of hypermarkets and convenience stores (see Table 6) as well as fast-food outlets, such as Kentucky Fried Chicken, Sizzler and Chester Grill, may help stimulate consumption growth; they introduced a stream of new products ranging from boneless and ready-to-cook products to luncheon meats, chicken nuggets and patties for

FIGURE 7
Broiler consumption and GDP per capita in Thailand, 1990 to 2006



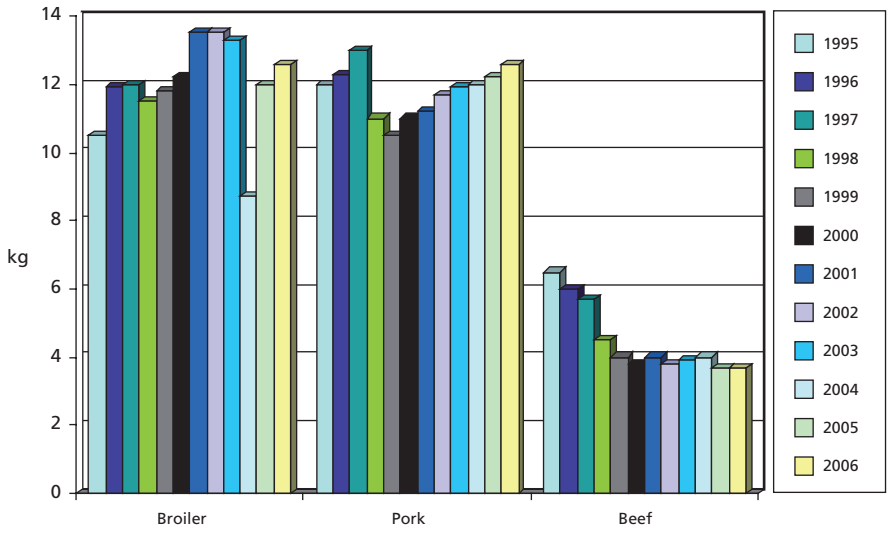
Source: Thai Broiler Processing Exporters Association and NESDB.

FIGURE 8
Retail prices of pork, beef, and chicken in Bangkok, 1993 to 2005



Source: The Ministry of Commerce.

FIGURE 9
Per capita meat consumption in Thailand, 1995 to 2006



Source: 1995–2004 Rabobank/USDA/FAO.
2005–2006 Thailand Development Research Institute (TDRI)'s estimation based on OAE's data and DLD's formulae.

restaurant use. At present, fast-food restaurants sell large quantities of chicken in many forms, including breaded chicken parts, nuggets, patties, breast filets, tenders and popcorn chicken. Many of these products are also available in the frozen food sections of hypermarkets and grocery stores. Some integrated companies, such as CP, have already established their own outlets. Chester Grill, for example, is an outlet for CP poultry products, especially

TABLE 6
Number of hypermarkets and convenience stores in Thailand

	1998	2006		
	Total	Bangkok	Up-country	Total
Carrefour	7	18	6	24
Tesco Lotus	13	28	28	56
Tesco Lotus Market	0	5	18	23
Lotus Express	0	212	33	245
Big C	20	23	26	49
Leader Price	0	5	0	5
Tops Supermarket	40	66	23	89
Total	80	357	134	491

Source: 1998 data from Poapongsakorn *et al.* (2002); 2006 data from Matichon Weekly, 9–16 February 2007.

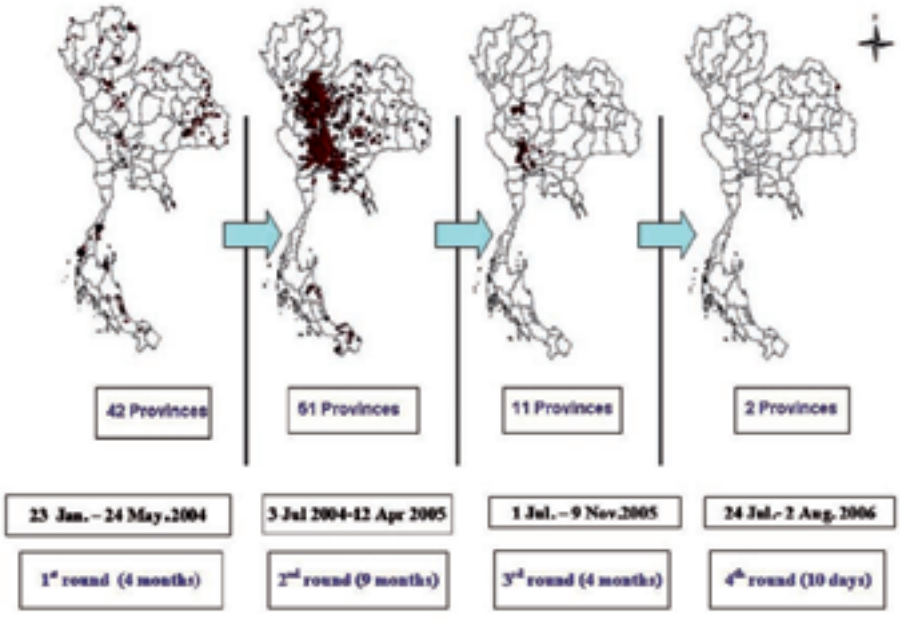
wings and legs (the parts that are not major export products). The less popular chicken parts are largely sold to the local market.

3.5 The HPAI outbreaks

Since January 2004, Thailand and other Southeast Asian countries have experienced outbreaks of H5N1 HPAI in poultry. Thailand was hit by four rounds of the outbreak between 2004 and 2006 (Figure 10) and another small round in early 2007. Since the first outbreak in January 2004, at least 25 people have caught the disease and 17 deaths have been reported (as of September 2007). Thailand rapidly applied control measures, including the killing of as many as 63 million chickens in 2004 (Table 7), disinfection, quarantine, control of animal movements and thorough surveillance (dubbed "x-ray measure" in Thailand). Checkpoints and disinfectant stations along the roads leading to slaughter houses have been increased, and officials from the DLD have been stationed at production centres to monitor the industry. A list of measures used in 2006 is shown in Box 1 below. Although HPAI control was chaotic at first, many have considered it to have been a successful undertaking. The fourth and fifth outbreaks involved only sporadic events which, in some cases, had nothing to do with the broiler or layer industry.

The "success" of the HPAI control in Thailand has, however, been accompanied by substantial costs. Besides the mass killing of poultry (65 million in 2004 alone – which

FIGURE 10
The HPAI outbreaks in Thailand 2004 to 2006



Source: Department of Livestock Development.

BOX 1
List of Thailand DLD's AI policy measures imposed in 2006

According to the DLD, the overall disease control measures implemented in 2006 were as follows:

- stamping out of animals in affected premises with 75 percent compensation (393 430 birds destroyed);
- disposal of carcasses and eggs, and infected/risk materials (e.g. litter, feed and egg flats);
- disinfection of affected premises, all infected/contaminated materials and other risk materials;
- quarantine and movement control;
- nationwide active clinical surveillance and notification for implementing disease control once a case is suspected according to the current AI case definition;
- intensive surveillance (known in Thailand as "The X-ray Campaign") for three rounds in all at-risk areas during 1–28 February, 1 June – 31 July, and 11–30 September 2006 (145 978 samples collected);
- routine sampling prior to movement (a total of 522 072 cloacal swabs were collected between January and October 2006);
- poultry restocking in the affected areas not carried out until 90 days after the completion of disinfection;
- ongoing long-term campaign of biosafety improvement;
- restructuring of free-grazing ducks production to a housed system, registration and flock identification for 7 333 987 birds of 3 109 owners;
- registration of fighting rings/arenas (2 400 holdings were listed);
- identification of fighting cocks (248 877 birds belonging to 107 163 owners were registered); and
- no AI vaccination allowed.

Source: USDA (2007).

incurred more than a billion baht of public-money compensation), some measures have affected smallholders adversely. Right after the first outbreak was formally admitted, the responsible minister and the DLD made numerous public announcements that, henceforward chickens should only be raised in closed farms. In addition, many contracted farms were also required by the integrators to upgrade their poultry housing to closed (evap-type) houses if they wanted to remain as a contractor. Many contractors – already hit hard by the epidemic – decided to call it quits (or switch to other businesses) than rather than invest further in a business with such apparently bleak prospects. In retrospect, their decisions may have been justified given that even among contractors who already had evap-type farms, many have suffered from the rationing and rotation schemes that some integrators employed after the outbreak.

TABLE 7
Number of poultry killed to curb HPAI in Thailand

Year	Number of birds killed
2004	63 000 000
2005	450 000
2006	320 000

Source: Thai Broiler Processing Exporters Association.

TABLE 8
Estimated loss of the poultry industry from HPAI in 2004

	Loss (million baht)
Hatchery farms	4 420
Feed mills	12 430
Broiler farms	27 950
Slaughter houses	28 400
Export	23 700
Total	96 900

Source: Thai Broiler Processing Exporters Association.

Thus far, there has been no systematic study to determine the impacts of the various measures on different groups of stakeholders. Our in-depth interviews with a few independent veterinarians and small farm holders have indicated a consensus belief that the DLD measures that have had the strongest negative impacts on small farms are the pressure to upgrade to closed housing, and some quarantine and movement control measures. Ironically, the first measure, while being clearly announced to the public, was not backed by corresponding changes in the rules and regulations. For example, the official poultry farm standards still allow both opened and closed housing. In practice, however, the DLD officials exercised their quarantine and movement control measures to block chicken raising in open farms. The quarantine and movement control measures were implemented under the umbrella of the Animal Epidemic Disease Control BE. 2499 (promulgated in 1959 and revised in 1999) which gives quarantine and movement control powers to the DLD authorities in the case of epidemics.

Vaccination has been one of the most controversial issues for the poultry industry in the past few years. The DLD has continued to ban AI vaccination since 2004. Its standpoint has been strongly supported by the then number-one broiler exporter (Sahafarm Co.). Another large multinational corporation (CP) – which probably uses (and may have successfully

developed) AI vaccine in its operations in China and/or Viet Nam – has during the past few years proposed the use of vaccination. Although the DLD has been firm in its decision, there have been strong rumours that AI vaccine has been used in many layer farms, because their losses would be more substantial if the birds were to catch HPAI.

Since the first outbreak, Thailand's two largest export markets for chicken products, Japan and the EU, have banned imports of frozen/fresh poultry from Thailand. Initially, this ban affected the industry adversely, as at the time frozen/fresh products accounted for two-thirds of the export. The Thai Broiler Processing Exporters Association claimed that the total loss suffered by the poultry industry as a result of the HPAI outbreak in 2004 was almost 100 billion baht (US$3 billion) (see Table 8). To help poultry farmers whose birds were culled, the government provided significant compensation[6] and set aside a hardship fund of 5 000 million baht. The fund was used to provide soft loans at low interest rates to affected farmers who wanted to start new businesses. In addition, Thailand's broiler exporters took many, mostly biosecurity-related, measures to protect the industry. Contract farms were required, by both the DLD and their patrons, to upgrade their poultry housing to the closed system. Those who were unable or unwilling to comply were left with no option but to leave the poultry business.

4 THE FUTURE TREND OF THAILAND'S POULTRY SECTOR

The HPAI outbreaks have been the most important factor shaping Thailand's poultry sector in the past few years. The outbreaks have also hit smallholders very hard, resulting in many leaving the industry altogether. However, strong and devastating as it has been, HPAI is unlikely to determine the future of Thailand's poultry industry. This is because structural change is almost complete and is unlikely to be reversible.

The Thai broiler industry will continue to move towards higher levels of industrialization and more vertical integration – most large integrated firms will include food processing as a part of their operation. Further industrialization and vertical integration will make it easier for the poultry industry to comply with the foreign importers' food safety and animal welfare requirements.

The trend towards further processing of poultry (cooked and semi-cooked products) – now included as part of the operation of many integrated firms – may increase employment in the poultry sector. However, additional employment in the integrators' farms will be very limited, as many are now fully automated. Moreover, any new employment will be created at the expense of smallholders whose room to operate as self-employed broiler farmers will be increasingly curtailed.

As the sector returns to "normal" business, its future will be shaped mainly by basic drivers, such as feed supply and demand. Another significant trend may be that movement towards replacing chemical protection (antibiotics, antiseptics, or even vaccination) with biosecurity and compartmentalization will shift the industry further towards integrated industrialization.

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[6] During the first outbreaks, the government provided full compensation (at market value of healthy chickens) for the stamped-out animals. Since the second round of outbreaks (July 2004), however, the compensation has been reduced to 75 percent of the market value in order to curb moral hazard problems.

4.1 Feed supply and demand

The supply of raw materials for poultry production, particularly grain and protein, has become a key issue determining the growth – and possibly competitive strength – and future of the industry. The Thai Feed Mill Association estimates that a total of 3.52 million tonnes of maize and 1.63 million tonnes of soybean were used to feed broiler and layer chickens in 2007 (Table 9). The amount required would be much more in the future should the industry grow back to the pre-HPAI level of production – which would be easily attainable. Shortage of local feed ingredients has made the industry reliant in part on imported feeds. In addition to the feed costs, some agricultural products are under tariff quota protection. For example, while the import duty on soybean meal in quota is a mere 4 percent, the "out of quota" import duty is prohibitively high – at 119 percent. Although the tariff

TABLE 9
Estimates of poultry production and feed use, 2007

	Production (million birds)	Feed use (tonnes)	Share	
			Soybean	Maize
Broilers	811.72	3 214 411	30	62
Parent stock of broilers	10.04	506 016	25	60
Young hens	30.63	663 650	25	60
Layers	37.05	1 482 000	25	55
Parent stock of layers	0.52	20 800	25	60

Source: Thai Feed Mill Association.

TABLE 10
Feed prices

		Soybean meal (baht/kg)	
Year	Maize	Domestic	Import
1997	4.77	10.81	10.65
1998	5.02	11.25	10.50
1999	4.67	9.65	7.47
2000	4.80	9.98	9.21
2001	4.37	10.94	10.70
2002	4.68	10.47	10.16
2003	4.94	11.96	11.07
2004	5.70	13.77	14.61
2005	5.50	12.02	11.92
2006	6.18	11.03	10.53

Source: Thai Feed Mill Association.

quota has been lifted, all importers are required to buy domestic soybean proportionately to their purchase of imported soybean at a guaranteed price which is usually higher than the imported price.

As many agricultural product exporting countries, including Thailand, have been promoting biofuel production, a large proportion of grain (such as maize) and tuber (such as cassava), as well as sugarcane production, has been diverted toward gasohol and bio-diesel production – pushing the prices of animal feeds significantly upwards. Table 10 shows that the maize price has increased significantly, and the price of soybean price has also tended to rise. Although the impact of rising feed prices on the competitiveness of Thailand's poultry sector is unclear – as this worldwide phenomenon could also affect competitors – it is very plausible that the growth rate of the sector will not be as strong as in the past.

4.2 Biosecurity and compartmentalization

An important driver of vertical integration in poultry firms has been their decision to solve major safety problems, such as banned antibiotics residuals and HPAI, by using biosecurity measures. In the past, the industry relied more on chemical solutions such as vaccination, antibiotics and antiseptics, which are costly and at times leave undesirable or unacceptable residuals in the products. After the HPAI outbreaks, it was also clear that vaccination would not be acceptable to the major importers, which often require even more stringent standards than those set by the World Organisation for Animal Health (OIE). The industry's only option was, therefore, to employ biosecurity measures.

As the chicken breeds currently raised are highly susceptible to HPAI, the objective has been raise them in a closed system – an environment that minimizes contact and contamination. Most integrated broiler farms have by now introduced closed housing. Moreover, to ensure higher levels of safety, the industry, with guidance from the DLD and OIE, has moved towards a more stringent form of control – compartmentalization.

If anything, compartmentalization means more integrated, and hence larger, operations. In theory, it is possible that many (or a few) companies could share facilities within a compartment. However, as all the leading integrators already own all types of facility, it is unlikely that any would be willing to share with a competitor. Nonetheless, it is plausible that some leading integrators may provide space or service to smaller companies.

On July 13, 2006, the DLD signed an agreement with 24 major broiler and duck companies to establish 92 compartments which will cover 1 276 farms (1 250 broiler farms and 26 duck farms) and a total of 120.6 million birds per batch. The target was that by the end of 2006 at least 1 000 farms would be compartmentalized. By the end of 2006, the number of farms that had applied for compartmentalization certification had increased to 1 877 broiler farms (from 18 companies) and 899 duck farms (from 2 companies) in 40 provinces.

5 IMPLICATIONS FOR SMALLHOLDERS

Rapid industrialization and increasingly stringent trade requirements imposed by importing countries during the past decade have led to a significant increase in in-house production of broilers and layers by many integrated companies. Once these developments were underway, the future of small poultry farms was always in doubt.

For many smallholders, however, the end came much earlier than most would have expected. Most of them were hit – directly or indirectly – by the HPAI outbreaks that started in 2004. Some farms that were able to avoid the initial impact were nonetheless affected adversely by the later structural adjustment.

5.1 Smallholders and the HPAI outbreaks

In order to see how structural adjustment has affected farms of various sizes – including smallholders – the Thailand Development Research Institute (TDRI) conducted a telephone survey of broiler and layer farms that had been selected as a sample in a previous TDRI–IFPRI–FAO study in late 2002 and early 2003.

Among the broiler farms, after repeated tries, we were able to contact about half (49 percent) of the sample of 170 from the previous study. Among the respondents, 71 percent continue to operate their broiler farms (see Table 11 below). Over half operate on the same scale as they did in 2003, with about 7 percent having expanded, and another 7 percent having decreased, their farm size. Among the 29 percent who have discontinued their broiler farms, 6 (out of 24) have switched to another type of poultry farm (duck or layer) and 2 have rented their broiler farms out, presumably to other broiler operators. As such, the great majority of the farms are still in the poultry business. Among the minority who left the poultry business, 4 are still in the livestock business. Seven have switched to crop farming. Only a few have moved out of agriculture (into retail business). It should be noted that large broiler farms in our samples appeared to have been more affected, as about half of them (4 out of 9) have left the poultry industry altogether.

It is plausible that, among the half of the old sample that we were unable to contact, a greater percentage may have left the poultry business or even left the area altogether. However, one should not draw too strong an inference regarding this section of the sample, as the major cause of the low response rate is that the vast majority of the phone numbers in our record (about 85 percent) are mobile phone numbers. In the past few years, it is not unusual for an average Thai to have changed their mobile phone numbers/providers as a result of fierce competition among the mobile phone service providers.

In the case of the layer farms, we were slightly less successful in reaching our old sample – we managed to contact only 40 percent of our 2003 study sample. About two-thirds of the respondents continue in the layer business. However, most farms reportedly have fewer layers than in 2003, especially among the smaller farms. As in the case of the broiler farm sample, most respondents who have discontinued their layer business moved to into another type of livestock keeping or agriculture.

Even though most respondents are still in the poultry business, this does not mean that they have not been affected by HPAI and the government measures that have been implemented in the wake of the outbreaks. Several farmers who moved to non-broiler activities indicated that after substantial losses resulting from the HPAI outbreaks they were unable to comply with the demands of the DLD or their patron companies for further investment in upgrading their farms.

TABLE 11
What the broiler farmers from the 2003 sample do in 2007: telephone survey results

Activities in 2007	Number of farms	Proportion of respondents (%)	Proportion of 2003 sample (%)	Size				
				S	ML	MH	L	n.a.
Continue to operate the broiler farm	59	71.1	34.7	24	20	8	5	2
Raise more broilers than in 2003	6	7.2	3.5	1	1	2	1	0
Raise same number of broilers as in 2003	47	56.6	27.6	23	18	5	4	2
Raise fewer broilers than in 2003	6	7.2	3.5	0	1	1	0	0
Stopped operating the broiler farm	24	28.9	14.1	10	6	2	4	2
Switched to other poultry farming								
- Duck farm	5	6.0	2.9	2	1	1	0	1
- Layer farm	1	1.2	0.6	1	0	0	0	0
Switched to other livestock farming								
- Pig farm	2	2.4	1.2	0	2	0	0	0
- Cattle farm	1	1.2	0.6	1	0	0	0	0
- Fish farm	1	1.2	0.6	0	1	0	0	0
Rent the farm out (still as a broiler farm)	2	2.4	1.2	2*	0	0	0	0
Switched to other crops	7	8.4	4.1	1	2	1	3	0
Switched to retail business	2	2.4	1.2	2	0	0	0	0
New occupation not specified	3	3.6	1.8	1**	0	0	1	1
Total respondents	83	100.0	48.8	34	26	10	9	4
Unable to contact via telephone	86	n.a.	50.6					
Number of observations in 2003 (170 farms)	170		100.0					

Note: Small (S) = 1–5,000; Medium low (ML) = 5 001–10 000; Medium high (MH) = 10 001–20 000; Large (L) > 20 000.
* includes a case of deceased farm owner and another case of farmer who becomes a factory worker.
** includes a case that discontinue before the HPAI outbreak.
Source: Telephone survey by TDRI, March 2007.

TABLE 12
What the layer farmers from the 2003 study do in 2007: results of a telephone survey

Activities in 2007	Number of farms	Proportion of respondents (%)	Proportion of 2003 sample (%)	Size			
				S	ML	MH	L
1. Continue to operate the layer farm	26	66.7	26.8	2	6	5	13
- Raise more chickens than in 2003	5	12.8	5.2	0	0	0	5
- Raise the same number of chickens as in 2003	6	15.4	6.2	0	2	2	2
- Raise fewer chickens than in 2003	15	38.5	15.5	2	4	3	6
2. Switched to other activities	13	33.3	13.4	4	5	3	1
Egg retailer	3	7.7	3.1	2	0	0	1
Fish farm	4	10.3	4.1	0	2	2	0
Pig farm	2	5.1	2.1	0	1	1	0
Other agriculture	3	7.7	3.1	2	1	0	0
Non-agriculture	1	2.6	1.0	0	1	0	0
Total respondents	39	100.0	40.2	6	11	8	14
Unable to contact via telephone	58	n.a.	59.8				
Number of observations in 2003	97	n.a.	100.0				

Note: Small (S) = 1–5 000; Medium low (ML) = 5 001–10 000; Medium high (MH) = 10 001–20 000; Large (L) >20 000.
Source: Telephone survey by TDRI, March 2007.

5.2 The future for smallholders

Even before the HPAI outbreak in 2004, the future of smallholders in the poultry sector looked bleak. When TDRI took part in two international comparison studies sponsored by FAO and IFPRI between 2001 and 2004, the definitions (categorizations) that our team employed were larger than those used by other research teams doing studies in other Asian countries (see Tables 11, 12 and 13). Even given this categorization, we found that smallholders' competitiveness (e.g. in terms of feed-conversion ratio and the egg yield) was problematic, both for broiler and layer farmers.

Table 13 above shows results from stochastic frontier estimation based on TDRI's farm survey in 2002/2003. The results suggest that small broiler farms (with less than 5 000 and between 5 000–10 000 birds per batch) are much less efficient than larger farms (with more than 10 000 birds per batch). A similar pattern was found – although less pronounced – in case of layer farms. Given the above-described advantages of large companies/integrators and the growing trend towards vertical integration, the results shown in Table 13 come as no surprise.

If anything, the gap between large and small producers tends grow wider over time. Some of the advantages that smallholders' had in the past – such as having lower investment costs in chicken housing and sometimes getting higher prices for chicken manure or

TABLE 13
Mean relative profit efficiency of broiler and layer farms across farm sizes, 2002-2003

	Proportion of maximum profit efficiency (%)			
Farm size (number of birds) N = 170	Small <=5 000 N = 74	Medium low 5 000–10 000 N = 51	Medium high 10 001–20 000 N = 27	Large >20 000 N = 18
Broilers (contracted farms)	49	71	88	87
Farm size (number of birds) N = 97	Small <=10 000		Medium >10 000–50 000	Large >50 000
Layers	52		55	61

Source: broilers – author's re-estimation based on TDRI data (see more details in Poapongsakorn *et al.*, 2003); layers – Poapongsakorn *et al.* (2003).

using it more productively to feed fish stock in ponds beneath the chicken houses – have ceased to operate as the DLD has "requested" that they turn to closed evap-type housing to counter the HPAI epidemic. During the past few years of HPAI outbreaks, such requests/regulations have been strictly imposed on smaller farms, even though many of these farms only intend to serve the domestic market. Practices like open farming and farming over fish ponds have been deemed "risky" and forbidden in most areas. In many areas, chicken manure has become a liability rather than the valuable asset it once was.

Many smallholders (and larger farmers) who used to have a contractual arrangement with large integrators (usually known as "contract farming") were required to upgrade their poultry housing after the outbreaks. Some were unable to comply and had to stop being contractors. For those who were able to comply, many were contracted only on a rotating basis, as the demand for broilers – in both foreign and domestic markets – has not yet returned to the pre-HPAI level. Some were offered a duck contract instead of a broiler contract by their original patron. Compared with a typical broiler contract, a duck contract is generally less lucrative – partly because of the longer raising period, worse feed conversion ratio, and lower number of birds per batch. However, most contractors who were offered the duck contract accepted because otherwise they would have had to leave their housing unused. Many even considered themselves "lucky" because there were many former contractors who were not offered any contracts at all. Faced with these problems, some farm owners remodelled their chicken housing to raise pigs. Other switched to other livestock or non-livestock professions.

The above examples indicate that many smallholders have made their own adjustments during the three years since the first HPAI outbreak in 2004. A significant number of small farmers (probably more than a half of small broiler farms) have managed to keep their poultry business, even during this difficult time. Some also shifted temporarily to other livestock businesses, hoping to return to poultry farming at some point in the future. A smaller number of farmers have left the broiler and layer sectors voluntarily. It is likely that the adjustments will continue, albeit at a slow pace.

Although it is clear that many smallholders are losing their battle to stay in the poultry industry, it would be wrong to underestimate their capacity to adjust. Many have success-

fully done so over the past few years by switching to other livestock, other agricultural activities, or even moving out of the agricultural sector[7] – in most cases with little or no assistance from the government or other organizations.

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[7] As many broiler farms have switched to non-broiler professions in the past few years, it would also be wrong to conclude as some analysts have, without a good study or survey, that the broiler industry has something like 30 percent idle/surplus capacity that could be reused immediately should the demand return. Although it is likely that some surplus/idle capacity does exist, it is not a trivial job to determine the actual size of the surplus capacity.

The poultry industry in India

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SUMMARY

India's poultry industry represents a major success story. While agricultural production has been rising at the rate around 2 percent *per annum* over the past two to three decades, poultry production has been rising at the rate of around 8 percent *per annum*, with an annual turnover of US$ 7 500 million.

This paper seeks to capture the dynamics of the industry over the more recent past. Utilizing production, price and export data from the period 1995 to 2004, the study seeks to: (a) examine the trends and features of development in Indian poultry over the last ten years or so; (b) identify forces that are driving these changes; (c) predict the structure of developments in the poultry sector, over the next ten or fifteen years and trace its consequences for income, employment, public health, environmental pollution, animal wealth, etc.; and (d) shed some light on how smallholders are likely to be affected by the ongoing structural changes, i.e. whether it will seriously undermine their competitiveness, and if so what are the options available. The analysis shows a sharp jump in India's egg and poultry meat production. Poultry meat has outpaced its two major competitors – beef and veal, and buffalo meat. Another major development in Indian poultry production is the spread of integration, which is occurring very rapidly, especially in broiler production, both in southern and western parts of India.

The forces that are sustaining this growth are many. High per capita income growth and relatively low prices have played a catalytic role. A moderate shift in the consumption pattern from vegetarianism to non-vegetarianism is also helping the industry by increasing the demand for poultry products. The future outlook for Indian poultry also appears to be very favourable. The most conservative estimates predict a two- to three-fold increase in poultry production over the next ten or fifteen years. However, a worrisome feature of the accelerated growth and the ongoing structural change seems to be its potential impact on the future of small and marginal producers. While several studies on the theme have contended that vertical coordination in agricultural supply channels helps to lower the transaction costs and market risk of smallholders, it has proved difficult to support the contention in the case of poultry. Drawing on an earlier study conducted by the first author, it is shown that contract farmers earned lower profits than non-contract farmers.

In this study, we draw three alternative scenarios and trace their implications, using the OECD-FAO Agricultural Outlook AGLINK-COSIMO model. First, we assume that import of maize, the main feed ingredient, is liberalized. Second, we study the consequences of import liberalization of poultry meat and eggs. Third, we evaluate the consequences of an outbreak of avian influenza (AI).

The complete elimination of tariff on maize will not affect India's imports, because domestic prices (plus tariff) are less than world prices. A complete liberalization of imports of poultry meat could be disastrous for the domestic poultry industry – production would fall significantly; however, the consumer price would decline leading to increased consumption. The consequences of an outbreak of AI would be a significant decline in consumer price and the level of consumer demand. However, prices would revert to their normal trend within a year, and the level of consumer demand would return to normal within a year.

1 INTRODUCTION

The poultry industry in India represents a major success story. What was largely a backyard venture before the 1960s has been transformed into a vibrant agribusiness with an annual turnover of Rs 30 000 crores. Today, India is the third largest egg producer in the world (after China and the United States of America), and the nineteenth largest broiler producer. Undoubtedly, this impressive growth is a result of several factors, such as active developmental support from the state and central government, research and development support from research institutes,[1] international collaboration and private sector participation. A point worth mentioning here is that Indian poultry is self-sufficient, supported by a broad and strong genetic base in which the productivity levels[2] of broilers and layers are equal to those achieved elsewhere (e.g. in the United States of America and the European Union). Undoubtedly, these achievements are quite significant. Today, however, globalization is posing greater challenges: namely, making the industry globally competitive and viable; and fulfilling the quite enormous potential for growth that is presented by changing food habits and preferences.

In what follows, an attempt is made to describe the trends and features of development in the Indian poultry industry over the last ten years; probe the underlying factors; and predict what lies ahead, including the threats posed to smallholders. Specifically, the study seeks to:

- describe the structural changes in the poultry industry from (approximately) 1995 to 2005;
- identify and evaluate the relative importance of the drivers that have caused this structural change;
- predict future scenarios and assess possible consequences for income and employment, biosecurity and public health, environmental pollution, animal welfare, food supply and demand; and
- speculate as to how smallholders are likely to be affected by the ongoing structural changes.

The analysis is carried out based on secondary data, including reports from the Govern-

[1] Among the public sector institutions, the Indian Council for Agricultural Research is the nodal organization and includes the Indian Veterinary Research Institute, (Izatnagar), the Central Avian Research Institute (Izatnagar), and the project Directorate on Poultry, ICAR, Hyderabad. In the private sector, the Institute of Poultry Management of India (IPMI) in Pune and C & M Hatcheries Pvt. Ltd, Nasik, have been imparting practical training in poultry management. Then there are 30 veterinary colleges and over 80 agricultural colleges functioning as constituent units of 27 agricultural universities.

[2] Productivity level is defined as feed conversion ratio (FCR). In this paper, productivity is generally defined as FCR unless otherwise stated.

ment of India (GOI), international agencies and the private sector, and interactions with different stakeholders including industry experts, state governments and cooperatives. The paper is organized as follows: in section 2, we begin by examining the growth of the poultry industry, including structural changes over the past ten years (approximately 1995 to 2005); in section 3 we seek to identify the main forces that lie behind this achievement; in section 4 we try to predict the future outlook, i.e. the long-term growth of the industry; three policy scenarios are also assessed using the AGLINK-COSIMO model; section 5 seeks to answer the question, what are the threats posed by large-scale industrialization of poultry to smallholders? In the final section we draw concluding observations based on our findings.

2 GROWTH AND STRUCTURAL CHANGE

Annual per capita consumption in India is only 42 eggs and 1.6 kg of poultry meat, which is below the levels recommended by the Nutritional Advisory Committee[3] – 180 eggs and 10.8 kg of poultry meat.

2.1 Recent trends in poultry production: eggs and meat

Trends in egg and poultry meat production for the period 1995-96 to 2004-2005 are shown in Table 1. For eggs and poultry meat, we report three alternative estimates of data: the first from FAO; the second from the United States Department of Agriculture (USDA); and third from the GOI. The official government data for poultry meat[4] are often alleged to be biased downwards; and hence, we are obliged to rest on FAO and USDA sources.

The data show several striking points:

- Columns (1) and (3) show a big increase in egg production. In 2004-2005, India produced 45.2 billion eggs compared to 27.1 billion eggs in 1995-1996. This represents a 66 percent increase over the ten year period. The table also shows that growth has been faster after 2000 than before.
- Columns (4) and (5) indicate a sharp increase in poultry meat production. The increase is 175 percent over the 1995 to 2005 period according to FAO data and 120 percent according to USDA data.

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[3] The National Institute of Nutrition, India has recommended that a balance diet should contain 30 grams of eggs per day (i.e. 180 eggs *per annum*) and 30 gms. of meat (11 kg *per annum*).

[4] FAO and USDA were earlier taking the same data as that of GOI, but they have now revised their time-series for poultry meat from 1993 onwards. In this context, USDA (2004) mentions "assessing recent trends in Indian poultry, production and consumption are complicated by poor and conflicting data. Government and industry sources publish very little reliable data on the Indian poultry sector. Available government data consist only of periodic poultry population estimates, with the most recent estimates based on a 1992 livestock census. Government sources also report wholesale poultry prices for a few markets, but there are no official statistics on poultry consumption, marketing, processing, or feed use. The Food and Agriculture Organization of the United Nations (FAO) and the United States Department of Agriculture (USDA) publish estimates of Indian poultry supply and use, but, in the absence of supporting survey information, these estimates do not have a strong statistical foundation. Trade associations, including the Poultry Federation of India, also do not currently compile industry wide data." As the USDA and FAO figures are close, official production statistics seem to be biased downwards. The flow charts given later in this section also support the view that Indian poultry meat production is higher than the GOI official trade statistics . In addition, there is significant difference between growth rates of production (quantity) and value (constant price), based on official statistics. AMAD also relies on FAO data.

TABLE 1
Production of eggs and poultry meat in India, 1995-1996 to 2004-2005

Year	Egg production			Poultry meat (1 000 tonnes)		
	FAO estimates (1 000 tonnes)	USDA estimates (million eggs)	GOI estimates, (million eggs)	FAO estimates	USDA estimates	GOI estimates
	(1)	(2)	(3)	(4)	(5)	(6)
1995-1996	1 496	28 000	27 198	624	590	--
1996-1997	1 512	29 100	27 496	714	610	--
1997-1998	1 579	32 000	28 689	648	630	--
1998-1999	1 621	34 000	29 476	763	670	361.81
1999-2000	1 675	35 000	30 447	875	690	382.3
2000-2001	2 015		36 631	1 136	710	364.06
2001-2002	2 130		38 729	1 307	1 250	393.51
2002-2003	2 190		39 823	1 460	1 400	439.05
2003-2004	2 222		40 403	1 662	1 600	507
2004-2005	2 468		45 201	1 715		507
2005-2006	2 539					537
Growth rate (% *per annum*)*	6.18	6.24	6.18	14.0	14.09	6.50
Growth rate 1998–2004 (% *per annum*)*	8.78		8.79	18.52	22.97	4.24

*Based on regression equations.
Sources: GOI, (2006); FAOSTAT (2006) as reproduced in GOI (2006). USDA estimates are from Foreign Agricultural Service GAIN Report, India Poultry and Products Annual, various issues.

- Overall, the data suggest that poultry industry has grown at the rate of around 14 percent *per annum*.

The upward trend is even stronger in value terms (see Table 2). Both egg production and poultry meat production appear to have registered a 100 percent growth in value terms (current prices in local currencies) over the 1995 to 2005 period. Meat is the most important product in the poultry sector having a 66.7 percent share of poultry output (in value terms). There is significant difference between the growth rate of the value (at constant price) and the growth rate of the quantity of egg production. This may be due to change in the balance between desi fowl and imported fowl in the production of eggs.

2.2 The relative importance of poultry in the national livestock sector

India is one of the most important livestock-rearing countries, with a large population of cattle, buffaloes, sheep, goats and other species of livestock. The country has 1/6 of the

TABLE 2
Value of output from poultry

	Current prices (Rs crores)			Constant prices (1993-1994 prices)	
Year	Egg	Poultry meat	Total value	Egg	Meat
1995-1996	2 834	5 846	8 680	2 515	5 036
1996-1997	3 168	6 217	9 385	2 536	5 032
1997-1998	3 419	6 916	10 335	2 682	5 208
1998-1999	3 516	6 808	10 324	2 708	5 280
1999-2000	3 874	8 223	12 097	2 817	5 486
2000-2001	4 587	10 714	15 301	3 222	6 793
2001-2002	4 874	11 926	16 800	3 396	7 894
2002-2003	4 956	11 020	15 976	3 571	7 740
2003-2004	5 013	11 283	16 296	3 623	8 004
2004-2005	5 567	11 259	16 826		
Growth. rate (% *per annum*)*	8.74	11.57		5.51	7.53
Growth rate 1998–2004 (% *per annum*)*	7.62	10.55		6.55	9.77

*Based on regression equations.
Sources: GOI, national income accounts statistics, various issues.

world's cattle and about 1/2 of the world's buffalo population. India ranks sixth terms of sheep and goat population. The pig population is about 12.79 million. The improved layer bird population is around 104 million.[5]

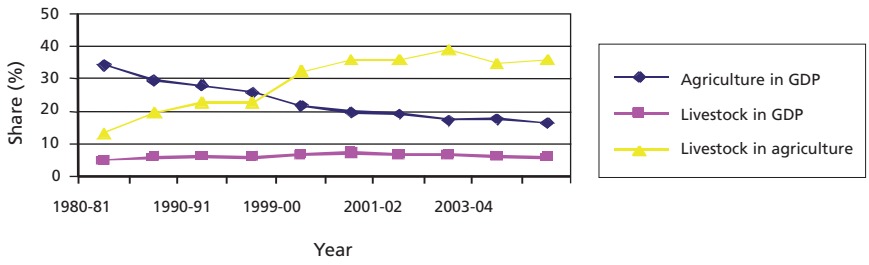
In terms of value, the share of livestock in GDP was 4.8 percent in 1980-1981, based on official GOI statistics. By 2000-2001 the share had risen to 7.33 percent; but it dropped to 6.10 percent by 2004-2005. The growing prominence of the livestock sector can also be seen if we look at trends in the relative share of this sector in the agricultural sector as a whole – 13.8 percent in 1980-1981 rising to 36.51 percent in 2004-2005, the latter figure indicating that out of every 3 rupees produced in agriculture, more than 1 rupee comes from the livestock sector. Figure 1 illustrates the changing structure of the Indian economy at large.

Compared with the rest of livestock sector, the poultry industry in India is better organized and is progressing towards modernization. What is the contribution of poultry sector to India's GDP? It has remained below 1 percent, as can be seen from Table 3.

The relative share of poultry in the national economy has remained below 1 percent, but its share in the livestock sector is continuously rising. This can be seen from Figure 2. The relative share of poultry in total livestock production has risen from 10 percent in 1996-1997 to 12 percent in 2003-2004.

[5] All India Poultry Year Book (2003–2004).

FIGURE 1
Share of agriculture and livestock in GDP (at current price in local currency)



Source: GOI, national accounts statistics, various issues.

TABLE 3
Share of poultry in GDP, 1995-2004

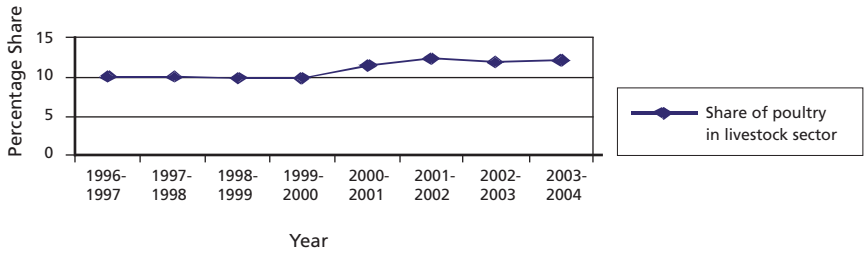
Year	Eggs*	Meat*	Total poultry (eggs + meat)*	Total GDP*	Share of poultry in GDP (%)
1995-1996	2 515	5 036	7 551	899 563	0.84
1996-1997	2 536	5 032	7 568	970 083	0.78
1997-1998	2 682	5 208	7 890	1 016 594	0.78
1998-1999	2 708	5 280	7 988	1 082 748	0.74
1999-2000	2 817	5 486	8 303	1 148 442	0.72
2000-2001	3 222	6 793	10 015	1 198 592	0.84
2001-2002	3 396	7 894	11 290	1 267 945	0.89
2002-2003	3 571	7 740	11 311	1 318 362	0.86
2003-2004	3 623	8 004	11 627	1 430 548	0.81
Growth Rate** (% *per annum*)	4.78	6.22	5.78	5.98	

*Rs crores, at 1993–1994 prices.
** Based on simple average of annual growth.
Sources: GOI, national accounts statistics, various issues.

2.3 The relative importance of poultry meat over other meats

Poultry is today the major source of meat in India. Its share in total meat consumption is 28 percent, as against 14 percent ten years ago. It has outpaced its two competitors – beef and veal, and buffalo meat (see Table 4). High mutton prices, religious restrictions on beef and pork, and the limited availability of fish outside coastal regions have all helped to make poultry meat the most preferred and most consumed meat in India. Expanding domestic production and increasing integration have pushed poultry meat prices downward and stimulated its consumption.

FIGURE 2
Share of poultry in the livestock sector in value terms



Note: calculated at 1993–1995 prices.
Source: GOI, national accounts statistics, various issues.

TABLE 4
Market shares of various meats in Indian meat production/consumption

Year	Beef and veal	Buffalo meat	Mutton/lamb	Goat meat	Pork meat	Poultry meat
			(%)			
1995	30	30	5	10	11	14
1998	29	29	5	10	10	17
2000	28	28	5	9	9	21
2001	26	26	5	9	9	25
2002	26	26	5	8	9	26
2003	25	25	5	8	9	28
2004	25	25	5	8	9	28

Sources: FAOSTAT (2006) as reproduced in GOI (2006).

2.4 Role of poultry in employment

In 1980, when the poultry sector produced 10 billion eggs and 30 million broilers, respectively, total levels of employment in the sector were not very encouraging. As the income and employment in the crop sector started to diminish, there was a big shift to the non-crop sector, which includes poultry and dairy. With demand increasing and the production level reaching 37 billion eggs and around 1 billion broilers in 1999-2000, the sector is estimated to employ around 1.6 million people (Mehta *et al.*, 2002). Whereas 80 percent of the employment is generated directly by the farms, 20 percent is generated in the provision of feed, pharmaceuticals, equipment and other services required by the poultry sector. Additionally, there may be a similar number of people who are engaged in marketing and other channels servicing the sector. By 2005, the total egg production in the country had passed 46 billion, and with higher broiler production, the estimated employment was 2.5 million (Desai, 2004). Employment statistics for 1999-2000 and 2005 are not comparable,

as there are no reliable time-series data. The statistics for these two years are based on the estimates of industry experts. However, GOI provides data on employment by usual-activity status for a few sectors including livestock. Table 5 shows total numbers employed in the livestock sector for selected years. As a large number of farm households do not consider livestock to be their primary employment, much livestock-related employment may not be reflected in the data presented in Table 5.

Presently, India's per capita annual consumption is 42 eggs and 1.6 kg of poultry meat. The National Institute of Nutrition recommends that a balanced diet should contain 30 grams of eggs/day (i.e. 180 eggs *per annum*) and 30 grams of meat (11 kg *per annum*). Assume that out of this at least 9 kg would be met by poultry meat, given the constraints affecting growth of other forms of meat such as beef. Thus, the gap between the present per capita and the recommended per capita consumption is 138 eggs and 7 kg of chicken meat. How much employment can the industry generate? As and when the gap in production is bridged and the industry grows to the desired level, it can be expected to provide employment to over 9 million people (ibid.).

TABLE 5
Employment by usual activity status

	1983 (38th round)	1987-1988 (43rd round)	1993-1994 (50th round)	1999-2000 (55th round)
		(1 000 people)		
Agriculture	178 277 (66.32)	189 922 (63.91)	207 576 (62.52)	193 766 (57.60)
Livestock	11 973 (4.45)	12 380 (4.26)	9 789 (2.95)	8 027 (2.40)
Mining	1 730 (0.64)	2 139 (0.74)	2 684 (0.81)	2 026 (0.60)
Manufacturing	29 390 (10.93)	32 510 (11.17)	35 451 (10.68)	36 487 (10.84)
Electricity, gas, water	850 (0.32)	1 032 (0.35)	1 312 (0.40)	893 (0.27)
Construction	6 642 (2.47)	11 598 (3.99)	11 512 (3.47)	15 405 (4.58)
Trade	17 920 (6.67)	27 345 (7.34)	26 287 (7.92)	34 138 (10.32)
Transport	7 261 (2.70)	8 186 (2.81)	10 209 (3.08)	12 712 (3.78)
Services	25 563 (9.53)	28 030 (9.63)	36 709 (11.06)	32 525 (9.67)
Total employed workers	268 820	290 930	332 000	336 610

Note: figures in parentheses are percentages of the total.
Sources: Sarvekshana 35th issue, April 1988, NSS 38th round, Jan 1983-Dec 1982.
Sarvekshana Special No: Sept 90, NSS 43rd round, Jul 1987-June 1988.
Sarvekshana15th issue Vol. V No. 1&2 July-Oct 1981, NSS 32nd round.
NSS Report No.409, 50th round (July 1993-June 1994).
NSS Report No 458, 55th round (July 1999-June 2000).

2.5 Livestock and poultry populations: Government of India statistics

Growth of the poultry sector depends partly on the size of the poultry population and partly on productivity. The annual growth rate of the livestock population (excluding poultry) in India was 0.93 percent during the period 1950–1956, rising to 2.60 percent by 1977–1982. However, it recorded a negative growth rate of -0.01 percent during 1997–2003. Growth in the poultry sector was 5.22 percent in 1951–1960, fell to 0.21 percent in 1961–1966, rose to 5.79 percent in 1982–1987, and to 5.85 percent in 1997–2003 (Table 6).

The population of layers increased from 166.07 million to 215.07 million between 2000-2001 and 2005-2006, indicating a growth of 29.5 percent over five years. Production of eggs increased from 28 443 million to 43 647.7 million during the same period, indicating a growth of 53.45 percent. The number of eggs produced per hen increased

TABLE 6
Trends in livestock and poultry populations since 1951

Year	Total livestock (excluding poultry)	Poultry
	Population in millions	
1951	292.80	73.50
1956	306.60	94.80
1961	335.40	114.20
1966	344.10	115.40
1972	353.40	138.50
1977	369.00	159.20
1982	419.59	207.74
1987	445.28	275.32
1992	470.86	307.07
1997	485.39	347.61
2003	485.00	489.01
	Annual growth rate (%)	
1951-1956	0.93	5.22
1956-1961	1.81	3.79
1961-1966	0.51	0.21
1966-1972	0.55	3.72
1972-1977	0.86	2.82
1977-1982	2.60	5.47
1982-1987	1.20	5.79
1987-1992	1.12	2.21
1992-1997	0.61	2.51
1997-2003	-0.01	5.85

Sources: GOI (2006).

from 171 to 203 *per annum*, indicating a growth of 18.71 percent (Table 7). Thus, productivity growth accounted for 35 percent of the growth in egg production. However, this productivity measure does not take into account the incremental cost of inputs. If the incremental cost becomes higher than the average cost, the farmers may start another cycle of production.

Assuming that the productivity of hens is the same throughout the country, the level of development of poultry production in a given region has to be judged on the basis of number of fowls per unit of population. The national average of the number of fowls per 100 persons is 47 (Table 8). The highest density is observed in the Southern region (62 fowls per 100 persons) followed by Eastern region (44 birds per 100 persons). The North and Central regions have the lowest densities (16 and 17 fowls per person, respectively). The annual growth rate of total poultry population during the period from 1997 to 2003 was 5 percent *per annum.*

2.6 Regional variations in production: Government of India statistics

Yet another striking feature of the Indian poultry industry is the presence of significant regional variation. Figures 3 and 4 illustrate these regional variations in egg production for

TABLE 7
Growth in numbers of layers and eggs produced

Year	Type	Number of layers (million)	Number of eggs (million)	Eggs per layer (yield)
2000-2001	Desi (local)	84.08	8 825.5	104.96
	Improved	81.99	19 617.5	239.26
	Total	166.07	28 443.0	171.27
2005-2006	Desi (local)	81.28	9 083.0	111.7
	Improved	133.79	34 564.7	258.3
	Total	215.07	43 647.7	202.95

Sources: GOI (2006).

TABLE 8
Poultry population and growth across India regions

State	Number of fowls per 100 persons	Annual growth rate of poultry 1997–2003
South	62	8.9
East	43	3.3
West	23	1.5
North	16	1.2
Central	17	5.0
India	47	5.2

Sources: GOI (2006).

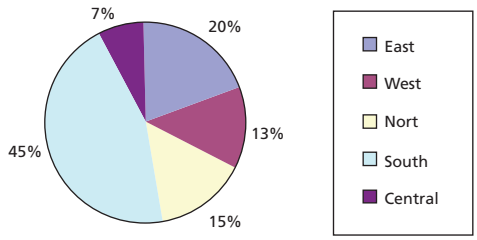
1997-1998 and 2005-2006. Both the Eastern and Northern regions accounted for about 13 percent of total production (the share of the Eastern region has fallen from 19.60 to 13.45 between 1997-1998 and 2005-2006) respectively. The West and the Central regions accounted for 10 percent or less of total egg production in 2005-2006.

Eight states account for bulk of egg production in India – Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Tamil Nadu and West Bengal. Andhra Pradesh is the largest egg producing state, accounting for nearly 40 percent of egg production in the country. After Andhra Pradesh comes, Tamil Nadu – the share of the state in all India production increased from 11.21 percent in 1997-1998 to 13.46 percent in 2005-2006.

One district, of Tamil Nadu – Namakkal – alone accounts for more than 30 percent of total broiler production. Although, a major portion of poultry production is concentrated in clusters, this is one of the most concentrated districts in India. There are several reasons that may account for this concentration, including the presence of an egg powder plant and availability of feed mills nearby.

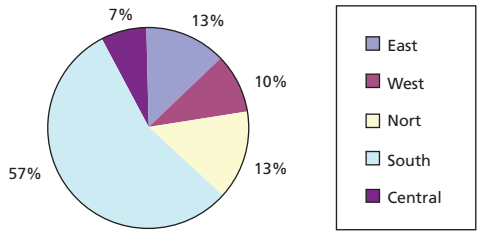
Per capita egg and chicken meat availability is also highest in the southern states, followed by the northern and western states, and least in the eastern and central states. The cost of production is also lowest in the southern region for both eggs and meat, largely because of: i) vertical integration in the sector; ii) lower variation in temperature in the

FIGURE 3
Share of various regions in egg production, 1997-1998



Source: GOI (2006).

FIGURE 4
Share of various regions in egg production, 2005-2006



Source: GOI (2006).

southern states; iii) easy availability of medicines, vaccines and veterinary services; and iv) the fact that the poultry revolution was started in the south by Dr B.R. Rao, who is commonly known as father of poultry sector in India. Though the distribution of poultry production is much greater in rural than that in urban areas, the markets are predominantly urban.

2.7 The poultry industry chain – layers

Figures 5 to 8 show flow charts for volume and value in the layer value chain for the years 2000-2001 and 2005-2006. The following points should be noted:

- The number of eggs sent for processing is calculated on the basis of information supplied by the industry. Approximately 2 percent of total egg production is reported to be sent for processing.
- Values other than exports are calculated based on the unit values derived from national income accounts statistics.
- The rural/urban division is made by applying a 60:40 ratio, again based on the opinion of industry experts.
- The number of spent layers (layers going to the live bird market after around 52 weeks) is calculated assuming a 15 percent mortality rate – information from industry sources. However, no such information was available for Desi fowls. Hence, it was difficult to work out the number entering the live bird market.
- The value of desi eggs is calculated by estimating the price to be 2.25 times that of normal eggs.

2.8 The poultry industry chain – broilers

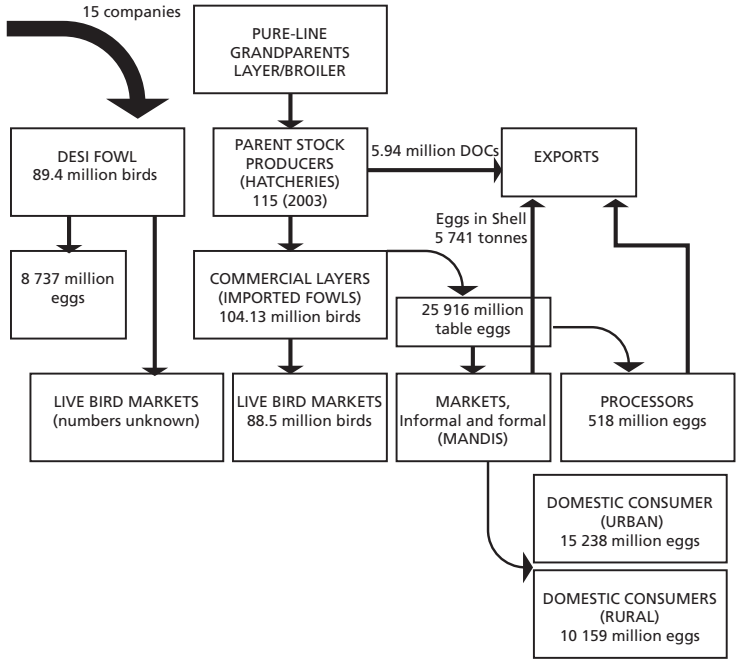
Figures 9 to 12 show flow charts for volume and value in the broiler value chain for the years 2000-2001 and 2005-2006. The following points should be noted:

- The number of broilers going for processing is calculated on the basis of information supplied by the industry. Approximately 5 percent of total broiler production is reported to be going for processing.
- Values other than exports are taken from FAO.
- Desi fowls are generally not used for commercial poultry meat.
- Sources of other data: for broilers and chicken meat: FAOSTAT; yield: Animal Husbandry Statistics, Department of Animal Husbandry, GOI; grandparent to DOCs: 100 pullet chickens for each parent for the year 2005, and 95 pullet chickens for the year 2000.

2.9 Trade scenario

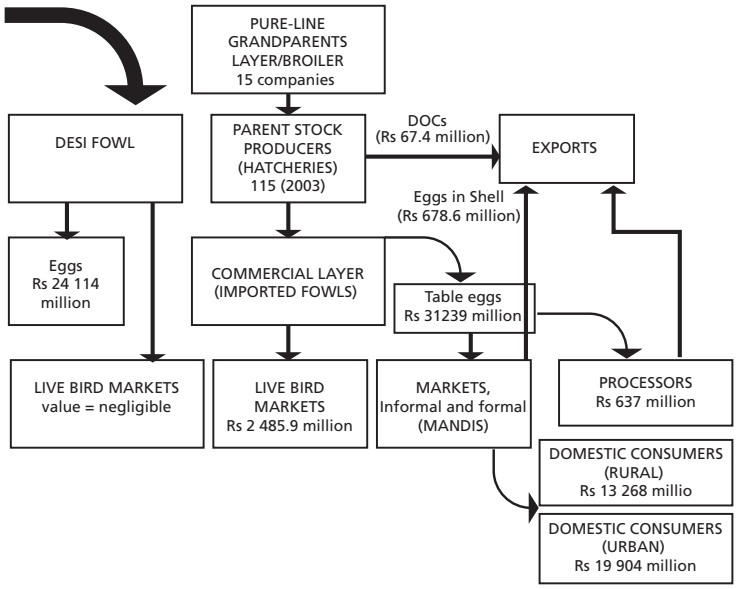
The trends in India's poultry exports for the period 1996-1997 to 2005-2006 are shown in Table 9. It can be seen that eggs and egg-based products account for 90 percent of India's poultry exports. Exports of hatching and table eggs have increased dramatically – from Rs 196 million in 1996-1997 to Rs 408 million in 2005-2006. Similarly, exports of egg powder have increased from Rs 351 million in 1996-1997 to Rs 1126 million in 2005-2006 (there was a drastic fall in exports of egg powder between 1997 and 2000 because of the ban imposed by the European Union (EU) on egg powder imports from India, but there was a

FIGURE 5
Flow chart for layers 2000-2001 – volume



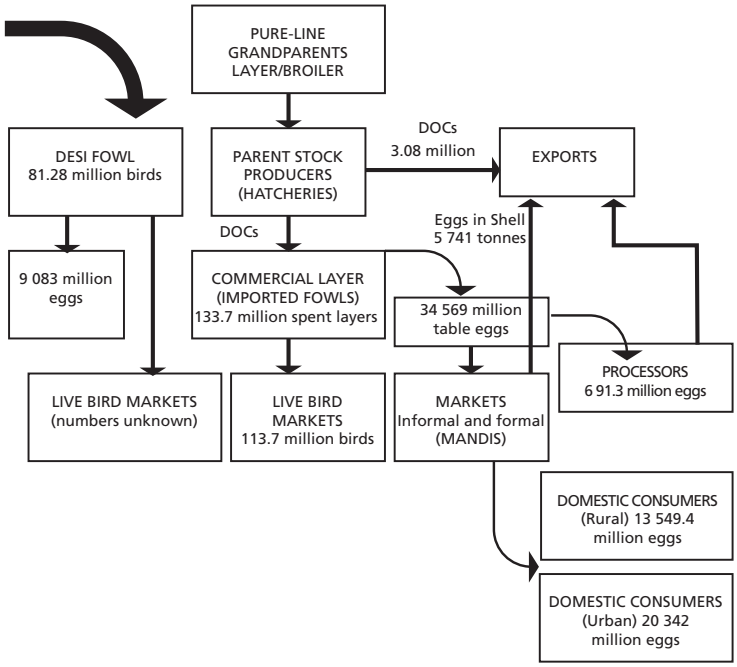
Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 6
Flow chart for layers 2000-2001 – value



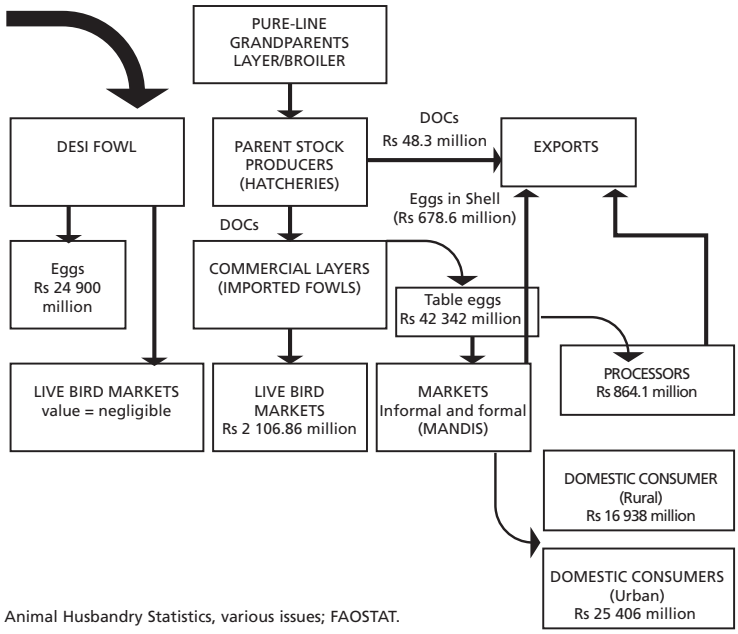
Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 7
Flow chart for layers 2005-2006 – volume



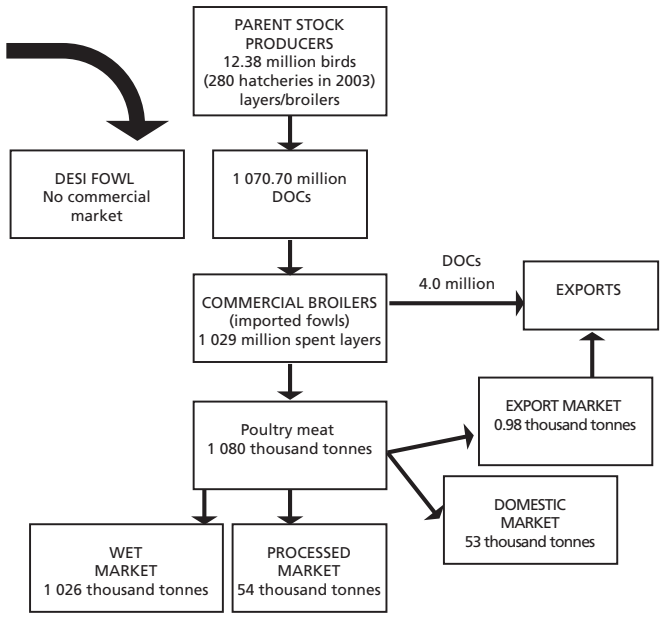
Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 8
Flow chart for layers 2005-2006 – value



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 9
Flow chart for broilers 2000-2001 – volume



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

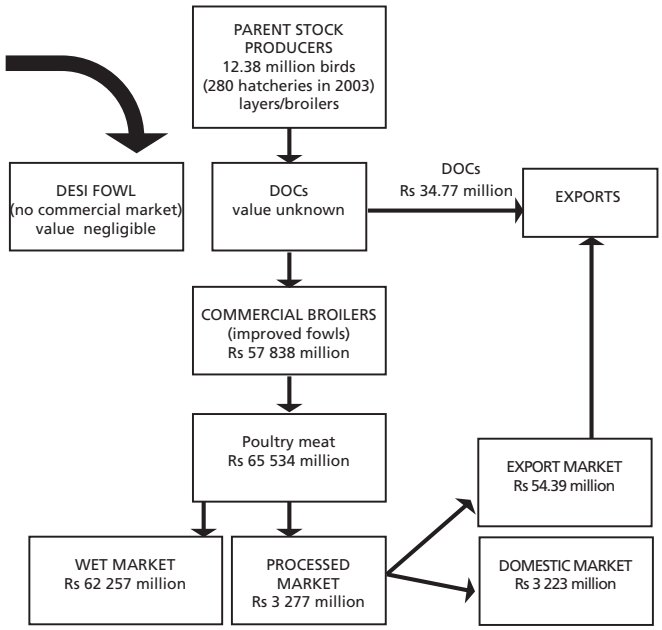
recovery from 2001 onwards). Another egg item that shows a rapid increase is "egg dried, frozen"; exports of this item have gone up from Rs 49 million in 1996-1997 to 107 million in 2005-2006. India's exports of genetic stock and feed (maize and soybean) are not very significant.

At the same time, imports of genetic stock, compound feed, maize, soybean and poultry products have been negligible, this can be attributed to several reasons. First, India's import policy restricted or banned imports of poultry genetic stock, feed and products through quantitative restrictions.[6] Although, from the early 1990s, India has sought to dismantle quantitative trade restrictions, this has so far by-passed the livestock sector except in some exceptional cases.[7] Second, the tariffs are still very high on poultry products. Third, Indians prefer fresh rather than processed poultry meat.

[6] It used to be called "negative list", which generally means that items cannot be freely imported.

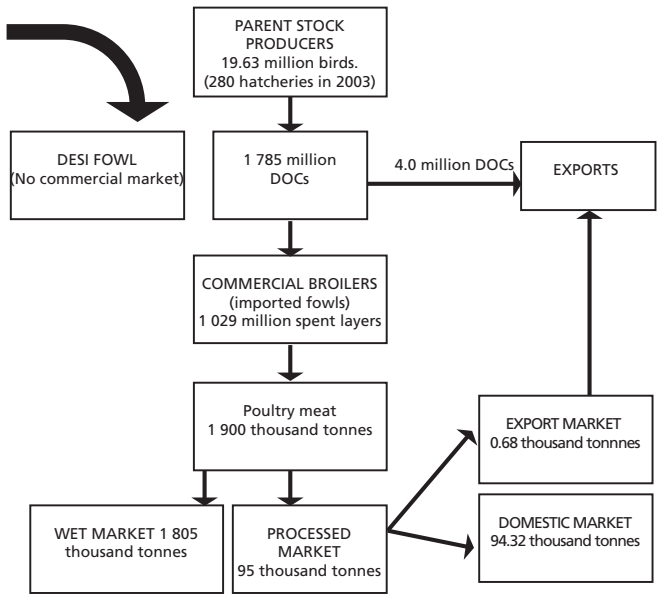
[7] For example, imports for hotels and restaurants were generally permitted. This restriction is also removed with effect from April 1, 2001, as per India's commitment to WTO (see Mehta *et al.*, 2005).

FIGURE 10
Flow chart for broilers 2000-2001 – value



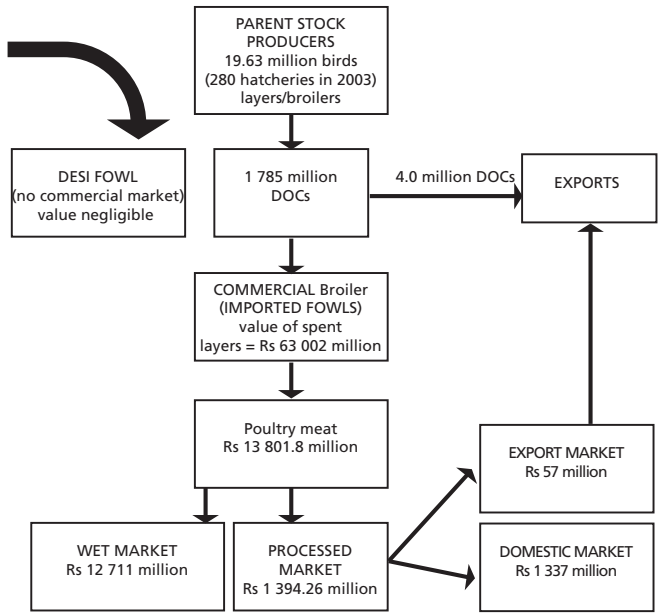
Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 11
Flow chart for broilers 2005-2006 – volume



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 12
Flow chart for broilers 2005-2006 – value



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

Main export markets

Kuwait, Oman, Saudi Arabia, the United Arab Emirates and Yemen have been major importers of India's table and hatching eggs. Similarly Germany, Austria, Japan, the Netherlands and the Republic of Korea have been the most important markets for India's egg powder. Due to a slump in sales in the EU and a decline in demand in Japan, egg powder exports declined sharply in 1998. The slump continued till 2000, after which it started to recover.

India also exports live poultry in the form of day-old chicks (DOCs). The main export markets for India's live poultry are countries of the SAARC (South Asian Association for Regional Cooperation) region (Table 10).

2.10 Structure of poultry production

Poultry farming involves breeding and raising chicks[8] for various purposes. Breeding farms hatch and raise poultry for sale to other farms. Broiler farms rear chickens for their meat, procuring day-old chicks and keeping them for around six weeks. Layer farms keep hens to produce eggs. Another category of operators, which can loosely be termed "integrators",

[8] In other countries, poultry consists of birds such as turkeys, ostrich, chickens, ducks, pigeons, geese, etc. But in India, poultry is largely confined to chickens and to some extent ducks.

TABLE 9
India's exports of poultry

Year	Live poultry		Eggs in shell		Egg powder		Egg dried and frozen		Poultry meat		Total value (Rs lakhs)
	Q	V	Q	V	Q	V	Q	V	Q	V	
1996-1997	-	630.96	4 080	1 962.4	2 407	3 519.02	461	491.12	357.42	321.99	6 925.49
1997-1998	-	125.98	2 223	3 907.1	1 955	2 927.00	1 660	1 320.97	223.80	172.21	8 453.26
1998-1999	-	324.30	6 123	3 503.62	800	1 301.88	4 457	999.00	881.02	220.58	6 349.38
1999-2000	2 725.2	256.04	3 445	3 400.00	1 057	1 064.00	1 139	705.00	159.80	158.17	5 598.21
2000-2001	4 598.0	518.46	5 741	4 021.00	1 946	2 551.00	3 548	1 536.00	109.80	123.80	8 741.26
2001-2002	4 047.0	347.75	-	5 090.02	1 774	2 353.99	8 924	5 312.90	304	142.91	13 247.57
2002-2003	4 448.0	535.21	-	4 359.68	3 365	4 324.32	12 425	6 617.06	917	524.50	16 360.78
2003-2004	3 843.0	465.58	-	7 228.36	3 238	4 989.26	6 968	5 900.71	4 575	2 419.38	21 001.29
2004-2005	2 987.0	474.96	-	5 731.23	2 246	2 873.95	3 477	6 407.39	2 733	1 536.32	17 023.85
2005-2006	594.0	99.78	-	4 079.33	7 700	11 261.30	1 500	1 068.07	667	441.76	16 950.24

Q = quantity in tonnes (for live poultry Q = number ×1 000); V = value in Rs lakhs.
Sources: All India Poultry Directory, Year Book: 2003-2004; and CMIE, India's Trade.

TABLE 10
India's country-wise exports of live poultry

Country	1995-1996		1997-1998	
	Q	V	Q	V
Fowls of the species *Gallus domesticus* - FGDD (DOC)				
Bangladesh	14.52	112.2	1.50	11.97
Nepal	0.2	3.74	0.66	2.49
South Africa	-	-	1.18	12.25
United Arab Emirates	2.48	28.87	2.14	16.32
United States of America	-	-	0.09	0.52
Sub-total	17.93	144.90	0.35	4.01
Live Poultry other than FGDD (DOC)			6.07	49.01
Bangladesh	65.57	392.64	5.89	51.37
Nepal	1.01	4.15	0.61	3.00
Oman	0.23	2.07	-	-
Saudi Arabia	0.89	8.67	0.20	1.32
Sri Lanka	2.60	24.32	1.33	14.57
United Arab Emirates	0.65	7.31	-	-
Sub-total	72.99	656.98	8.54	74.99
FGDD (excluding DOC)				
Bangladesh	0.01	0.53	-	-
Nepal	-	-	0.19	1.10
Sri Lanka	-	-	0.03	0.33
Sub-total	0.01	0.53	0.33	1.56
Live Poultry other than FGDD (non-DOC)				
Bangladesh	0.50	6.20	-	-
Nepal	0.34	4.81	0.06	0.19
Sri Lanka	0.02	1.35	0.17	1.70
United Arab Emirates	-	-	-	-
Sub-total	0.85	12.36	0.23	1.88
Total	91.78	814.45	15.07	127.44

Note: Q = number in lakhs; V = value in Rs lakhs.
Source: Animal Quarantine and Certification Service Stations Department of Animal Husbandry and Dairying, Government of India.

keep breeding stock and also operate hatcheries and commercial broiler farms. There are estimated to be roughly one lakh layer farmers and an equal number of broiler farmers.[9] About 70 percent of these are small-scale (3 000 – 10 000 birds) and medium-scale (10 000 – 50 000 birds) farmers.[10] Only 10 percent are large-scale farmers with units varying from 50 000 to 4 lakh birds.

Large farms require a good level of automation. Automation has become necessary for a number of reasons, such as hygiene and sanitation, disease prevention and, in the case of hatchery operations, to produce a greater number of chicks in a single hatch and to ensure better quality chicks. The whole organized poultry sector uses hybrid varieties of poultry and has adopted cages. The small and marginal farmers generally operate on the deep litter system.[11] In terms of technology, farmers have adopted new feeding and water systems and new management, healthcare and hygiene practices.

A distinctive feature of Indian poultry production is that it is self sufficient, supported by a very broad and strong genetic base in which the productivity level (feed conversion ratio – FCR) of broilers and layers is equal, if not superior, to those found in developed countries such as the United States of America and the European Union. India is also one of the few countries of the world, which has put into place and a sustained specific pathogen free (SPF) egg production project, which can be described as the last word in poultry technology.

There are a dozen processing units for broilers and about three units for egg processing (a further three are not producing at present). All egg-processing units, such as Balaji Foods of Venketeswara Hatcheries and SKM of Erode, have put in place the hazard analysis and critical control point (HACCP) system in their processing units.

The poultry processing industry in India is still at a nascent stage and is growing at a very slow pace. Most chickens in Thailand, Indonesia and Malaysia are processed and branded. However, in India only 2 to 3 percent of the total poultry meat is processed. The major impediments to the poultry processing are as follows:

- Indian consumers mostly prefer live and fresh chicken butchered before their eyes, which results in 95 percent of chickens being slaughtered by the retailers in a very unhygienic manner.
- a lack of cold chain facilities, exacerbated by power shortages, which makes it difficult to make frozen, freshly chilled chicken available to the consumer; and
- a lack of promotional campaigns for chicken products, as some sections of society are opposed to non-vegetarian food.

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[9] See Mehta *et al*. (2002).

[10] Since the 1980s, there has been a great change in both structure and size of layer and broiler farms. Particularly, broiler farms have grown rapidly both in terms of number and size. Earlier, broiler farms would raise a few hundred birds per cycle, whereas today farmers raise 10 to 15 thousand birds per week cycle (Mehta *et al.*, 2002)

[11] See Mehta *et al*. (2002).

2.11 Major players in the poultry industry

Venketeswara Hatcheries (VH), one of the leading names in the poultry industry in India, has played a major role in disseminating the latest techniques in poultry keeping and animal health care. It undertakes activities such as pure-line breeding, supply of grandparent and parent stock, feed manufacturing, chicken processing, egg processing, SPF production, poultry vaccine production, diagnostic services, human-resource training and production of pet foods. It is also the first Indian company selling processed chickens under the "Venky's" brand name. It supplies a number of large international fast-food companies. The product range caters to retail as well as institutional markets, and includes fresh chilled chicken, frozen chicken (whole, boneless and portions), and several economy products. Venky's Mintomein, an array of ready-to-cook products (freezer-to-fryer, microwaveable and cold cuts) has wide appeal among homemakers. Although, the company has operations in all parts of India, it is concentrated in the south and west. Despite the liberalized trade regime, the conglomerates constitute around 80 percent of the layer market and 65 percent of the broiler market.

Godrej Agrovet set up its integrated poultry business in 1999. Today, the company covers the whole spectrum of the poultry industry, from breeding, hatching and rearing of broilers to processing and marketing of its branded chicken "Godrej Real Good Chicken". It also has contract farming operations in south and west India working with 1 000 farmers.

2.12 Supporting sectors

India is almost self-sufficient as far as inputs required for producing eggs and chicken meat are concerned – the industry receives excellent support from its various input industries. They consist of a network of about 600 hatcheries, 10 000 veterinary pharmaceuticals, numerous equipment manufacturers, 130 feed mills and several education and research institutes. However, there has been insufficient production of maize, a major feed ingredient, in India during last couple of years.[12]

Hatcheries produce almost all commercial breeds of chicks that are available in North America and Europe. The annual turnover of the veterinary pharmaceutical sector is estimated to be Rs 75 000 million, indicating the presence of a vital support service to country's poultry industry. The growing veterinary infrastructure – 40 000 veterinary hospitals/dispensaries/first aid centres – provides health care. In addition to several veterinary colleges and premier institutes, each state government extends technical and marketing support through the cooperative sector. In spite of the tremendous progress made in developing diagnostics and vaccines, serious problems still exist with respect to disease surveillance and monitoring because of lack of adequate infrastructure. India is self sufficient in all basic equipment that is required for rearing and breeding poultry. All nationalized commercial banks in the country provide facilities to invest in poultry ventures.

[12] Compound feed is not very common in India – around 30 percent of poultry feed is made up of compound feed. Maize and soybean are the major feed components used in India.

2.13 Vertical integration/contract farming

The economies of scale that have led to integrated poultry production in other countries have also begun to take hold in India. In southern and western parts of India, large-scale vertical integration is catching up especially in broiler production. Under this system, the integrator invests in the entire value chain, including:

- grandparent farms;
- parent stock farms;
- hatcheries; and
- feed mills.

Poultry farmers invest in poultry sheds and equipment on their existing land. Integrators provide:

- day-old chicks;
- feed;
- medicines/vaccines;
- training to farmers in process and cost management; and
- technical supervision.

Integrators take the broilers at around 42 days of age, and farmers are paid growing charges according to agreed rates. The farmers are given an incentive bonus if the FCR and/or mortality rate is better than the contracted level. Thus, the farmers get considerable price insurance. Moreover, the advantage is that there are no intermediaries: only integrator – farmer – wholesaler in the market. Farmers do not have to make any investments in working capital. There is also no risk to farmers from fluctuations in selling process – they get a fixed income. This arrangement has encouraged a number of small farmers to enter the poultry business in order to supplement their income with a stable return on their investment.

Poultry integrators have been expanding rapidly in the states of Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra. In Pune, in the State of Maharashtra in western Indian, a major poultry rearing area, about 6 000 poultry farmers are on contract with Venkateshwara Hatcheries, popularly known as Venky's, or with Godrej Group. Similarly, in the south, particularly in the Coimbatore area of Tamil Nadu, integrators now reportedly account for 75 percent of production and consumption. Integration has moved rather slowly in the northern and eastern parts of India.

The current status of integration is: South – 80 percent; West – 70 percent; North – 10 percent; and East – 50 percent.[13]

[13] Source: Suguna Group, personal communication. Contract farming in India is still not legal, and the poultry sector falls under state rules. The integration process was started by Venkateshwar Hatcheries in the mid-1980s in the south and the north, but it failed miserably in most areas. It was again started during mid-1990s when large numbers of small and medium farmers stopped producing chicken products. Integration started to draw on the services of some of these experienced farmers utilizing infrastructure such as shades. Integration increased in popularity in the south and then in the west. In the north, it did not become popular, probably because: i) there were significant differences in the costs of production during different seasons; ii) farmers were not ready to honour contract integrators, if market prices were high; and iii) a large number of the farmers had benefited from the green revolution in Punjab, Haryana and Western Uttar Pradesh. However, there are two or three integrators operating exclusively in the north along with some national-level integrators.

BOX 1
Suguna Poultry Farm Ltd

The Rs 1 400-crore Suguna Poultry Farm Ltd produces over 55 lakh broiler chickens through a large network of contract farmers across the country (except in the Kerala). They are marketed as live birds, dressed whole birds, and processed and branded parts. It has launched its branded eggs, "Sumegga Pro" sourced from its own high-tech layer farm in Namakkal. The farm has a capacity to produce 6 000 to 8 000 eggs a day. The company is implementing a Rs 950-crore long-term programme for setting up hatcheries and feed mills across the country. It is seeking a US$20 million (Rs 100 crore) IFC (International Finance Corporation) loan for the projects. IFC has already invested Rs 50 crore (US$11 million) as equity in Suguna Poultry Farm. Work is under way to build four hatcheries, two in Andhra Pradesh and one each in Tamil Nadu and Maharashtra. They will be completed this year (2007). Suguna has a tie-up with Ross Breeders, United Kingdom, for the supply of grandparent chicks. The company is also setting up four feed mills, two in Andhra Pradesh, and one each in Karnataka and Maharashtra. Suguna is also experimenting with contract farming in maize, the main ingredient of chicken feed, in Karnataka. It has tied up with farmers for the cultivation of 16 000 acres (6 474 hectares) of maize this season. If the experiment is found to be successful it will be replicated in all other maize-growing states in the country. Suguna, which revolutionized the way chickens are grown and marketed in India, has established itself in the market for a variety of chicken products. The Indian market is still a live-bird market, and Suguna has a very large network for retailing live birds. It caters to the high-end market, and branded restaurant chains from its high-tech processing plant Supreme Suguna Food Co. Ltd, a joint venture with Supreme Foods Co. Ltd in the Gulf. A small portion of the products are exported. Suguna is a major supplier to McDonald's in India. Suguna owns the "Sugies" brand of ready-to-cook preferred chicken parts sold through high-end retail stores. The next stage in chicken marketing would be the introduction of ready-to-eat products such as sausages and nuggets.

Source: personal communication.

Key players in integration include:

1. Venkateshwara Hatcheries
2. Suguna
3. Godrej
4. Shanti
5. Taffa
6. Arumbagh
7. Skylark

Integration has not only contributed to greater production efficiencies including lower FCR and mortality rates, but has also reduced marketing margins as a result of the increased market power of the integrator. Besides reducing production costs, the integrators have helped to cut consumer prices by cutting into the traditionally large marketing

TABLE 11
Type of vertical integration or contract farming common in the broiler industry

Broiler farmer	Integrator
Owns the broiler shed and equipment. Buys deep litter/cage material. Attends to rearing activities, such as brooding, feeding, watering (own labour or hired labour). Bears cost of electricity/fuel for brooding. Takes the manure (litter) and empty gunny (food) bags.	Supplies the following inputs: • day-old broiler chicks (owns a breeder farm and hatchery for this purpose); • broiler food required by the birds (owns a feed-mixing unit); • medicines and vaccines (buys quality medicines and supplies them to the farmers as required); and • emergency and routine veterinary services (engages qualified veterinarians for the purpose). Pays the rearing cost to the farmer to meet the cost of litter, labour, electricity, rent for buildings and equipment, and also a part of the profit. Takes back the grown broilers and arranges for their sale mostly through traders.

Sources: personal communication.

TABLE 12
Partnership activities in the layer industry

Input by the farmers	Input by the trader
Land and housing	Feed
Equipment and cages	Vaccines
Chicks	Marketing of eggs
Medicines	Transport
Labour	Consultancy
Electricity	

Sources: personal communication.

margins. The integrators have tended to establish wholesale and retail price leadership in the markets where they operate by reducing the number of intermediaries or by selling directly through their own retail outlets (e.g. in Coimbatore). In other regions, particularly in the north, traditional wholesalers still dominate the markets and marketing margins and retail prices are considerably higher than in the south. Lower retail prices have stimulated consumption, with per capita consumption in southern India reported to be 4 times the national average.

2.14 Producers' association

The National Egg Coordination Committee (NECC), which has a membership of more than 25 000 farmers, is probably the largest association of poultry farmers in the world. Its genesis goes back to 1981. Around this time, the Indian poultry industry was going through an unprecedented crisis. The intermediaries controlled trade and forced prices down. As

a result, farmers were being paid less than their production costs. The scenario looked quite bleak. Over 40 percent of farmers had stopped operations because the business had become economically unviable – feed costs had more than doubled, but egg prices remained static at 35 paisa. Determined to do something, the late Dr B.V. Rao, along with a group of farmers, started a mass movement – they travelled across the country holding meetings with farmers and traders. Their objective was to unite poultry farmers from all over India, and see that they get better prices by eliminating intermediaries from the trade. Thus, NECC was born. Since then, NECC has played a significant role in the betterment of poultry farmers, and the egg industry in general, through its various programmes such as market intervention, price-support operations, egg promotion campaigns and consumer education.

The manifold activities of NECC include:

- price declaration;
- deciding a reasonable price for eggs that ensures a reasonable return for the farmer, decent margins for the intermediary and a fair price for the customer;
- monitoring the egg stock levels in different production centres;
- managing stock levels and regulating the movement of stocks from surplus to deficit regions so as to maintain a balance between demand and supply;
- market intervention through Agro Corpex India Ltd;
- organizing and uniting poultry farmers across the country;
- creating a dependable distribution network so that eggs can reach every household in every village;
- generating employment by encouraging people to take up egg farming and egg trading;
- promoting exports and develop export markets;
- making available technology and information for increased production of eggs;
- obtaining governmental support and financial aid from banks for various schemes in rural India;
- creating awareness among customers;
- undertaking egg promotion campaigns to increase the consumption of eggs;
- conducting market research, identify potential market and develop new markets; and
- preparing and submitting position papers to the government on issues affecting the poultry industry.

NECC is a completely voluntary body created by farmers, and runs on cooperative spirit. It makes no profits and subsists mainly on contributions from its members. Most of today's egg production comes from NECC members.

In the broiler sector, there is no national organization that looks after the producers' interests. No doubt, some regional organizations (e.g. the Broiler Growers' Association) have emerged and are trying to organize farmers, but the broiler marketing is largely in the hands of big traders and commission agents in mandis (wholesale markets) like Ghazipur in Delhi and Crawford market in Mumbai. In general, intermediaries are vital links between producers and consumers. The margin between the farm gate price for broilers and the price paid by the consumer is about 20 to 25 percent.

There are also efforts by a southern-based consortium of broiler producers and marketers (the National Broiler Coordination Council) to promote the consumption of poultry meat and to stabilize wholesale prices of poultry meat.

2.15 Government-supported infrastructure

Infrastructure is in place at the government level to promote the poultry industry through financing by the National Bank for Agriculture and Rural Development (NABARD). As banks and the National Cooperative Development Cooperation (NCDC) have started financing small and marginal farmers in villages, poultry insurance has also been introduced under the Indian Rural Development Programme (IRDP). The General Insurance Corporation (GIC) of India has introduced poultry insurance which covers the following:

- comprehensive cover for poultry farmers;
- epidemic poultry insurance through hatcheries; and
- poultry insurance schemes for parent stock through hatcheries.

Agriculture and Processed Food Products Export Development Authority (APEDA)

The Agriculture and Processed Food Products Export Development Authority (APEDA) came into existence in 1986 in order to promote exports of agricultural commodities and processed food products. Promotion of processed farm produce, in turn, benefits farmers through: (a) higher returns for products sold in the export market; and (b) creation of employment opportunities in rural areas through various kinds of processing activities. The main function of APEDA is to build links between Indian producers and global markets; to achieve this, APEDA seeks to identify new markets, provide better support systems for exporters and manufacturers, and introduce new products into the international market. The main activities of APEDA include the following:

- development of a database of products, markets, and services;
- publicity and dissemination of information;
- receiving official and business delegation from abroad;
- organization of product promotions abroad and arranging visits abroad for official and trade delegations;
- participation in international trade fairs in India and abroad;
- organization of buyer-seller meetings and other business interactions; and
- dissemination of information through newsletters and feedback.

APEDA also offers financial assistance under various schemes to promote agro-exports, including poultry. The following are some of the activities that are eligible for financial assistance:

- strengthening market intelligence and databases through studies and surveys;
- quality upgrading;
- development of infrastructure facilities;
- research and development; and
- upgrading of meat processing facilities.

2.16 Summing up

In short, the poultry industry has been growing at a fast pace, the number of broilers has increased ten fold and egg production has doubled. Supporting industries are also keeping pace. Above all, the growth of the poultry industry should be viewed not only in terms of the commercial success it has achieved, but also as one of the core support systems for small and marginal farmers.

3 FACTORS BEHIND THE GROWTH OF THE POULTRY INDUSTRY

3.1 Important government initiatives

In discussing policy initiatives, a clear distinction is made between the pre-reform and post-reform periods. The former refers to the period up to June 1991, when the policies were too restrictive and highly centralized. The latter refers to the period after June 1991, during which the government sought to open up the economy and integrate it with the world economy by relaxing controls and regulations especially on trade and industry.

Policies affecting the sector in the pre-reform period

Major policy initiatives sponsored by the government during this period were:

- Launching the All India Poultry Development Programme which led to a sharp increase in the number of commercial farms. As a result, poultry farming emerged as a leading component of the livestock sector. The main strategy during successive five year plans has been to increase production of eggs and poultry meat through increasing the availability of chicks and supply of inputs such as feed and health care, and making cold storage facilities available.
- Poultry farming was recognized as an important activity for poverty alleviation. Hence, the weaker sections of society, such as small and marginal farmers, and agricultural labourers were provided with help through credit facilities, subsidy and technical assistance to adopt poultry farming as a supplementary source of income.
- Establishment of a number of poultry estates in collaboration with government-initiated agencies, such as the National Cooperative Development Corporation (NCDC) and the National Bank of Agriculture and Rural Development (NABARD), state governments and non-government organizations (NGOs).
- Funding several research activities related to poultry breeding and health management. This included setting up various regional poultry breeding farms, introduction of Intensive Poultry Development Projects (IPDP), and setting up a Central Training Institute for Poultry Production and Management (CTIPPM) in Bangalore.

In its drive for self-sufficiency, the government insisted that India should have its own genetic programme, so that the requirement for DOCs can be met domestically without depending on imports of grandparents. Thanks to such efforts, India has now become more or less self-sufficient in terms of grandparents, parents and DOCs. VH group's BV-300 accounts for 85 percent of the layer market, while Vencobb accounts for around 65 percent of India's broiler market.

Again, as part of the drive to self-sufficiency, imports of all poultry products were banned or restricted through tariff and quantitative restrictions. For instance: "live poultry" (HS 02.02 and 01.15), "meat and edible offal... of the poultry, fresh, chilled or frozen" (HS

BOX 2
Central government expenditure on poultry development

Plan period	Total plan outlay (Rs million)	Expenditure on poultry (Rs million)	Expenditure on animal husbandry (Rs million)
Second plan : 1956–61	46 000.00	28.00	334.00
Third plan: 1961–66	85 765.00	46.00	770.00
Annual plan 1966–69	66 254.00	-	597.00
Fourth plan: 1969–74	157 788.00	115.00	1 542.60
Fifth plan: 1974–78	394 262.00	355.00	2 324.60
Annual plan: 1978–80	-	NA	2 087.70
Sixth plan: 1980–85	975 000.00	426.00	3 374.20
Seventh plan: 1985–90	1 800 000.00	602.00	4 767.80
Eighth plan: 1992–97	4 341 001.00	NA	11 234.80
Ninth plan: 1997–2002	8 592 000.00	NA	15 456.40
Tenth plan: 2002–2007	15 256 390.00	NA	17 450.00

Note: NA = not available.
Sources: GOI Economic Survey, various issues.

02.02), and "birds eggs in shell, preserved or cooked" where in the restricted category. All processed poultry meat preparations where subject to a duty of 35 percent. Though the duty rate was comparatively low, there were quantitative restrictions.

Policies affecting the sector in the post-reform period

As mentioned above, in June 1991 India launched a policy of economic liberalization with a view to integration into the world economy. Under the new policy regime, the government sought to simplify rules and regulations governing industry, liberalize taxation policies and relax foreign exchange regulation. Initially, the thrust of liberalization rested only on the industrial sector; the agriculture sector was not touched. In 1997, liberalization of trade in agriculture and consumer food products was initiated by shifting several of these items from the "restricted status" category to the "open general license (OGL)" category. Table 13 shows the number of items/lines placed under OGL from 1995 onwards. It can be seen that the coverage of OGL rose from less than 10 percent of all commodities in the pre-reform period to 56 percent in April 1995 and 94 percent in April 2001. In short, all the quantitative trade restrictions banning or restricting imports of agricultural commodities and consumer food items were being dismantled from 1997 onwards. From then on, tariffs would be the most important instruments in managing India's imports.

Table 14 shows how this policy reform affected the poultry sector. The table displays the tariff rates applicable to different poultry products for the years 1999 to 2005. Note that prior to 1999 all these products fell within the "restricted category". In 1999-2000, however, all were shifted to OGL, with tariff rates ranging from 15 percent ("meat, and edible offal, of the poultry of heading 01-05, fresh, chilled or frozen") to 40 percent ("live poultry, that is to say, fowls of the species *Gallus domesticus*, etc." and "sausages or similar products ... based on these products"). In 2001-2002, the rates were revised to 35 percent, with

TABLE 13
India's imports subject to quota restrictions, 1995 to 2004

Year	Percentage of commodity lines* that are free of restrictions
April 1995	56.00
April 1997	65.80
April 1998	70.20
April 2000	86.41
April 2001 onwards	94.37

* At 8 or 10-digit harmonized system level.
Sources: Mehta (1997); Mehta (1999).

a few exceptions. Thus, for items under the headings "cuts and offal, fresh or chilled; of fowls of the species *Gallus domesticus* (0207.14), "sausages and similar products, of meat, meat offal or blood; food preparations based on these products" (1601.00) and "of fowls of the species; of poultry of heading No. 01.05" (1602.32) the tariff rates were raised from the prevailing 15 percent rate to 100 percent. In 2004-2005, the rates were lowered to 30 percent, while the four items cited above continued to have a 100 percent tariff rate.

What can be said regarding the effects of trade liberalization on the poultry industry in general? It will not be easy for the industry to survive in the new environment. The domestic industry is definitely price competitive in the egg segment and to some extent in broilers. But this has to be viewed in the context of production subsidies and export subsidies prevailing in the United States of America and in European countries. The presence of such subsidies leaves India at a price disadvantage. This might lead to reckless imports, erode the country's genetic base and increase its dependence on imports.

Policies affecting feed products

The poultry industry is highly dependent on feed ingredients. Feed alone constitutes 70 percent of the costs of producing broilers and eggs. Hence, the prices of feed ingredients have a substantial effect on the costs of egg and broiler production, and thereby on its profitability.

The main feed ingredients are maize, soy, rice bran, and groundnut cake. Of these, maize is the most crucial in India – alone accounting 80 percent of the feed consumed. Hence, the availability of maize at a competitive price will determine the growth of egg and broiler production. The availability of maize depends first on domestic production and second on imports.

The domestic production of maize is, like that of all other agricultural commodities, dependent on the area under cultivation and the yield per hectare. The area under maize cultivation has remained stagnant at around 6 to 7 million hectares. Similarly, the yield per hectare is around 2 tonnes per hectare, which is one of the lowest in the world. Furthermore, its production, like all other agricultural commodities, is dependent on monsoon; and very often there has been a severe shortage of maize owing to failure of monsoon which in effect has led to high feed costs. Overall, maize production in India has remained stagnant

TABLE 14
India: Most Favoured Nation tariffs and Uruguay Round bound rates for poultry products

Harmonized system (commodity groups)		India's tariff rate[b] (%)			UR final bound rate[c] (%)
HS code[a]	HS description	1999-2000	2001-2002	2004-2005	
01.02	Live bovine animals				
0102.10	Pure-bred breeding animals	40	35	30	100
Ex 0102.10	Cows, heifers, bulls, goats, sheep, and pure line poultry stock	5	5	5	100
0102.90	Other	40	35	30	100
Ex 0102.90	Grand parent poultry stock and donkey stallions	25	25	N.A.	100
01.05	Live poultry, that is to say, fowls of the species *Gallus domesticus,* etc.				
0105.11	Fowls of the species *Gallus domesticus*; weighing not more than 185 g	40	35	30	100
0105.92	Fowls of the species *Gallus domesticus*, weighing not more than 2 000 grams; other	40	35	30	100
0105.93	Fowls of the species *Gallus domesticus*, weighing more than 2 000 grams; other	40	35	30	100
02.07	Meat, and edible offal, of the poultry of heading 01.05, fresh, chilled or frozen				
0207.11	Not cut in pieces, fresh or chilled; of fowls of the species *Gallus domesticus*	15	35	30	100
0207.12	Not cut in pieces, frozen; of fowls of the species *Gallus domesticus*	15	35	30	352
0207.13	Cuts and offal, fresh or chilled; of fowls of the species *Gallus domesticus*	15	100	100	100
0207.14	Cuts and offal, frozen; of fowls of the species *Gallus domesticus*	15	100	100	100
Ex 0207.34	Fatty livers, fresh or chilled; of ducks, geese, etc.	15	35	30	352
04.07	Birds' eggs, in shell, fresh, preserved or cooked	35	35	30	150
04.08	Birds' eggs, not in shell, and egg yolks, fresh, dried, cooked by steaming or by boiling in water, molded, frozen or otherwise preserved, whether or not containing added sugar or other sweetening matter	35	35	30	150
0408.19	Egg yolks: other	35	35	30	150
0408.91	Other than egg yolks: dried	35	35	30	150
0408.99	Other than egg yolks: other	35	35	30	150
1601.00	Sausages and similar products, of meat, meat offal or blood; food preparations based on these products	40	100	100	150

(Continued)

TABLE 14 (*Continued*)
India: Most Favoured Nation tariffs and Uruguay Round bound rates for poultry products

Harmonized system (commodity groups)		India's tariff rate[b] (%)			UR final bound rate[c] (%)
HS code[a]	HS description	1999-2000	2001-2002	2004-2005	
16.02	Other prepared or preserved meat, meat or blood				
1602.10	Homogenized preparations	40	35	30	552
1602.20	Of liver of any animal	40	35	30	150
1602.31	Of turkeys; of poultry of heading No. 01.05	40	35	30	150
1602.32	Of fowls of the species; of poultry of heading no. 01.05	40	100	100	150
1602.39	Other, of poultry of heading no. 01.05	40	35	30	150
1602.41	Of swine, hams and cuts thereof	40	35	30	552
1602.42	Of swine, shoulders and cuts thereof	40	35	30	552
1602.49	Of swine; other, including mixtures	40	35	30	150
1602.50	Of bovine animals	40	35	30	150
1602.90	Other, including preparations of blood of any animal	40	35	30	150

Notes:
a. The commodity groups defined by the Harmonized System of Indian Trade Classification (HS-ITC), in 1999/2000.
b. These rates represent the most favoured Nation (MFN) tariff rate defined as the Basic Custom duty (ad valorem) in Indian custom classification. The different types of exemptions are not taken into consideration to work out the rates.
c. The Uruguay Round Final Bound Rates. The definition of Harmonized System (HS) Codes for some items was different during the year of Uruguay Round commitments. The final bound rates are worked out after making correspondence between the custom classification (HS) of the Uruguay Round negotiation period (1992) and HS-1996.
[1] The basic custom duty of Grand Parent Poultry Stock is 25 percent instead of 35 percent.
[2] Commitments for these items were made in earlier rounds.
Sources: WTO (1995); GOI, Custom Tariff of India, various issues.

at around to 10–11 million tonnes *per annum* (see Table 15). Of this, the current consumption requirement of the poultry industry alone is 5 million tonnes. It is estimated that by the year 2020 the requirement of the poultry industry will rise to 31 million tonnes,[14] assuming that the egg production grows at the rate of 10 percent *per annum,* and broilers at the rate of 20 percent *per annum*. If these estimations hold good, there is a risk of a major imbalance between supply and demand – supply or availability falling short of demand. There are two ways to bridge the gap. One is to increase domestic production by adopting improved seeds for cultivation. The other is to import maize. To promote the former, the government has already set up a Maize Development Mission under the Technology Mission of the Government of India. The Mission is urged to intensify research and development to increase yields, oil content, etc. in order to cope with the mounting demand.

[14] Confederation of Indian Industry (CII) and McKinsey (1998).

TABLE 15
Maize availability, 2000-2001 to 2006-2007

Year	Area under cultivation (million hectares)	Production (million tonnes)	Yield (tonnes per hectare)
2000-2001	6.61	12.04	1.82
2001-2002	6.59	13.16	2.00
2002-2003	6.45	10.30	1.60
2003-2004	6.77	12.77	1.89
2004-2005	7.00	13.58	1.94
2005-2006	6.70	13.50	2.01
2006-2007	7.10	11.00	1.55

Sources: GOI, published data.

TABLE 16
Production of soybean, 1999-2000 to 2004-2005

Year	Production (million tonnes)
1999-2000	7.08
2000-2001	5.28
2001-2002	5.96
2002-2003	4.65
2003-2004	7.82
2004-2005	6.88
2005-2006	8.35

Sources: RBI (2005-06).

In 2000-2001 the government announced a tariff quota (TRQ) for maize imports. Under this regime, imports of maize up to 350 000 tonnes attract a duty rate of 15 percent, and imports above attract a duty rate of 50 percent. Soon after this announcement the maize price in the domestic market stabilized. Currently (2007-2008), the in-quota limit stands at 4 lakh tonnes with a tariff of 15 percent; above that, 50 percent duty is applied with the request from Agriculture Ministry; however, even the 15 percent duty is being waived.[15] To sum up, the domestic price of maize in the medium to long term can be expected to depend on: (i) domestic production; and (ii) the level of applied tariff. That means there will be increasing pressures on farmers to switch to high-yielding varieties and on government to reduce applied tariff on maize.

[15] As per the Finance Ministry notification, the existing policy in items falling at EXIM Code 1005 9000 [Maize (Corn), others] shall remain in abeyance till 31st December 2007. During this period, imports of this item will be allowed freely (See Custom Tariff 2007-08).

TABLE 17
Soybean demand and supply situation, 2003

	Quantity (1000 tonnes)
Total production	6 800
Imports	2.89
Stock variation	500
Export	253.1
Seed	444
Food manufacture	6 045
Waste quantity	328.5
Food	232.29

Source: FAOSTAT.

After maize, the next widely used feed is soy. The annual production of soybean is shown in Table 16. Its current demand and supply situation is given in Table 17.

It is envisaged that during the next three to four years, industry will demand an additional 2.50 million tonnes over and above the existing production. That means additional cultivation will be required to meet the additional demand.

3.2 Financial incentives

The Indian agriculture sector gets direct and indirect subsidies in the form of fertilizer, pesticides, electricity, etc. Although the poultry industry is an integral part of agriculture, and treated on a par with the rest of the livestock sector in India, it faces restrictions on its use of agricultural land, attracts higher electricity tariffs and sales tax than agriculture, pays tax on income earned from poultry farms, and is subject to different land and labour law,. It is also not getting benefits such as tax holidays which are enjoyed by a number of Indian industries. Another point worth mentioning in this context is that a large number of products are reserved for exclusive manufacture in the small-scale sector. A few years ago, the poultry feed sector fell into this category and was not subject to larger investments. The industry could not enjoy the benefits of operating on a large scale.

3.3 Foreign direct investment in the poultry sector

Foreign direct investment (FDI) has not been a significant factor in the expansion of integrated poultry operations. A large integrator operating in both the southern and western regions runs a processing facility built recently with the assistance of private investment from Saudi Arabia. Two large Asian integrators, Japfa from Indonesia and CP from Thailand, have been in the feed business in India for several years, but so far have not expanded into poultry integration. Although farms are importing breeding stock and technology from foreign breeders, there is currently almost no FDI in the broiler sector. FDI is more common in pharmaceuticals (poultry production inputs) where most companies are either multinationals or Indian joint ventures with multinationals. Most drugs or vaccines for poultry

are produced by these units. The major feed companies are Indian owned.[16] According to the Reserve Bank of India, the actual inflow of FDI in the food and food-processing sector was more than US$711.4 million (Rs 3 187 crores) up to March 2004. Nearly 30 percent of FDI in this sector comes from EU countries such as the Netherlands, Germany, Italy and France.[17]

Constraints affecting the inflow of FDI in the poultry sector include:

- poor power and transport infrastructure;
- poorly defined phytosanitary measures;
- limited market for frozen poultry;
- lack of cold-chain facilities making it a difficult task to handle significant volumes of chilled or frozen products;
- competitive local prices; and
- high taxes on processed food.

A more favourable policy environment than is presently available is therefore warranted. This would include: policies for improving infrastructure facilities which will help to stabilize the price of poultry products, creating efficient marketing channels that will help producers to obtain more remunerative prices; and increasing maize production by using improved seed varieties (FAO, 2003). Landes *et al*. (2004) note that "with the expansion of the poultry industry, the country's government must address these new issues, including economic tradeoffs between poultry producers, feed producers, and consumers, potential public health concerns associated with traditional slaughter an marketing practices, and additional tariff and non-tariff policies for imports".

3.4 Veterinary health care services

In India, animal husbandry is administered at state level. During the 1970s, when the poultry industry was just picking up, the state governments provided veterinary care services to local farmers. But since the emergence of private companies in breeding, it has been these operators that have helped to sustain the growth of the poultry sector. The farmers are well aware of the need to safeguard the health of their birds. A number of hatcheries also provide animal health services to farmers. Veterinary products and diagnostic facilities are readily available to most farmers. Large farmers/integrators employ their own veterinary consultants. The danger of flock disease is relatively low in India.

Both the public and the private sectors in India produce vaccines for use in the poultry sector. Vaccines are produced by these institutions with the use of SPF eggs as mandated and laid down by British Pharmacopoeia. The private sector is more prominent in vaccine production, production of animal health care products and other drugs required by the poultry sector. The role of government is that of a facilitator and administrator of the legal framework. Organizations like NECC are engaged more in promotional activities than in production. The prices of vaccines, animal health products and food additives in India are either comparable or slightly higher than international prices. In terms of quality, they meet international standards.

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[16] Economic Research Survey/USDA: Development of prospects/WRS-04-03.

[17] Government of Kerala, Virtual University for Agriculture Trade, Project by Department of Agriculture.

As mentioned above, India also has very successful breeding operations supported by research and development, biosecurity measures and strict quarantine for the breeder flocks. The breeding operations are supported by hatchery health and hygiene. The breeding flocks are subject to compulsory tests for salmonella. Disease and diagnostic laboratories are located in different regions, in addition to institutions such as the Indian Veterinary Research Institute. The private sector has set up its own sophisticated laboratories for surveillance and diagnostic services.

3.5 Food-safety standards and trade in processed foods

International trade in processed food has grown substantially during the past two decades. The main factors that have propelled its growth include rising incomes, changing food consumption habits and consumers' preferences for "ready to eat food". This rapid expansion in international trade of processed food products has in turn given rise to some new concerns regarding food safety, i.e. that food is safe and free from contaminants, toxins and diseases-causing organisms. Effective hygiene and safety controls are therefore vital to avoid the adverse consequences of food-borne diseases, food-borne injury and food spoilage.

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures sets out the basic rules for food-safety and animal and plant health standards. It allows countries to set their own standards, but it also stipulates that regulations must be based on science. They should not arbitrarily or unjustifiably discriminate between countries where identical and similar conditions prevail.

One of the problems with these standards is that these are so stringent that many countries, especially developing countries, have difficulty in implementing them. India is no exception, and is trying to harmonize its standards with those of the FAO/WHO Codex Alimentarius. However, there is a feeling in the industry that sometimes the importing countries, particularly for egg products, are using these food-safety standards in a discriminative manner (Mehta, 2005). Though, Indian standards for egg processing plants have been derived from USDA and EU regulations, many countries, including Australia, do not recognize these standards, and equivalence has not been granted by many developed countries. Similarly, the importing countries do not approve the veterinary certificates issued by competent authorities like the Export Inspection Agencies, and insist on a separate health certificate issued by the veterinary authorities. In some cases, the importing countries have their own specifications which differ from their own national standards. It is therefore evident that despite the spirit of the SPS and the Technical Barriers to Trade (TBT) agreements, these measures are being used by developed countries to hinder exports from developing countries. There is discrimination, in spite of the fact that under Article 12 of the TBT agreement there is a mention of special and differential treatment to be given to developing-country members.

The Indian poultry sector, particularly the egg processing units, has already started integrating itself into the global system in the light of the SPS and TBT agreements. All of the egg-processing units in India already operate HACCP systems.

India has also prepared and implemented its own residue-monitoring plan for egg and chicken products. The Government of India, Department of Commerce and Industries, vide

order dated 19 December 2003, has authorized APEDA to operate a residue monitoring plan (RMP) (APEDA, 2006).

Objectives of the residue-monitoring plan: to establish the surveillance system, to monitor residues of drugs and pesticides in egg products exported to EU countries, to establish a system for corrective action in the event of detection of residues at a level higher than those permitted under the RMP.

Scope of the residue-monitoring plan: all egg processing units intending to process eggs for export, their affiliated feed mills, layer farms, recognized laboratories would get covered under these guidelines.

Monitoring and surveillance plan:

- Egg products exported to the EU will be sampled and tested by the nominated laboratories as provided in the plan.
- APEDA will decide on the nominated laboratories that will be responsible for the implementation of the RMP for each process.
- Procedures for obtaining the test certificate are laid down.
- The national reference laboratory will monitor the work of other nominated regional laboratories by conducting surveillance, and audit on a six-monthly basis to ascertain the criteria laid down under the RMP is followed properly.
- APEDA will assess the work carried out by the National Reference Laboratory.
- Nominated laboratories will submit bi-monthly statements of sample testing to the National Reference Laboratory as well as to APEDA.
- The report of National Reference Laboratory will be evaluated to ensure that test results submitted by the nominated laboratories on a bi-monthly basis are properly implemented and conveyed and that other control measures suggested by the National Reference Laboratories are implemented.

The RMP also:

- identifies a list of laboratories that have been approved and nominated by APEDA for sample testing;
- lays down procedures to be followed by nominated laboratories for sampling and testing of egg products for exports;
- describes the methods of sampling for checking the level of pesticide residue in egg products;
- describes the methods of sampling for checking the levels of pesticides and pharmacologically active substances in egg products;
- describes and gives a list of pesticide residue limits applicable for egg products; and
- provides a list of maximum residue limits for pharmacologically active substances.

While these regulations are certainly for export purposes, the Indian poultry sector is also looking to implement domestic standards. The quality standards that govern the food industry include: Prevention of Food Adulteration Act, 1954 (PFA); Vegetables Product Order, 1967 (VPO); Food Products Order, 1955 (FPO); Meat and Food Products Order, 1973 (MFPO); Meat and Meat Product Order, 1992 (MMPO); Agriculture Produce (Grading and Marketing) Act, 1973; Bureau of Indian Standards (BIS); Export Quality Control and Inspection Act, 1963. Good manufacturing practices (GMP), good hygiene practices (GHP), HACCP, Codex, Alimentarius and ISO 9000 are among the other certification procedures applicable to food products.

BIS has about 700 Indian standards applicable to agricultural produce and value-added products. The key issues addressed by these standards include preventing adulteration, regulating hygienic conditions, informing consumers about the product and providing product specifications.

An integrated food law, the Food safety Standards Act 2005, has come into existence, which consolidates most of the food-related laws in India to meet international standards.

3.6 Consumer demand and preferences

Patterns of poultry meat and egg consumption in India show certain peculiarities. First, the Indian poultry market remains primarily a live bird market. The consumption of chilled and frozen poultry products is very small – only 5 percent of the total production is sold in processed form; all the rest is sold alive. Second, the demand for eggs is seasonal – very low in summer compared to other seasons of the year. Eating eggs is prohibited in certain months. Further, when fish catches are high, the demand for eggs tends to be low. Thus, the demand for eggs fluctuates throughout the year, while supply is continuous. Developing storage facilities or converting eggs into egg powder would be options to address the problem. However, the demand for egg powder has so far remained low, and building up cold storage facilities to preserve eggs takes a long time. Third, cities and towns, home to 30 percent of India's population, account for 75 percent of total poultry consumption. The annual per capita egg consumption in India's major cities, such as Mumbai, Calcutta, Delhi and Chennai, is reported to be 100 or even as high as 150 or 200. In contrast, annual per capita consumption in rural areas is as low as 15 eggs. The low consumption in rural areas is due to non-availability and higher prices.

As described in Section 3, poultry meat has been gaining prominence over other meats. It has outpaced its two main competitors – beef and veal and buffalo meat. Does this represent a shift in the preference pattern of households from other meats to poultry meat, or more generally a shift from vegetarianism to non-vegetarianism? It can be speculated that high mutton prices, religious restrictions on beef and pork consumption, and the lower availability of fish in non-coastal regions may have combined to make poultry meat the preferred and most consumed meat in India. Alternatively, expanding domestic production and increasing integration may have pushed poultry meat prices downward, probably increasing its competitiveness. The shift to poultry meat may also be attributable to growing concern over red meat-borne illnesses such as bovine spongiform encephalopathy.

Data originating from periodic surveys conducted by the National Sample Survey Organization (NSSO) constitute the main source of information on preference patterns. However, the usefulness of these data is constrained by the act that they do not include poultry as a separate item – it is grouped under "meat, fish, and eggs". However, for two rounds – the 38th and 50th rounds (years 1983 and 1993-1994) – disaggregated data are available and may be used to shed light on preference patterns.

Table 18 shows the percentage of households reporting consumption of "meat, fish and eggs" at the national level during three NSS rounds. More than 42 percent of households in both urban and rural areas did not consume meat, fish and eggs in 1999-2000. Moreover, the change in preference is slow. Between 1987-1888 and 1999-2000, the proportion of people consuming any of the three items increased by 1 only percent in urban areas and by 4 percent in rural areas.

Obviously, it would be interesting to know whether there is a noticeable change within the product category "meat, fish and eggs". The NSS data tabulated from 38th (1987-1988) and 50th rounds (1993-1994) are summarized in Table 19. These data show that in rural areas, fish is preferred over eggs, while there is no special preference between fish and goat meat. The story is different in urban areas. There, eggs are preferred over fish and goat meat. The conclusion that can be drawn from this is that eggs seem to have entered the vegetarian diet of urban people but not of rural people. Note, however, that although rural people exhibit lower preference for eggs compared to urban people, the change in the preference pattern in favour of eggs is higher in rural areas than in urban areas. For instance, the percentage of households consuming eggs increased from 17 percent in 1987-1988 to 22 percent in 1992-1994.

As income increases, the proportion of income spent on food declines and the proportion spent on non-food items increases. This is known as Engel's law of demand. The economic growth in India over the past five decades and rising incomes are known to have brought significant changes in the consumption basket – a persistent decline in the per capita consumption of cereals, and a persistent increase in the per capita consumption of non-food items. Table 20 shows food expenditure figures for the years 1993-1994 to 2004 grouped into three broad categories: cereals; meat and fish and eggs; and other food.

The figures clearly show that non-food expenditure has been growing faster than food expenditure – leading to a steep decline in the share of food expenditure. Between 1991 and 2004, the share of food items in total expenditure dropped from 63.1 percent to 53.9 percent in rural areas and from 52.5 to 41.6 percent in urban areas. This shift from food to non-food is mainly due to decline in the share of cereals in total expenditure. The shares

TABLE 18
Proportion of households consuming meat, fish and eggs

Year	Rural (% of households)	Urban (% of households)
1987-1988	54.1	56.8
1993-1994	56.4	57.0
1999-2000	57.9	58.0

Sources: GOI, NSSO, All India National Consumers Surveys, various issues.

TABLE 19
Proportion of households consuming poultry products and other meat

Item	Rural (% of households)		Urban (% of households)	
	1987-1988	1993-1994	1987-1988	1993 1994
Eggs	17.1	22.0	32.7	34.9
Poultry meat	-	7.5	-	9.0
Goat meat	-	20.3	-	28.0
Fish	-	30.7	-	27.1

Sources: GOI, NSSO, All India National Consumers Surveys, various issues.

of meat, fish and eggs, and that of other food increased during the period under consideration. Thus, there is a shift from cereal to non cereal food. The share of cereals in food expenditure has declined from 38.4 percent to 32.8 percent in rural areas and from 25.3 to 24.0 percent in urban areas. The share of meat, fish and eggs rose from 5.3 percent to 6.2 percent in rural areas, and remained at around 6.4 percent in urban areas. In other words, while the expansion of the expenditure share of meat, fish and eggs is sustained in rural areas, it has remained stable in urban areas.

TABLE 20
Trends in the share of commodity groups in total expenditure

Year	Share in total consumer expenditure (%)					Share in food expenditure (%)		
	Cereals	Meat, fish and eggs	Other food	Total food	Total non-food	Cereals	Meat, fish and eggs	Other food
Rural								
1993-1994	24.5	3.3	35.3	63.2	36.8	38.8	5.3	55.9
1994-1995	24.6	3.2	33.3	61.1	38.9	40.3	5.2	54.5
1995-1996	23.5	3.2	33.6	60.4	39.6	39.0	5.3	55.7
1997	23.2	3.0	33.6	58.7	41.3	37.8	5.1	57.2
1998	23.1	3.3	34.4	60.8	39.2	38.0	5.4	56.6
1999-2000	22.4	3.3	33.7	59.4	40.6	37.6	5.6	56.8
2000-2001	20.3	3.3	32.7	56.3	43.7	35.8	6.3	57.8
2001-2002	19.2	3.4	32.9	55.5	44.5	34.3	6.1	59.6
2002	18.2	3.4	33.4	55.0	45.0	33.0	6.2	60.8
2003	19.8	3.4	32.8	54.0	46.0	33.0	6.0	61.0
2004	17.9	3.5	32.5	53.9	46.1	32.8	6.2	61.0
Urban								
1993-1994	14.3	3.4	37.0	54.7	45.3	26.6	6.3	67.1
1994-1995	14.6	3.4	35.4	53.4	46.6	27.3	6.4	66.3
1995-1996	13.3	3.2	33.6	50.7	49.9	26.5	6.4	67.1
1997	13.5	3.4	33.1	50.0	50.0	27.2	6.0	66.8
1998	13.3	3.4	33.2	49.9	50.1	26.7	6.4	66.9
1999-2000	12.5	3.4	32.4	48.3	51.7	26.0	6.4	67.6
2000-2001	11.0	3.3	29.8	44.1	55.9	25.1	6.8	68.1
2001-2002	10.5	3.3	29.8	43.6	56.4	24.3	6.5	69.2
2002	9.9	3.2	29.9	43.1	56.9	23.2	6.4	70.4
2003	10.0	2.7	29.3	42.0	58.0	23.8	6.4	70.0
2004	10.0	2.6	29.0	41.6	58.4	24.0	6.4	70.0

Sources: GOI, NSSO, All India National Consumers Surveys, various issues.

3.7 Trends in feed prices: maize and soybean

Feed, is the largest cost in broiler and egg production, constituting 70 percent of the total. The main feed ingredients are maize, soy, rice bran and groundnut cake. Maize and soy are the most widely used. Thus, the price movements of these two feed items will have a direct effect on the prices of eggs and broilers. Moreover, the future growth of the poultry industry will depend on the availability and price of maize and soy. The industry has projected that demand for maize in 2010 will be 16.65 million tonnes, and foresees a major shortfall in maize production. The poultry sector consumes about 50 percent of the total maize production – followed by human consumption, other livestock, starch and breweries. Farmers need to increase the area under maize cultivation and increase productivity to meet the demands of industry. Trends in the domestic wholesale prices of maize and soy meal are shown in Table 21.

It can be seen from the table that the prices of the two main feed ingredients have tended to rise. In the case of maize, prices have almost doubled: Rs 5 650 per tonne in 2005-2006 compared to Rs 2 756 per tonne in 1993-1994. Stagnating production and rising feed demand have tended to keep maize prices high. The situation is same in the case of soy. The prices of soy in 2005-2006 were 50 percent higher than in 1993-1994.

TABLE 21
Trends in the price of maize and soy

Item	Domestic price		Wholesale price index	
	Maize (Rs/tonne)	Soy (Rs/tonne)	Maize	Soy
1993-1994	2 756.00	6 300.00	100.00	100.00
1994-1995	3 417.00	7 119.00	123.80	113.40
1995-1996	4 079.00	8 001.00	147.60	126.80
1996-1997	4 437.00	9 135.00	161.10	144.80
1997-1998	4 106.00	8 757.00	148.50	138.80
1998-1999	4 244.00	7 812.00	154.40	124.30
1999-2000	5 347.00	6 804.00	193.60	107.50
2000-2001	4 933.00	7 623.00	178.90	121.10
2001-2002	4 740.00	8 190.00	171.50	130.00
2002-2003	5 236.00	9 639.00	189.50	153.40
2003-2004	4 988.00	9 954.00	181.20	158.40
2004-2005	5 181.00	11 844.00	187.90	187.80
2005-2006	5 650.00	9 954.00	205.00	157.50

Sources: GOI, Office Economic Advisor, Department of Industry, Index Number of Wholesale Prices; various issues.

3.8 Disease outbreaks

Avian influenza[19] has been circulating for centuries with four known outbreaks recorded in the last century. The present wave of highly pathogenic avian influenza (HPAI) commenced in Hong Kong in 1997. India, however, remained free of the disease until 2006. Between January 27 and April 18 2006 outbreaks of HPAI virus subtype H5N1 were reported in two districts (Navapur and Jalgaon) of Maharashtra and adjoining areas in Gujarat and Madhya Pradesh. In view of the global threat of HPAI and apprehensions about a human pandemic, it had been necessary to take steps to ensure preparedness for a possible outbreak.[20] Control measures included culling the entire poultry population and destruction of eggs, feeds, consumables, litter and other potentially infected material within a radius of 10 km from the location of the outbreak; restriction on the movement of poultry, poultry products and personnel to and from the affected area; and cleaning and sanitation of the infected area. More than 1 million birds and over 1.5 million eggs were destroyed. Farmers were compensated for their losses. The government carried out surveillance (clinical, virological and serological) within a radius of 15 km from the location of the outbreak. Surveillance also was undertaken throughout the country based on random sampling of observed abnormal mortality in poultry and wild migratory birds. On August 11, 2006, the government declared that India had regained its notifiable AI-free country status as per the regulations of the World Organisation for Animal Health (OIE).

When the news of the influenza spread, the price of chicken dropped from Rs 36/kg to Rs 16/kg. Mumbai and Pune, where business dropped by 40 percent, were the worst affected.[21] Production declined from 15 lakh birds to 12 lakh birds; egg production declined from 12 lakhs to 8 lakhs. Governments of other states banned imports of poultry from Maharashtra. The total estimated loss to the poultry industry is reported to be Rs 12 000 crore. Big integrators like Venketeshwara Hatcheries and Godrej Aggrovet are reported to have suffered huge losses.

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[19] Avian influenza is an infectious disease of birds caused by the type A, strain of influenza virus. The disease occurs worldwide. While all birds are thought to be susceptible to infectious virus, many wild birds carry these viruses with no apparent sign of harm. Other bird species, including domestic poultry, develop disease when infected with avian influenza. Once domestic birds are affected, avian influenza can be difficult to control, and often causes major economic impacts for poultry farmers in affected countries, as mortality rates are high and infected fowl must generally be destroyed in order to prevent disease. Indonesia suffered a direct loss of US$170 million and Thailand suffered a loss of US$1.2 billion during recent outbreaks.

[20] As a part of this preparedness, the Department of Animal Husbandry prepared an action plan. The draft plan was discussed at a meeting held with State Secretaries of Animal Husbandry chaired by the Secretary of the Department of Animal Husbandry Dairying and Fisheries in New Delhi on 26 October 2005, and thereafter circulated to the states by letter dated 16th November 2005. This document proved to be very useful in conducting the AI control operations in the States of Maharashtra, Gujarat and Madhya Pradesh. (See Appendix for details of this action plan).

[21] The wide area coverage of HPAI outbreak panicked consumers, most of whom avoided poultry meat. In a leading article, Surojit Gupta described the case of an example of poultry trader who even after buying chickens at a discount of 40 percent was sad, because after the news of the AI outbreak, sale of chicken in the wholesale market had fallen drastically.

The poultry industry initiated a media campaign on the safety of poultry meat to regain consumer confidence. In early April, the government announced a relief package for the poultry industry. The scaling down of production and increasing consumer demand meant that poultry meat prices recovered from May onwards. More and more units are getting back to production. Financial losses caused by HPAI have prompted several small poultry operators to switch to contract agreements with large poultry integrators so as to minimize price risk.

After India was declared "avian influenza free" on August 26 by the Department of Animal Husbandry and Dairying and Fisheries, the decline in poultry off-take slowed. In October, exports grew by 5.4 percent to Rs 26.5 crore. Because of the downfall in exports during the earlier months, total offtake during April to October 2006 was down by 27.7 percent at Rs 127.7 crore. Exports to all major markets have fallen, with the sharpest decline being in exports to the United Arab Emirates, Kuwait and Oman. The United Arab Emirates, which banned egg imports from India in February 2006, resumed imports on 18 January 2007.

3.9 Role of large retailers

India is at present the most attractive destination for the world's big retailers such as Wall-Mart, Woolworth, Tesco, Reliance, Bharati, Birla, Tata and Godrej. All top retailers are making a beeline for the Indian market. The latest report by AT Kearney and CII (2006) shows India, China and the Russian Federation at the top of the annual list of most attractive emerging markets for retail investments.[22] Moreover, India has retained its top position three years in a row. The Russian Federation kept its place at number two, while China moved from the fifth rank to third this year. Viet Nam and Ukraine are fourth and fifth respectively.

What is luring them all to the Indian market? The retail industry is almost untapped and undeveloped. The current total value of the Indian retail sector is estimated to be US$330 billion. Well over 95 percent of the market is currently unorganized – small family run stores. It is predicted that by 2011, the Indian retail sector will be worth US$892 billion. What is more important, especially from the point of view of global players eyeing opportunities in India, is that the fastest growth is in "modern retail" – supermarkets, department stores, hypermarkets and special shopping malls. Only 4 percent of India's total retail now falls within the "modern" or "organized" category, compared to 85 percent in the United States of America and 20 percent in China. Organized retailing in India is predicted to grow from the current $US12 billion a year to almost $US100 billion by 2011 and a dazzling $US239 billion by 2015 (IBEF, 2006).

What is driving this spectacular growth? India's vast middle class. It is estimated that 70 million Indians in a population of about 1 billion now earn a salary of US$18 000 a year,

[22] The study reports that China gained largely on the basis of its continued growth in consumer spending and retailers moving into smaller markets. It reveals that modern retail formats grew between 25 to 30 percent in India and 13 percent in both China and the Russian Federation. The study also shows how retailers now prefer to invest in tier II and III cities globally. For example, in China, Wall-mart and Tesco, are moving into smaller cities, such as Yuxi, Weifan, Nanchang and Westice. This explains the sudden spurt of retail activity in cities like Pune, Mysore and Kanpur.

a figure that is set to rise to 140 million by 2011 (BBC News, 2006). Driven by changing lifestyles and strong income growth, these people are looking for more choice as to where to spend their new-found wealth. The changing consumption pattern of Indian consumers is encouraging the big business houses to invest in this sunrise sector.

However, the road to this rapid growth in retail is not without difficulties. Lack of refrigeration and cold storage chains for perishables, poor transport links, red tape at state borders, and too many intermediaries mean that 40 percent of perishables are spoilt. Moreover, the Indian retail sector has until now been protected. Recently, restrictions on foreign investment have been eased, allowing overseas retailers to own 51 percent of outlets as long as they sell only single branded goods. For the first time, chains such as McDonald's, Marks and Spencer and The Body Shop can open and control their own operations in India. Previously, many of them worked with franchisee partners.

3.10 Food retail

Food dominates the shopping basket in India. The US$6.1 billion Indian food industry, which forms 44 percent of all fast moving consumer goods (FMCG) sales, is growing at 9 percent *per annum* and has set the growth agenda for modern trade formats. As nearly 60 percent of the average Indian grocery basket comprises non-branded items, the branded food industry is homing in on converting Indian consumers to branded food. However, the degree of supermarket penetration of the food retail market in India is still low – under 5 percent – compared to around 75 percent in Brazil, 57 percent in Argentina, 50 percent in Chile, 45 percent in Mexico, 30 percent in Kenya, 40 percent in Thailand, 60 percent in the Philippines and 25 percent in China.

Will the rise of supermarkets and hypermarkets throw small farmers out of business? Or will it give rise to bigger opportunities for small and poor farmers? There is, of course, a widespread perception in India that the growth of supermarkets will pose a threat to small farmers. This stems from the experiences of other countries. In China, for example, it is reported that producers who are certified as "green food" producers and sell to supermarkets are paid five times more than they would receive elsewhere. However, to get certified as a "green food" producer it is necessary to have production records inspected and to have the production environment sampled and checked. Supermarkets, therefore, usually sign contracts with large producers (Birthal *et al*., 2006). Similarly, in the Philippines, small producers of vegetables often found it difficult to hold on to their business links, and eventually dropped out. Supermarkets are concerned to reduce transaction costs. Reducing transaction costs requires fewer transactions, and hence greater significance is given to food quality and reliability in supply. For smallholders, these demands become an entry barrier to the supply chain.

At the same time, supermarkets open up opportunities for smallholders. They reflect the product requirements of high-income consumers, and transmit this information to farmers. In practice, however, supermarkets hardly buy directly from producers. They procure goods through commissioned agents or assemblers. Depending on the crop, and the distribution of farmers in terms of size, these consolidators or assemblers may or may not choose to work with small farmers. Smallholders may find it difficult to penetrate the system individually. The solution lies in new forms of vertical integration such as contract

farming that would enable small farmers to continue to participate in the supply chain (Gulati *et al*., 2006).

4 THE FUTURE OUTLOOK

The future outlook for the Indian poultry sector appears to be bright. The most optimistic forecasts predict a two- to three-fold increase in poultry production. According to one projection, egg production is expected to reach 106 billion by 2020 (Mohanty and Rajendran, 2003). According to estimates based on a Pilot Information Survey project (Khare, 2003/2004), egg production will rise to 120 billion by 2020 and poultry meat production to 4.2 million tonnes. *Poultry vision 2010: the Indian perspective,* a study by the All India Poultry Breeders' Association forecasts that total egg production will reach 61 billion by 2010, 84 billion by 2015 and 101.8 billion by 2020; the study predicts that poultry meat production will rise to 4 million tonnes by 2010 and 8.6 million tonnes by 2020. A USDA report on Indian Poultry published in 2004 (Landes *et al*., 2004) is perhaps the most comprehensive study on Indian poultry. Using a simple economic model, the study forecast that poultry meat production and consumption would increase by 66 percent (2.3 million tonnes) by 2010; in the case of eggs, production and consumption were forecast to expand more slowly (an increase of 16.8 percent by 2010).

What, according to these studies, are the propelling forces that drive Indian poultry to these heights?

1. Today the world population is just over six billion people. By 2020, this number is expected to climb to 7.5 billion people. They are predicted to be eating 327 million tonnes of meat. Much of this growth is expected to originate in non-OECD countries. In 1997, the developing world consumed 111 million tonnes of meat; it is predicted that by 2020, the developing world will be eating 230 tonnes of meat. Poultry is expected to continue its dominance over other meats, accounting for 40 percent of the total meat eaten. India will not be an exception: the Indian population in 2020 is predicted to be around 1 350 million, and this huge population will have to be fed.
2. Because high birth rates prevailing over recent decades, a large proportion of the Indian population is relatively young – in the 20–59 year age group. People in this age group are high consumers. Thus, this factor is expected to further boost the growth of consumption in India.
3. Income levels across population segments have been growing in India. According to a National Council for Applied Economic Research (NCAER) study (reported in IBEF, 2006), the consuming class, with an annual income of US$980 (RS 45 000) or above is growing; and is expected to constitute over 80 percent of the population by 2009-2010. The increasing in income levels of the Indian population offers great growth opportunities.
4. Given the price of mutton, and fact that the availability of fish is restricted to coastal regions of the country, poultry meat has wider acceptance than any other meat.
5. There is a slow but gradual shift from vegetarianism to non-vegetarianism especially among the youth in India, implying strong growth potential for the poultry market.
6. The only constraint that will tend to restrict growth is input availability. The production of the main feed ingredients, maize and soy, has been static; until recently their

import was restricted. This scenario may change, as production may be increased through the use of high yielding varieties, and imports of maize may be liberalized.

While all these forecasts are promising for the Indian poultry sector, they are (except the USDA estimates) not based on strong economic analysis, and do not allow the impact of alternative policy parameters to be taken into consideration. The following sections, therefore, consider alternative scenarios and their possible consequences.

4.1 The OECD/FAO Agricultural Outlook, 2007-2016

The OECD/FAO *Agricultural Outlook* for 2007-2016 offers an assessment of agricultural markets covering cereals, oilseeds, sugar, meats, milk and dairy products. Using the AGLINK-COSIMO model, it presents a plausible scenario for the evolution of agricultural markets over the next decade, and provides a benchmark for the evolution of these markets. These projections are made for 20 agricultural commodities across 37 countries including India. We draw on these estimates because of the model's ability to perform alternative scenarios.

The AGLINK model began as a pilot project by OECD in 1992 for forecasting agricultural outlook. It is a recursive-dynamic partial equilibrium, supply–demand model of world agriculture developed by OECD Secretariat in close cooperation with member countries and with certain non-member countries. It covers annual supply, demand and prices for the principal agriculture commodities produced, consumed and traded in each of the countries represented in the model. The proximate goal of the model is to trace the potential impact of various trade and other economic policies on agricultural markets in the medium term. The model has, since its first application in 1992, played an important role in predicting the medium-term outlook for agriculture commodities.

The Food and Agriculture Organization of the United Nations (FAO) has long been doing agricultural projections based on its World Food Model. In 2004, FAO decided, after discussions with OECD, to collaborate in the AGLINK model, extending it to a large number of developing countries, and jointly to undertake the annual medium-term outlook exercise. The project to develop new modules has been known as the COSIMO (Commodity Simulation Model) project, and the parameters of the World Food Model were used as a basis for the development of new country models. Thus the AGLINK-COSIMO model was born – a more detailed economic model representing both OECD markets and developing-country markets for medium-term commodity projections. The model is currently composed of 10 800 equations and covers 39 countries and 19 regions. The main commodities covered by the model, and which have complete representation of supply, demand, trade and prices are: wheat, coarse grains (barley, maize, oats, sorghum, rye, other cereals), rice, oilseeds (soybeans, rapeseed, sunflower seed), vegetable oils (palm oil, oilseed oils, soybean oil, rapeseed oil, sunflower oil), milk, butter, cheese, whole milk powder, skim milk powder, fresh dairy product, other dairy product, whey powder, casein, beef and veal, pig meat, poultry meat, sheep meat, and eggs.

The projections are based on certain assumptions:

- population growth is assumed to slow to 1.08 percent *per annum* for the world as a whole;
- world oil prices are projected to remain high relative to historical levels, declining to around US$55 by 2012, then to rise slowly to just over US$60 by the outlook horizon;

- it is assumed that trade polices as agreed in the Uruguay Round agreement on agriculture will hold the entire period, and no conjectures as to the future outlook of Doha Development Agenda negotiations are incorporated;
- strong growth in the newly emerging economies such as India, China and Brazil will persist, which will support broader growth in Asia and South America – all three countries have growing presence in agriculture markets; and
- for the meat sector it is assumed that normal conditions will prevail, which is to say an absence of animal disease outbreaks and no explicit disease restrictions on production, trade or computation.

OECD-FAO Agricultural Outlook: projection of Indian poultry meat and egg production

These projections have been produced under the following assumptions or forecast values:

- real GDP is assumed to grow at the rate of 7 percent *per annum* in 2007 and 2008, and thereafter to decline to 6.6 percent in 2010 and to 4.9 percent in 2015 and 2016;
- population is assumed to grow at the rate of 1.35 present *per annum* till 2011 and then slowly fall to 1.18 percent in 2016;
- the rupee–US$ exchange rate is assumed to fall to Rs 51.6 per US$ in 2010 and, to Rs 64.8 per US$ in 2016;
- import tariff for both, poultry meat and eggs, is assumed to remain at the current level of 87 percent for poultry meat and 150 percent for eggs; and
- the price of maize, the main feed ingredient, is expected to rise to Rs 6 044.5 per tonne in 2007 to Rs 6 691.9 per tonne in 2010 and to Rs 8 320.5 per tonne in 2016.

The projections for poultry meat and eggs are shown in Table 22.

4.2 Alternative scenarios for the Indian poultry sector

Keeping the estimates shown above as a benchmark, we present three alternative scenarios and trace their implications. First, we assume that imports of poultry meat are further liberalized. Second, we study the consequences of liberalization of the import of maize, the main feed ingredient. Third, we evaluate the consequences of an outbreak of HPAI.

Scenario 1: import of poultry meat is liberalized

In the first scenario, we consider the likely impact of a complete opening up of trade in poultry meat. Currently, poultry meat imports are subject to an 87 percent tariff rate. Assuming that India removes these tariffs, imports of cheap poultry meat can be expected to invade the domestic market and compete with domestic production. What would be the magnitude of this effect?

First, for poultry meat, a tariff reduction of 87 percent can in all probability be expected to reduce the domestic price. The exact magnitude of the fall in price will depend on the response of imports to tariff cutting. As we have no information of the magnitude of this effect, the AGLINK-COSIMO model is used. The difference in the price before and after tariff reduction works out to be Rs 52 940 per thousand tonnes, which as a proportion of

TABLE 22
OECD-FAO Agricultural Outlook Projections: selected variables of Indian poultry meat

Commodity head	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Poultry Meat (1 000 tonnes)										
Consumption	2 203.7	2 338.5	2 449.5	2 595.5	2 755.6	2 870.8	3 042.3	3 144.4	3 322.7	3 428.8
Production	2 212.4	2 383.9	2 516.5	2 674.1	2 830.1	3 008.9	3 174.6	3 332.3	3 485.4	3 666.3
Exports	8.6	45.3	67.0	78.5	74.5	138.0	132.3	187.7	162.6	237.5
Imports	-	-	-	-	-	-	-	-	-	-
Producer price (Rs/tonne)	62 942.3	66 843.9	68 025.3	69 885.0	73 010.2	75 544.8	78 066.9	81 271.8	83 818.1	87 262.6
Egg (1 000 tonnes)										
Consumption	2 054.8	2 023.4	2 070.1	2 066.8	2 133.8	2 142.5	2 222.9	2 232.0	2 316.3	2 316.7
Production	2 069.4	2 038.4	2 084.6	2 081.4	2 148.4	2 157.1	2 237.4	2 246.6	2 330.9	2 331.4
Trade balance	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Producer price (Rs/tonne)	25 875.2	27 522.9	28 056.9	28 675.8	29 575.3	30 398.2	31 406.6	32 537.5	34 251.5	36 350.2

Sources: OECD Statistics.

TABLE 23
Impact of elimination of tariffs for Indian poultry: results of the AGLINK-COSIMO model

	Percentage change from the baseline solution shown in Table 22									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Consumer price	-40	-40	-39	-39	-39	-39	-38	-38	-38	-37
Per capita consumption	29	29	28	28	28	27	27	27	26	26
Producer price	-49	-49	-49	-49	-49	-49	-49	-49	-49	-49
Production	-29	-29	-29	-29	-29	-29	-29	-29	-29	-29
	Quantity (1 000 tonnes)									
Import	1 273	1 329	1 367	1 432	1 519	1 528	1 617	1 625	1 729	1 725
Net trade	-1 272	-1 365	-1 424	-1 500	-1 583	-1 656	-1 739	-1 803	-1 882	-1 952

pre-liberalization price comes to be 40 percent. This is to say, consumer price of poultry meat can be expected to fall by 40 percent as a result of tariff cutting in the first year of simulation (2007), see Table 23. This in turn can be expected to stimulate imports. Thus, India's imports of poultry meat are expected to increase from a negligible level in 2006 to 1 273 thousand tonnes in 2007 and 1 725 thousand tonnes in 2016. See Table 23 for estimates of the magnitude of the production response.

A full liberalization of imports of poultry meat could, as the figures above indicate, be disastrous to the domestic poultry industry – production would fall by 29 percent.

Scenario 2: imports of maize are further liberalized

One of the major factors that might constrain further growth of the poultry industry is as mentioned above, the availability of maize and soy at reasonable prices. Feed costs alone account for 70 percent of the cost of production of eggs and broilers; and maize and soy are the two major feed ingredients, maize being the most important. Stagnating domestic production of maize and increasing use for other purposes (such as starch) have often led to shortages of maize for feed, and consequently increases in its price.

Importing maize can mitigate domestic shortages to some extent. Until recently, maize imports were affected by a tariff-quota formula,[23] under which imports attracted a 50 percent import duty.[24] We seek to trace the potential impact of the elimination of this tariff for production of poultry meat.

[23] In-quota imports up to 350 000 tonnes attracted a duty rate of 15 percent.

[24] Because of the rising pressure of domestic demand, maize prices were rising in the domestic market during early 2007; to mitigate this, the government temporarily relaxed the tariff quota to 4 lakh tonnes, and the 15 percent duty was withdrawn (will be in effect till 31st December 2007).

The first step in this exercise is to measure the likely impact of tariff elimination on domestic price. Surprisingly, we find from the results of applying the AGLINK-COSIMO model that the proposed tariff removal does not affect domestic price, probably because the domestic price is much lower than world price of coarse grains.

Scenario 3: Effect of an avian influenza outbreak

The consequences of an outbreak of HPAI can be manifold. First, there are direct production costs because of losses of poultry due to disease and control measures such as culling. The effects of such losses extend not only to farmers, but also to upstream and downstream sectors such as poultry traders, feed mills and breeding farms. Second, there are indirect effects resulting in demand shifts, emanating from measures adopted to contain the spread of disease, such as bans on exports/imports; consumer responses in the form of reduced consumption; and reduced levels of economic activity in sectors such as tourism, travel, transport and the hospitality industry. Finally, there are costs of prevention and control, which include costs incurred by the government for the purchase of poultry vaccines, medications and other inputs; and hiring workers for culling, clean up, etc. Governments are also faced with the need to at least partially compensate poultry owners – an important factor in persuading owners not to conceal outbreaks of contagious poultry diseases.

A total assessment of all these costs warrants far more information than what we possess at present. Therefore, we limit our assessment to the effects generated by a decline in consumption. In all principle consumption areas, i.e. nearly 40 countries from western Europe, the far East, and Africa, the outbreaks of HPAI in 2005 and early 2006 led to major consumption shocks (OECD/FAO, 2006), which translated into shifting trade flows, declines in domestic price, and supply responses in both affected and non-affected countries. Hence, to trace the potential impact of a possible outbreak of AI in India, we start by assuming that total consumption will decline by 10 percent – people will stop eating

TABLE 24
Impact of avian influenza on Indian poultry: results of AGLINK-COSIMO

	Percentage change from the baseline solution shown in Table 22									
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Consumer price	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Export	1.9	-100.0	-7.9	3.4	2.0	0.0	0.2	0.5	0.4	0.2
Import*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Per capita consumption	0.0	-6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Producer price	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Production	0.0	-0.2	-0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0

*negligible value.

poultry meat and instead shift to other meats and vegetables. Moreover, it can be assumed that imports of poultry from India will be banned. As expected, the effects are substantial in the short term (Table 24). This is based on results obtained using the AGLINK-COSIMO model. The consumer price (all India average) declines by 0.2 percent. Furthermore, exports decline by 100 percent within one year of an HPAI outbreak. Nevertheless, they will start picking up within one year. The per capita consumption declines by 7 percent in the first year of the outbreak. However, it will return to its trend within a year.

4.3 Possible consequences of rapid growth on public health and biosecurity

Disease is the main threat to any livestock industry. Diseases are mostly caused by bacteria, viruses, protozoa and fungi. Disease-causing organisms may enter farm premises via air and water, or may be are carried mechanically by human visitors or by equipment brought onto the premises in vehicles. Preventing disease entry is broadly known as "biosecurity".

In the poultry sector, one aspect of biosecurity is that farms should not be close to each other. However, the industry is now shifting towards integration, which tends to give rise to concentration of farms in a limited geographical area. Though integration may help to improve efficiency, it may pose a threat to animal health. The large-scale poultry operations of today may turn into the disease heavens of tomorrow, where even a disease of low virulence may seriously affect the entire flock. Therefore, biosecurity is one of the most formidable challenges for both the rural and commercial set-ups.

In the rural areas, animal health provision is at present insufficient to counter the high mortality rates that prevail particularly in young birds. In the commercial sector, health requirements are even more stringent and demanding given the threat posed by emerging diseases. Vaccination and medication, coupled with strict biosecurity measures, are needed to address the threat. Availability of vaccines and drugs, and their safety in terms of levels in end products for human consumption, are other issues that need to be considered. High-level surveillance is also needed to keep diseases like HPAI at bay.

4.4 Animal welfare

In the next 20 years, the poultry industry is going to be increasingly concerned about animal welfare. The cage-based system is being phased out, and those cages that are being retained will have to meet tough standards. Legislation in force sets a minimum space of 500 cm^2 for such cages. By 2012, any new cages that are added to a farm will have to provide 750 cm^2. There are also welfare issues concerning the transportation of animals. There is strong resistance to animals being transported over long distances for slaughter. The perception is that slaughter must be close to where the animals are reared. Given the extreme climatic conditions found in India, ensuring appropriate methods of transportation is an important aspect of welfare.

4.5 Environment

The commercial poultry sector not only produces eggs and meat, but also by-products such as slaughter waste, hatchery waste, poultry droppings and litter manure. The huge problem of poultry waste poses a serious threat to the environmental safety of the region. It may

lead to contamination of groundwater, which has serious long-term implications. Environmental impact assessment is, therefore, another important area to be considered.

5 EFFECT ON SMALLHOLDERS

Livestock production in India, in general, is the activity of smallholders, and is extremely important for livelihoods. Poultry is, however, something of an exception it is characterized by a very wide range of operations, with livelihood and subsistence at one end of the spectrum and highly commercial operations at the other. More than 50 percent of the landless and marginal farmers at the bottom end of the smallholder spectrum supplement their livelihoods through poultry keeping. Poultry has, thus, been a core support system for subsistence farmers, providing them with supplementary income. The birds are cared for by the family, especially the women.

A worrisome feature of the introduction of poultry factory farming and its accelerated growth in India is its potential impact on small and marginal farmers. What is the prospect for these farmers in the near future? Will they benefit or will they be pushed out of business? Will they be able to participate in the fast changing environment? These are a few of the questions that concern policy-makers, and hence merit some attention here (Garces, 2002).

Compassion in World Economy Trust (CWFT), a research-based farm welfare organization that investigates the development of factory farming at an international level recently studied the effect of the rise in factory farming in southern countries. A striking finding of the study was that the introduction of industrial livestock rearing not only harms the individual small-scale farmers, but also developing countries as a whole. Because of industrial livestock rearing, these countries have become more import dependent – grains, tractors, fuel and fertilizers are required for the intensive livestock rearing. During the last decade, Asia has begun to import large amounts of grain to feed its industrially produced livestock. Machines, oil and producing units are being imported. The study reports the following example to highlight how significant family level poultry rearing is for food security: an average flock of five chickens enabled a woman in central United Republic of Tanzania to earn an additional US$38 per year, equivalent to a 9.5 percent increase in income – poultry rearing has contributed to the "greater empowerment of women by improving their financial status; and the loss of family farming to industrial farming could seriously affect women and children" (Garces, 2002).

In the Indian context, a recent study by Birthal *et al*. (2006) sought to address the issue of whether and under what conditions smallholders could benefit from such a fast-changing environment. Their main contention or key hypothesis is that vertical coordination in agricultural supply channels helps to lower the transaction costs and market risks of smallholders. "Proper market institutions are needed to reduce transaction costs, manage risks, build social capital, enable collective actions, and redress missing markets ... Unless small holders enter vertically coordinated supply chains with processors and retailers, they will have increasingly difficulty in participating in the growing high value markets." The study considered three commodities: milk, broilers and vegetables. For each, they assessed the performance of farmers under contract farming and non-contract farming.

First, they assessed the profitability of farmers under contract farming vis-à-vis those

under non-contract farming. Profits of contract farmers in all three commodities were found to be higher than non-contract farmers. However, in the case of broiler production there was no statistical difference between the average profits of contract and non-contract farmers. The advantage of the contract farmers was a result of savings in production and marketing costs. Second, they found that fears that the processor/retailers may discriminate against small farmers by having a tie up with a few large farmers are misplaced. Contract farmers irrespective of the size were found to be producing at lower cost than non-contract farmers; these facts reveal that small farmers were neither being deprived of participation nor being exploited by the firm. Third, they concluded that even if markets work well, small farmers have trouble to take advantage because of poor infrastructure. This warrants provision of proper physical infrastructure that connects small farmers to markets.

That contract farming is more efficient than non-contract farming in the Indian context has been shown by another study by Ramaswami *et al*. (2006). They sought to evaluate production costs of contract growers relative to non-contract growers in Andhra Pradesh, a state in southern India. The simulated cost for contract growers is Rs 24.3 to produce a kg of bird; for the non-contract grower, it is Rs 26.22, i.e. a saving of Rs 1.9 for every kg of bird produced. If the interest cost, say 15 percent, is added, the savings of contract growers amounts to Rs 2.07. "The higher efficiency of contract grower is driven by its lower feed conversion ratio" (ibid.). To test this, they pooled the samples of contract and non-contract production, and regressed feed quantity on output, as well as output interacted with a contract dummy variable. The coefficient of interaction variable estimates the difference in FCR between the two groups of producers. The difference between the FCR was found to be statistically significant.

A recent study on Indian poultry based on a household survey of 320 farm households carried out across the states of Andhra Pradesh and Haryana has something more to say on these issues (Mehta *et al*., 2003). Specifically, the study sought to probe:

- Why do some poultry farms have higher nominal profits per unit of output than others?
- Why do some farms have higher negative environmental impact per unit of output than others? Do the negative environment externalities explain relative competitiveness?
- To what extent are these differences across farms a result of differences in transaction costs, environmental extremities, and policy subsidies, as compared to technical or allocative efficiency once these factors have been taken into account?
- What is the relative importance of each of these explanatory factors across farm sizes?

Several key points emerged from this study:

First, profitability does not differ much between small and large producers: profitability (profits per unit of output) does not differ much between small and large-scale farmers, whether layer or broiler. In other words, profitability is not significantly affected by the scale of operations. This is evident from the Tables 25 and 26.

Second, small producers expend more efforts and make more investment in pollution abatement than large producers. Due to growing awareness of the need to protect the environment, poultry farms today are increasingly required to adhere to environmental

TABLE 25
Distribution of layer units by profitability

Profitability (Rs/egg)	Small (<10 000 birds) (no. of units)	Large (>10 000 birds) (no. of units)	Total (no. of units)
-1.00–0.00	4	7	11
0.00–0.10	11	18	29
0.10–0.20	12	24	36
0.20–0.30	8	32	40
0.30–0.40	23	15	38
0.40–0.48	5	2	7
Total	63	98	161

Note: average price of output is Rs 1.19 per egg.
Source: Mehta *et al.* (2003).

TABLE 26
Distribution of broiler units by profitability

Profitability (Rs/bird)	Small (<10 000 birds) (no. of units)	Large (>10 000 birds) (no. of units)	Total (no. of units)
-0.50–0.00	2	1	3
0.00–1.00	11	2	13
1.00–2.00	8	5	13
2.00–3.00	5	7	12
3.00–5.00	10	7	17
5.00–7.00	10	4	14
7.00–11.00	19	6	25
11.00–15.00	18	3	25
15.00–20.00	10	7	17
20.00–30.00	7	4	11
30.00–53.00	9	3	12
Total	109	49	158

Source: Mehta *et al.* (2003).

regulations, particularly with regards to water purity, manure removal and carcass disposal. Conventional wisdom would have suggested that small producers would be worse offenders than large producers. When this was put to test by regressing environmental cost per

unit of output[25] – with a select list of explanatory variables,[26] it was found that the scale coefficient was positive in the case of both layer and broiler production. Small-scale producers tended to spend a larger amount per unit of output in terms of pollution abatement than did large producers.

Third, profitability is determined by the price of chicks, wage rate, price of eggs/broilers, value of capital stock and FCR. The main factors that determine profitability are price of DOCs, price of labour (wage rate), price of eggs/broilers, value of capital stock and FCR – profitability is inversely related to the price of chicks, wage rate, price of feed and FCR; it is positively related to the price of eggs/broilers and value of capital stock. This emerged clearly when in the estimation of frontier profit function, the dependent variable, namely profitability, was first regressed with frontier variables: price of DOCs, wage rate, price of feeds, price of eggs/broilers, family labour per unit of output, value of capital stock per unit of output, labour housing, FCR, and a scale dummy (1 for small units and 0 for large units). The results, as expected, showed profitability to be negatively related to the price of chicks and the price of feeds, and positively related to the price of eggs.

Fourth, small farms are less efficient: though profitability does not differ much between small and large farms, their efficiency differs significantly. Small farmers are relatively inefficient; and the principle reasons for their inefficiency are high transaction costs and high pollution abatement costs. That is to say, small producers are disadvantaged compared to large producers in obtaining credit, information, marketing, transportation and storage facilities. They are also constrained to spend more on collection, drying and transporting poultry manure (pollution abatement costs) to keep poultry sheds and the surrounding environment clean. This emerged clearly when in the second step run for the frontier function, technical inefficiency (the residual terms obtained from the application of the first step) is taken as the dependent variable, and the explanatory variables are transaction costs[27] and pollution abatement costs[28]. From the estimated coefficients, one can make inferences about the direction and magnitude of the contribution of each determinant to the relative inefficiency of the farm in question. A significant positive coefficient means a positive contribution to increased inefficiency.

Fifth, contract farmers earned less profit than non-contract (independent) farmers. To check profitability of contract farms vis-à-vis non-contract farms, financial profits of sample

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[25] Environment cost is defined as the sum of the costs of controlling flies + dead bird disposal + cost of pollution payment + manure disposal cost value of manure used/consumed.

[26] Explanatory variables include: family labour, number of houses in a 500 metre radius (proxy for concentration of units), total no. of years of experience, information source, independent/contract farmers dummy, gender of decision maker, state dummy, education, and age of the decision-maker. The regression is run with an intercept dummy (ip.scale) which takes a value of 1 for small and 0 for large. If the intercept dummy has a positive value, it confirms that small producers invest a larger amount in pollution abatement than do large producers. Alternatively, if the intercept takes a negative value, then the opposite is the case.

[27] The proxy variables selected for transaction costs are: age of the decision-maker, education of decision maker, information source, and distance to output market, gender of decision maker, access to credit, primary source of income, membership of a community organization, years of experience in poultry, no. of training programs attended, and region/state characteristics.Alternatively, if the intercept takes a negative value, then the opposite is the case.

[28] Pollution abatement costs are taken as costs of controlling flies + dead bird disposal cost + cost of pollution payment + manure disposal cost + value of manure used/consumed.

TABLE 27
Average profitability of non-contract vs. contract farms

Category	Average profitability (Rs/bird)
Non-contract broiler: small	13.130
Non-contract broiler: large	10.930
Non-contract broiler: total	12.436
Contract broiler: small	1.034
Contract broiler: large	3.164
Contract broiler: total	1.615
2005-2006	8.35

Source: Indian Poultry Survey (2002).

contract farms and non-contract farms were compared. Table 27 shows the results of these calculations.

The table shows that in terms of financial profitability, non-contract farms perform better than contract farms. Average profitability in the case of non-contract farms turns out to be Rs 12.43 per bird compared with Rs 1.62 per bird for contract farms. Not only are the differences substantial, they are also statistically significant. When the comparison is drawn between small non-contract farms and small contract farms, or between large non-contract farms and large contract farms, the differences remain substantial and statistically significant, and prove the contention that non-contract farms are more profitable than contract farms.

When comparisons are drawn between small and large farms within the same category (i.e. small contract farms vs. large contract farms; or small non-contract farm vs. large non-contract farms), the differences are not sufficiently significant to state categorically that small farms are more profitable than large farms.

Sixth, differences in policy subsidies across regions/states are also found to harm the efficiency of small producers more than that of large producers. This is evident from the regression results run separately for small producers – the coefficient for regional character is statistically significant and negative. More specifically, small farms in a state such as Andhra Pradesh are more inefficient than their counterparts in Haryana, because Andhra Pradesh levies a 4 percent processing tax on poultry products in addition to taxes on poultry feed, while Haryana has no such taxes.

To sum up, studies of the effects of the livestock revolution on small farmers reveal, many striking points. First, all these studies indicate that small and marginal farmers are being pushed out of business by factory farming. Farmers in the United States of America and in Europe have already experienced the painful consequences of this process, and the same pattern is being repeated in developing countries. Second, two critical instruments that might help to break this deadlock are (a) institutional arrangements such as cooperative contract farming that tend to reduce marketing risks; and (b) provision of physical infrastructure that connects small farmers to markets. Third, some of the alleged fears that the new institutional arrangements discriminate against small farmers are not well founded. Fourth, there is no strong evidence to show that profitability differs between

small and large farmers, and there is conflicting evidence with respect to profitability of contract vs. non-contract farming. Though some recent studies have come down very strongly in support of contract farming stating that profits of contract farmers are higher than non-contract farmers, strangely their data suggest the opposite conclusion, i.e. that non-contract farmers earn more profit than contract farmers. It is, thus, difficult to draw firm conclusions as to whether the profitability of contract farmers is higher than that of non-contract farmers – more research in this area is warranted.

6 CONCLUSIONS

Poultry is one of the fastest-growing segments of the agricultural sector in India, with an average growth rate of 8 to 10 percent *per annum* (production of agricultural crops has been rising at a rate of 1.5 to 2 percent *per annum*). Production levels have reached 45 billion eggs and 1.7 million tonnes of poultry meat *per annum*. India is now the world's third largest egg producer and nineteenth largest producer of broilers. Poultry production contributes around 1 percent to India's GDP. A notable feature of the Indian poultry sector is that it is self sufficient, supported by a broad and strong genetic base, with the productivity levels (FCR) of broilers/layers being equal to those achieved in developed countries. India is one of the few countries that possess the technology for producing SPF eggs. Per capita annual availability of poultry products has increased to 44 eggs and 1.76 kg of meat – still below than the recommended levels of 180 eggs and 11 kg of meat. Bridging this gap through focused research and development efforts is likely to create at least 9 to 10 million jobs, export potential and nutritional security.

Undoubtedly, the credit for this impressive growth goes to poultry farmers, poultry breeders, integrators, feed mills, and above all to pro-active government policy. The government has funded several research activities, set up a number of poultry estates in collaboration with agencies like the National Bank for Agriculture and Rural Development (NABARD), provided veterinary health care services, and made animal health and diagnostic facilities available. Disease and diagnostic laboratories are located in different regions through institutions such as the Indian Veterinary Research Institute. Population growth and sustained growth in per capita income are the other driving forces behind the accelerated growth in poultry production.

The key structural change spurring production growth has been the emergence of integrated production systems bringing about economies of scale and the sustained profit margins necessary for the expansion of the sector. Vertical integration has spread in both southern and western parts of India, while it is less developed in the north and east.

Poultry exports from India have been on the rise. However, India's poultry exports are mainly confined to table eggs and egg powder, which are growing as a result of their cost competitiveness, improving hygienic standards and logistical advantages. Poultry meat exports are negligible because of high costs, inadequate meat-processing facilities and infrastructural bottlenecks

The future of the poultry industry appears to be bright. The most optimistic predictions suggest a two- to three-fold increase in poultry production in the coming 20 years. Egg production for instance, is expected to reach 105 to 106 billion and poultry meat to 8.6 million tonnes *per annum* by the year 2020. Integration in broiler farming will spread to other regions. This is likely to reduce the price of chicken meat.

The main hurdles to future growth of poultry are: (a) availability of feed, especially maize and soy, at reasonable prices; (b) serious morbidity and mortality caused by diseases such as AI and Newcastle disease; the recent outbreak of AI in Maharashtra in February 2006 proved to be devastating for the Indian poultry sector; the fear of disease transmission led to reduced poultry consumption, depression of prices and adversely affected exports; and (c) poor infrastructure.

The future requirements for the Indian poultry industry are:

- improved biosecurity to maintain the health status of the growing number of birds in the country;
- increased productivity of feed – maize and soybean; and
- improved infrastructure.

APPENDIX I. ACTION PLAN OF THE DEPARTMENT OF ANIMAL HUSBANDRY TO CONTROL HPAI

The strategy of the government of India has been to contain the disease at sources, i.e. at the level of animal itself. This is the principle way to reduce opportunities for spread of the disease and for possible human infection. Therefore disease intelligence active animal surveillance, strengthening the early warning system in the pre-outbreak stage and total culling in prescribed radius resulting in rapid containment in the outbreak phase are critical assets to reduce such opportunities for spread of infection.

I. Pre-outbreak preparedness:

I.1: Surveillance: Need to be in a state of alertness and preparedness. Surveillance is the most important part of the strategy to control and contain HPAI. India has a poultry population of 481 million both commercial and backyard. About 60 percent of the population is in the commercial sector. It is indicated that the migratory birds play a role in the spread of the virus across countries and continents. India lies within three major internal fly ways of migratory birds. Surveillance will therefore have to include both poultry and migratory birds.

I.1.1: Poultry owner, especially commercial poultry owners including consultants, franchisees, service providers and those related to rearing of poultry are individually and collectively responsible to immediately report unusual mortality and sickness in birds to the government.

I.1.2: The state governments are advised to develop routine surveillance plans. Representative random sampling may be done.

I.1.3: A system of active and large targeted surveillance has been initiated. It includes immediate response to unusual sickness/mortality among the birds.

I.2: Sample collection, packing and Transportation: The states must ensure proper collection, packing and transportation of samples, and give particular attention to the quality and quantity of samples forwarded to the labs.

I.3: District collector has to play a central and coordinating role especially concerning aspects of quarantine closure of shops, corporation, money control, ban on sale of poultry related products, administering vaccination plan etc. Therefore the district collector should be thoroughly formalized with the action plan.

II: Steps to be taken in case of suspicion of outbreak of AI:

II.1: In case of suspicion of outbreak of AI such as receipt of any preliminary report regarding unusual sickness or above average mortality of poultry as well as wild and migratory birds at a place for any other source, the investigation officer shall visit the place immediately and ascertain the facts of the case.

II.2: The investigation officer should carry out a clinical investigation with the aim to establish the clinical situation on the farm, including ill and suspect birds. The clinical investigation must be performed on all susceptible species present on the farm, and it must begin for the most peripheral units. All this information must be reported in the epidemiological inquiry report.

II.3: If the preliminary and clinical investigations indicate that it is an unusual situation indicating surveillance of AI, then the investigating officer has to ensure that steps as indicated in the subsequent paras are taken immediately.

II.4: Collection of samples and dispatch for laboratory tests: Samples should be sent to lab immediately.

II.5: Immediate report to Director, Animal Husbandry.

II.6: Identification of alert zones.

III: Action plan in case of outbreak of NAI is confirmed:

III.1: Notification and information of outbreak: In case lab test confirmed the occurrence of Notifiable AI; HSAD Bhopal will inform the Govt. of India. The Govt. will dispatch Central Rapid Response teams of Dept of Animal Husbandry.

III.2: The International Agencies are to be notified by the Dept of Animal Husbandry.

III.3: In view of the threat of human infection for particular strain of NAI, public health aviation is to be immediately notified.

III.4: Demarcation of surveillance and infected areas and actions to be taken in these areas.

III.5: Immediate tasks to be carried out by the veterinary officer on confirmation of

(i) Quickly report the state and condition of the farm to determine the nature and scope of operations to be conducted.

(ii) Identify locations on the farm where vehicles leaving the farm can be properly washed and disinfected.

(iii) Active disinfection procedures at the point of entry/exit from the infected premises.

(iv) Ensure that vehicles are washed and disinfected internally and externally.

(v) Absolute ban on movement of poultry.

(vi) Closure of poultry and egg.

(vii) Ban on movement of farm personnel.

(viii) Destruction of birds in the infected zone of 3km radius.

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DEFINITIONS AND ABBREVIATIONS

Units of Conversion

1 lakh	= 100 000
1 crore	= 10 000 000
1 million	= 10 lakh
1 million	= 0.1 crore
1 billion	= 100 crore

US$1 = Rs 45.92 (2003-2004) = Rs 44.27 (2005-2006)

Indian Financial Year = April – March

AI	avian influenza
APEDA	Agriculture and Processed Food Products Export Development Authority
BIS	Bureau of Indian Standards
CII	Confederation of Indian Industry
CTIPPM	Central Training Institute for Poultry Production and Management in Bangalore
DOC	day-old chick
ERS	Economic Research Service
EU	European Union
EXIM	Export-Import Bank of India
FAO	Food and Agriculture Organization of the United States

FCR	feed conversion ratio
FDI	foreign direct investment
FMCG	fast moving consumer goods
FPO	Food Products Order, 1955
GDP	gross domestic product
GHP	good hygiene practices
GIC	General Insurance Corporation of India
GMP	good manufacturing practices
GNP	gross national product
GOI	Government of India
HACCP	hazard analysis and critical control points
HPAI	highly pathogenic avian influenza
HSAD	High solids anaerobic disegestion, main facility to develop poultry vaccine
IBEF	Indian Brand Equity Foundation
IPDP	intensive poultry development projects
IRDP	Indian Rural Development Programme
MFPO	Meat and Food Products Order, 1973
MMPO	Meat and Meat Product Order, 1992
NABARD	National Bank for Agriculture and Rural Development
NAFED	National Agricultural Co-operative Marketing Federation
NAI	notitiable form of avian influenza
NCDC	National Cooperative Development Cooperation
NECC	National Egg Coordination Committee
NGO	non-governmental organization
NPDB	National Poultry Development Board
NRL	National Reference Laboratory
NSS	National Sample Survey
NSSO	National Sample Survey Organization
OGL	open general license
OIE	World Organisation for Animal Health (Office International des Epizooties)
PFA	Prevention of Food Adulteration Act, 1954
QRs	quantitative restrictions
RMP	Residue Monitoring Plan
SAARC	South Asian Association for Regional Cooperation
SPF	specific pathogen free
SPS	sanitary and phytosanitary
TBT	technical barriers to trade
TM OPM	Technology Mission on Oilseed, Pulses and Maize
TRQ	tariff rate quota
USDA	United States Department of Agriculture
VH	Venketeswara Hatcheries
VPO	Vegetables Product Order, 1967
WHO	World Health Organization
WTO	World Trade Organization

Case study of the Egyptian poultry sector

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SUMMARY

The poultry industry is one of the main agricultural industries in Egypt, where investment in this industry is about LE18 billion. The size of the labour force is about 1.5 million permanent workers and about 1 million temporary workers. The industry contributes a large part of the country's supply of animal protein (white meats and eggs). During the last decade of the twentieth century and the early years of the twenty-first century, local poultry meat production was sufficient to cover local consumption. Local production was on average 874 000 tons during the period 2001 to 2005, compared to an average local consumption of 871 700 tons. Local egg production was 310 000 tons on average for the same period, which also covered local consumption. The poultry industry not only supplies animal protein for feeding the human population, but is also linked to other industries such as animal feed, medicine and veterinary inputs.

The value of poultry meat and egg production in 2004/2005 was about LE9.7 billion (LE7.6 billion for poultry meat and LE2.1 billion for eggs) – representing around 24.6 percent of the value of the country's animal production and around 8.8 percent of the value of agricultural production. Poultry meat contributed 20 percent of the total daily per capita consumption of animal and fish protein, which is about 30.3 grams/day. Poultry meat is popular among Egyptian consumers across all income categories, because of its low cost compared to red meat and fish. Poultry also represents an income source for many poor families who practise traditional aviculture. About 90 percent of rural households and a great number of urban households rely on aviculture as a clean and cheap source for animal protein and as a contributor to income, especially given the rising price of red meat which reached LE30–40/kg during the period after 2004/2005. Poultry keeping is considered to be one answer to the high rate of unemployment in Egypt, which stood at 11 percent of the total labour force in 2004/2005.

Poultry production differs from other animal production activities in several ways. The most important is the rate of capital circulation: while broiler chicken production requires between 50 and 60 days, the production of red meats needs 9 to 12 months. Additionally, poultry production needs relatively little capital. Poultry require about 3 kg of feed to produce 1 kg of meat – compared to the 7 kg of feed needed to produce 1 kg of red meat.

1. ECONOMIC IMPORTANCE OF POULTRY PRODUCTION IN EGYPT

1.1 The economic importance of the animal production sector in the Egyptian agricultural economy

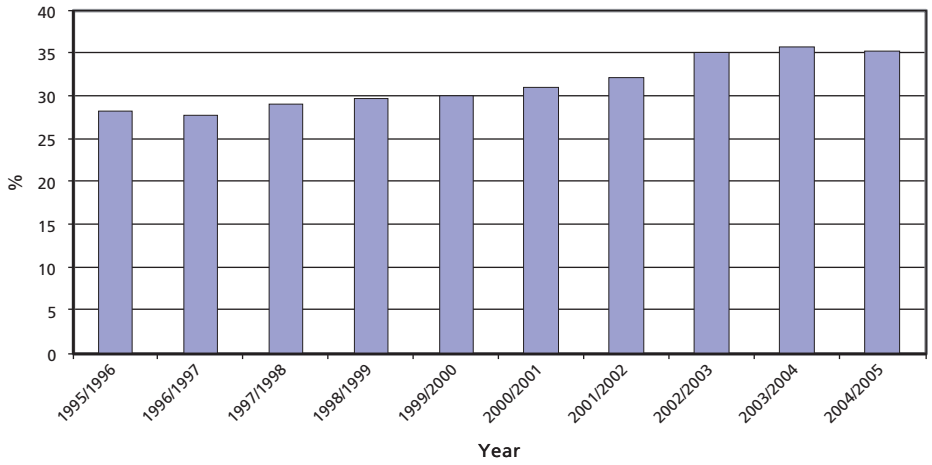
Table 1 shows that the value of animal production was LE39.3 billion in 2005, representing 35.2 percent of agricultural production; crop production represented 58.2 percent and

TABLE 1
The value of animal production relative to that of other agricultural activities, 1995/1996 to 2004/2005

Year	Plant production		Animal Production		Fish Production		Total Agricultural production	
	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%
1995/1996	33 750	67,5	14 102	28,2	2 133	4,3	49 985	100
1996/1997	38 046	67,7	15 556	27,7	2 564	4,6	56 166	100
1997/1998	40 312	65,8	17 815	29,1	3 144	5,1	61 271	100
1998/1999	40 786	64,1	18 871	29,7	3 983	6,3	63 640	100
1999/2000	43 997	63,9	20 683	30	4 207	6,1	68 887	100
2000/2001	43 852	61,2	22 126	30,9	5 686	7,9	71 664	100
2001/2002	44 744	59,9	24 003	32,1	5 993	8	74 740	100
2002/2003	48 516	57,6	29 556	35,1	6 188	7,3	84 260	100
2003/2004	55 500	57,3	34 600	35,7	6 700	6,9	96 800	100
2004/2005	65 100	58,2	39 300	35,2	7 400	6,6	111 800	100

Source: National Agricultural Income, Economic Affairs Sector (EAS) Ministry of Agricultural and Land Reclamation.

FIGURE 1
Relative importance of the value of animal production in Egyptian agriculture, 1995 to 2005



fishery production 6.6 percent. The table also shows that over the period 1995 to 2005 the value of animal production increased by 178.7 percent. Its relative importance within agriculture also increased from about 28 percent to about 35 percent over this period. Figure 1 illustrates the changes in the relative importance of animal production in Egyptian agriculture through the period from 1995/1996 to 2004/2005.

1.2 The economic importance of poultry production within the animal production sector

Table 2 shows the relative contribution of poultry meat and eggs to the value of the output of the livestock sector during period from 1995/1996 to 2004/2005.

Table 2 and Figure 2 show that in 2005 the value of poultry meat production represented 19.3 percent of the value of animal production, while eggs represented 5.3 percent. Between 1995 and 2005, the value of poultry meat production rose from LE2.3 billion to LE7.6 billion, and the value of eggs production rose from LE707 million to LE2.1 billion. The value of poultry production (meats and eggs) rose from LE3.1 billion in 1995/1996 to almost LE9.7 billion in 2004/2005. Figure 3 illustrates the relative importance of the poultry sector to total animal production in value terms; it can be seen that the share of poultry production rose from 21.6 percent in 1995/1996 to 24.6 percent in 2004/2005, reaching a maximum of 27.7 percent in 2002/2003.

Table 2 shows that the value of poultry meat production represented 78.4 percent of the total value of poultry production in 2004/2005, while egg production represented 21.6 percent. Figure 4 shows that the relative importance of poultry meat production increased from 76.8 percent of total poultry production in 1995/1996 to 78.4 percent in 2004/2005. The relative importance of egg production decreased from 23.2 percent to 21.6 percent over the same period.

Figure 4 illustrates that throughout the period 1995/1996 to 2005/2005 poultry meat represented about 80 percent of the value of poultry production, while eggs represented about 20 percent.

2 STRUCTURE OF THE POULTRY SECTOR IN EGYPT

Figure 5 illustrates the structure of the poultry sector in Egypt, which consists of two main divisions: poultry enterprises and the household poultry sector. Poultry enterprises include: broiler enterprises; table egg enterprises; rabbit enterprises; duck and turkey enterprises; broiler breeder stations; poultry grandparent enterprises; ostrich and quail enterprises; auto-slaughter enterprises; local hatching laboratories; industry hatching laboratories; and feed enterprises. Statistics related to the capacity, distribution and development of poultry enterprises are presented in the appendix to this paper.

The household poultry sector is one of the main income sources for numerous families, both in the countryside and in the cities. All types of poultry are kept – chickens, turkey, geese, ducks, rabbits and pigeons. Statistics on the household poultry sector are presented in the appendix to this paper.

TABLE 2
Value of the various components of animal production in Egypt in value terms, 1995/1996 to 2004/2005

Year	Cattle meat		Milk		Poultry meat		Table eggs		Bee honey		Wool, hair and camel hair		Manure		Total animal production	
	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%
1995/1996	6 426	45.6	3 426	24.3	2 346	16.6	707	5.0	75	0.5	77	0.5	1 045	7.4	14 102	100
1996/1997	7 463	48.0	3 553	22.8	2 551	16.4	705	4.5	83	0.5	77	0.5	1 124	7.2	15 556	100
1997/1998	8 038	45.1	4 685	26.3	2 757	15.5	868	4.9	84	0.5	86	0.5	1 297	7.3	17 815	100
1998/1999	8 086	42.8	5 052	26.8	2 912	15.4	879	4.7	80	0.4	95	0.5	1 767	9.4	18 871	100
1999/2000	8 494	41.1	5 383	26.0	3 315	16.0	959	4.6	87	0.4	97	0.5	2 348	11.4	20 683	100
2000/2001	8 936	40.4	6 065	27.4	3 477	15.7	1 028	4.6	90	0.4	107	0.5	2 423	11.0	22 126	100
2001/2002	9 061	37.7	6 385	26.6	4 458	18.6	1 347	5.6	97	0.4	114	0.5	2 541	10.6	24 003	100
2002/2003	11 407	38.6	7 035	23.8	6 266	21.2	1 923	6.5	99	0.3	125	0.4	2 701	9.1	29 556	100
2003/2004	12 500	36.1	9 500	27.5	6 400	18.5	2 100	6.1	100	0.3	132	0.4	3 868	11.2	34 600	100
2004/2005	15 500	39.4	9 900	25.2	7 600	19.3	2 100	5.3	109	0.3	135	0.3	3 956	10.1	39 300	100

Source: National Agricultural Income, Economic Affairs Sector (EAS).

FIGURE 2
Relative contributions of the components of animal production in value terms in Egypt in 2005

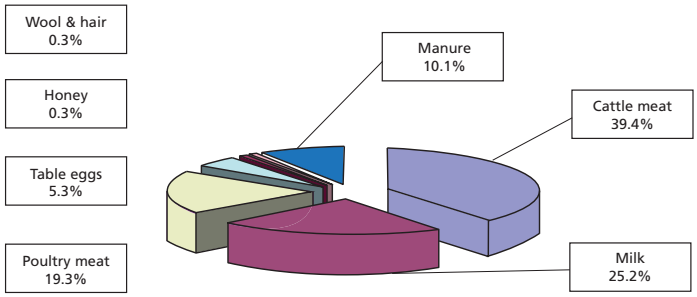


FIGURE 3
Relative importance of poultry production in value terms as a component of animal production in Egypt, 1995/1996 to 2004/2005

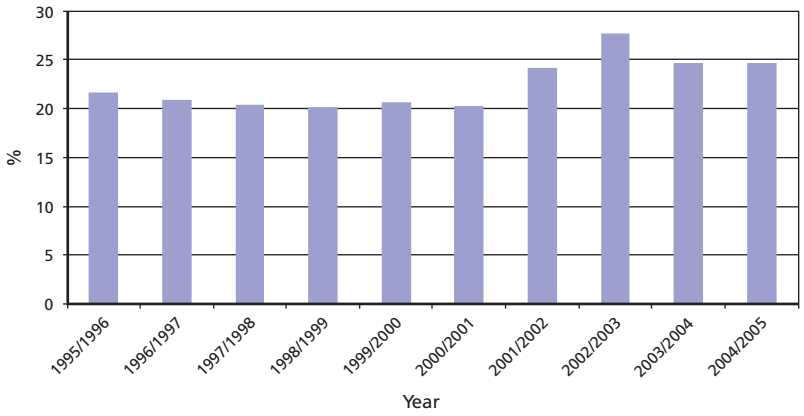


FIGURE 4
Share of meat and eggs in the value of poultry production

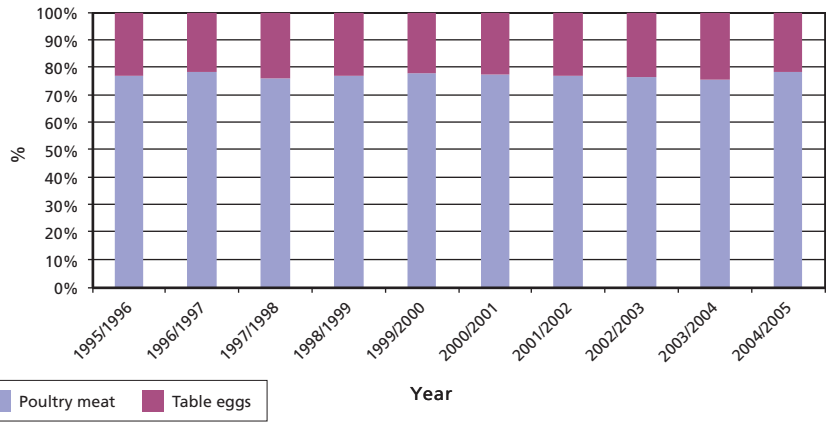
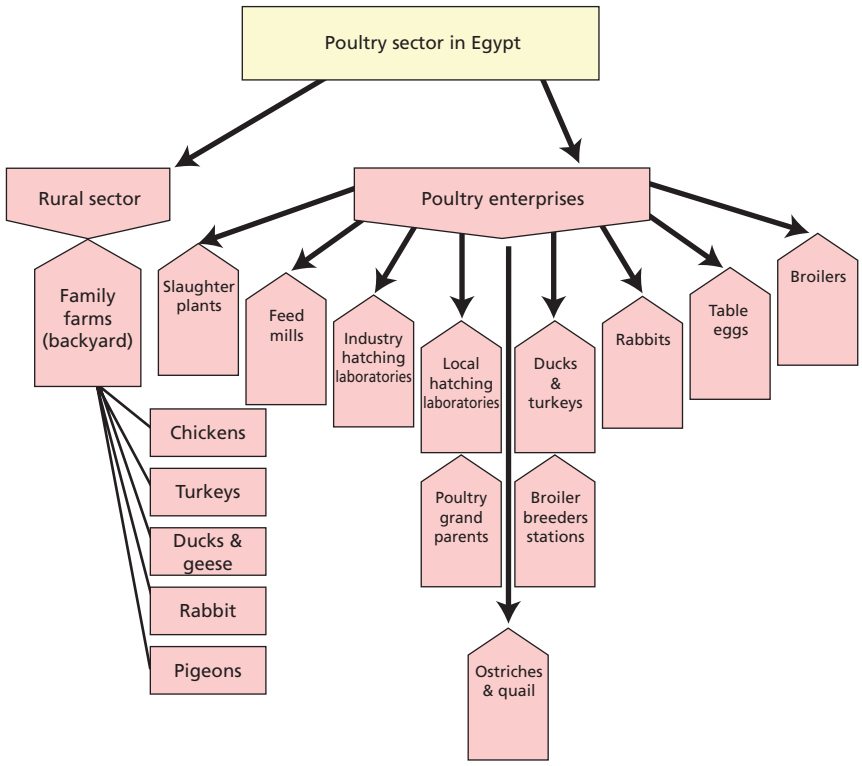


FIGURE 5
Structure of the poultry sector



3 ECONOMIC AND SOCIAL IMPACTS OF AVIAN INFLUENZA IN EGYPT

The first appearance of the disease in Egypt was in February 2006. The latest statistics (late 2007) show that the disease has caused the death of 11 people in Egypt. The total number of culled birds has reached 29 million, with an estimated value of LE463.4 million. This represents about 9.2 percent of the net annual income of the poultry sector, which was about LE5.060 billion in 2004. This means that over three months the disease caused financial losses of around LE half billion (at current exchange rate) to the poultry sector.

3.1 Economic effects

Culling of birds

Table 3 illustrates the number and value of culled birds from different classes of poultry up to 21 April 2006. It can be seen that the largest number of losses were among layers. Table 4 shows the figures for culled birds broken down by governorate.

TABLE 3
Number and value of culled poultry in Egypt up to 21 April 2006 (1 000)

	Broilers	Layers	Layer parents	Broiler parents	Grand parents	Ducks	Turkeys	Local poultry	Total
Number of culled birds (1 000)	8 182	17 737	960	1 113	28	422	60	495	28 997
Value of culled birds (1 000 LE)	108 101	239 450	32 160	61 215	NA	14 135	3 184	5 154	463 399
Total population	50 5499	18 529	317	7 966	NA	4 281	495	57 020	594 107

Source: Economic Affairs Sector (EAS), Ministry of Agriculture and Land Reclamation, 2006.

Unemployment resulting from the avian influenza outbreak

At the time of the outbreak, employment in the poultry sector was about 1.5 million permanent (full time) workers plus about one million (temporary) part time workers. As a result of the spread of the disease, about 250 000 of these workers lost their jobs – representing 10 percent of total workers in the industry on the level of the republic. Job losses were caused by the cessation of production of broiler poultry farms, as well as by the closure of feed production plants and retail and marketing operations.

Decreased demand for poultry and poultry products

Decreased demand for poultry and poultry products led to a significant decline in their prices. The poultry price index decreased by 5.5 percent, 7.9 percent and 7.0 percent, respectively, during October, November, and December 2005. This represented a serious loss for producers. The Egyptian cabinet estimated that the losses experienced by the Egyptian economy between October 2005 and February 2006 amounted to about LE3 billion.

As a result of the falling demand, poultry farmgate and consumer prices have decreased significantly – by 37 percent and 40 percent, respectively. In addition, the total marketing margins of traders have decreased by 64 percent. Consequently, the total revenue of broiler production has decreased by 28.6 percent, with a loss of 35.2 piaster per broiler; the return per Egyptian pound has decreased by 4.04 piaster. Numerous farm owners left the industry. There was also a decline in demand for inputs such as young chickens (25 percent) and concentrated feed (9.77 percent). In contrast, demand for vaccinations and drugs has increased by 11.6 percent.

The disease had both short-term and long-term effects. In the short term, it led to a 70 percent decline in poultry consumption. Demand for alternatives such as fish and red meats has, therefore, increased and their prices have risen significantly. Moreover, the significant decrease in the poultry supply led to increases in the prices of poultry and eggs when the rates of infection retreated. In the longer term, it is expected that there will be some changes to the structure of poultry industry – especially increased dependence on large-scale farms that are able to implement the required biosecurity measures. There is expected to be an increase in poultry prices, and a gap between production and demand for poultry products, which will have to be filled by imports. Moreover, it is expected that

TABLE 4
Geographical distribution of birds culled up to 21 April 2006

Governorate	Broilers	Layers	Layer parents	Broiler parents	Grand parents	Ducks	Turkeys	Local poultry	Total	Share of total (%)
Cairo	13 500	40 265	0	54 419	0	36 500	13 200	0	157 884	0.54
Gize	1 469 762	2 729 760	16 9532	597 612	0	70 212	760	0	5 037 638	17.37
Qalyubiya	1 651 626	30 472 846	0	41 700	0	24 280	15 600	0	4 776 052	16.47
Bahaira	23 041	0	6 000	0	0	11 475	0	0	40 516	0.14
Ghrabia	477 384	1 148 100	0	0	0	214 366	00	65 117	1 904 967	6.57
Sharkia	3299 790	9 452 728	779 000	385 484	28 000	8 000	5 000	0	13 958 002	48.14
Ismailia	34 000	354 820	0	0	0	0	0	0	388 820	1.34
Beni suef	4 864	0	0	0	0	0	0	0	4 864	0.02
Luxor	75 110	0	0	0	0	4 961	0	0	80 071	0.28
Aswan	22 700	0	0	0	0	0	0	0	22 700	0.08
Elminia	29 265	1 510	0	0	0	29	18 600	0	49 404	0.17
Menoufia	148 498	615 621	0	19950	0	404	2 000	00	786 473	2.71
Dakahlia	479 482	271 810	0	0	0	1 121	0	291959	1 044 372	3.61
Fayoum	21 670	6 200	5470	0	0	34 340	0	57 405	125 085	0.43
Suhag	18 588	0	0	0	0	6 100	0	00	24 688	0.09
Kafer El sheikh	55 000	5 000	0	14 000	0	1 000	0	76917	151 917	0.52
Alexandria	00	63 600	0	0	0	751	0	0	64 351	0.22
Qena	93	0	0	0	0	140	4 505	0	4 738	0.02
Damietta	353 462	4 245	0	0	0	7 980	0	3926	369 613	1.27
Assuit	4 000	0	0	0	0	0	0	0	4 000	0.01
Total	8 181 835	177 36 505	960 002	1 113 165	28 000	421 659	59 665	495 324	28 996 155	100

Source: Public Authority of Veterinary Services, 2006.

there may be a change in consumption patterns, with more consumers opting for frozen poultry products.

Financial burdens on the state

The spread of avian influenza compelled the state to compensate the owners of farms and marketing outlets. Farm owners were compensated at rate of LE5 for each culled chicken. In addition, the state spent millions of pounds to import vaccines to vaccinate the poultry flocks, and imported 2.5 million doses of drugs to treat infected humans. Moreover, the state compensated the owners of about 50 thousand licensed poultry selling shops by LE1000, which amounted to a total of LE 50 million. The state also lost huge amounts as a result of foregone revenue from taxes and customs from the poultry industry.

Reduction in revenues in sectors related to the poultry industry

The effects of avian influenza extend beyond the poultry farms to other sectors, such as the industries that provide inputs for poultry production and pack poultry meat, as well as those involved in internal and foreign trade in poultry products, and in retail and catering. It was difficult for the state to find alternative options for those involve in such businesses, because of the large financial commitments required.

Losses on uninfected farms

Uninfected farms faced losses as a result of the refusal of about 70 percent of consumers to buy poultry in the wake of the disease outbreak. Moreover, farms were unable to liquidate their production because of a lack of operating abattoirs in the affected governorates, and lack of capacity to freeze and refrigerate meat. The movement of poultry between governorates was also prohibited. Farm owners had no option but to slaughter birds randomly and sell them at low prices (LE3 per chicken). This led to losses estimated at LE266 million. The farms that couldn't market their products were obliged to pay for the ongoing maintenance of the birds (feed, labour, etc). Furthermore, on some of these farms, rates of mortality increased significantly.

3.2 Social impacts

Human health impacts

An estimated 11 people have died of avian influenza in Egypt, with about 22 infected (according to figures available in late 2007). There is a lack of awareness among citizens about how the disease spreads; this is particularly true among the rural population who live with poultry in their homes or breed poultry on their roofs. Fear of the disease has had a negative affect on tourism in Egypt.

Negative impacts on low-income consumers

The spread of avian influenza has affected a large number of low-income consumers, who depend upon poultry meat as a cheap source of animal protein. It is expected that some farms will cease production and that the prices of poultry and eggs will rise. Moreover, it is expected that prices of other protein sources such as red meats and fish will also rise.

Increases in unemployment

When poultry farms and feed factories stopped production as a result of avian influenza, thousands of workers lost their jobs. Furthermore, when about 50 thousand licensed poultry shops and an undetermined number of unlicensed poultry shops stopped operating, thousands of workers lost their jobs. In spite of a decree issued by the prime minister and the efforts of many of owners to shift towards the sale of frozen poultry or other activities, many were unable to adapt their operations because of a lack of financial capabilities and practical experience, as well reduced demand for frozen poultry products.

4 THE FUTURE OF THE POULTRY INDUSTRY IN EGYPT

4.1 Trends

A description of the crisis that hit the poultry industry in Egypt, both specialized enterprises and household flocks in rural areas, can shed some light on the future of the sector. The prices of poultry and alternative sources of animal protein were affected, as were the prices of vegetarian protein. Companies involved in marketing these products were affected.

The period from October 2005 to February 2006 saw a big fall in white poultry prices. The estimated decline was 30.14 percent, with the price of 1 kg of meat falling from LE7.3 to LE5.1 Moreover, the prices of domestic poultry also fell by an estimated 26.08 percent during the same period – from LE9.09/kg to LE6.72/kg. The prices of alternatives to poultry products recorded a significant increase. Red meat prices increased by between 0.17 to 4.83 percent. Fish prices increased by an estimated 4.45 to 20.15 percent. The state intervened in order to reduce the prices of red meats and to stabilize the local market. Prices of vegetarian protein also increased. The price of beans rose by 2.35 percent, but lentils fell by 3 percent. These are considered to be commodities used by poor families.

The shares of Cairo Poultry Company registered a decrease of 10.64 percent during the crisis period. However, the Egyptian Poultry Company registered an increase of 0.9 percent. The prices of seven companies in the milling sector registered falls of between 1.75 percent and 21.5 percent.

The process of importing grandparent poultry was affected negatively, being suspended during the period from October 2005 to February 2006. There is no doubt that this will affect the poultry industry greatly. It is expected that this cessation of imports will affect production of live birds and eggs and increase prices, particularly given the need for biosecurity and the heavy losses suffered by breeders during the outbreak. The breeders suffered from: (i) a shortage of grandparent birds, (ii) high feeding costs; and iii) lower selling prices for young chicks. Hence they need to compensate their losses in the near future. It is worth stating that the union of poultry producers has estimated the operating losses to be LE 3 billion, as an accumulative loss, which represent about 17.6 percent of the total value of investments made in the industry during the period from October 2005 to February 2006.

As a result of the changes that have affected the sector in the aftermath of the outbreak, it is expected that there may be an increase in poultry prices in local markets after the recent period of low prices. Since July 2007, prices have risen significantly – to LE10.5/kg for white poultry and LE12.5/kg for red and domestic poultry. Feed prices are increasing and farms owners are investing in veterinary services and expensive drugs.

Some breeders consider that the prices of poultry will settle at LE9–10/kg, but prices remain difficult to predict as they are subject to the volume offered in market, the volume of demand, feed prices and prices of alternative commodities. Moreover, intermediaries between farms owners and traders are playing a big role in the pricing process in the absence of a poultry bourse.

4.2 Development of slaughtering and marketing infrastructure

Loss of foreign trade, prohibition of selling and marketing live poultry in great Cairo and the governorate capitals, and reluctance of Egyptians to consume poultry products, have negatively affected the poultry industry in Egypt. About 2.5 percent of poultry farms have gone out of production. The lack of sufficient capacities of automative slaughter houses and refrigerators and large fluctuations of producer prices are considered major obstacles for the poultry industry in Egypt. There is slaughter capacity for only about 18.6 percent of the total production of broilers in Egypt with a substantial imbalance between the different Governorates (see Tables A51 and A52 in the appendix). There is a need to evaluate options for shifting the orientation of the marketing system from live to slaughtered chickens. This requires redistribution of automated abattoir capacity across governorates, as well as re-organizing production, increasing efficiency and achieving higher environmental and safety standards.

APPENDIX 1
POULTRY PRODUCTION STATISTICS

TABLE A1
Broiler production capacity, 1991 to 2005

Year	Number of farms	Number of poultry houses			Capacity (1 000 chickens)	
		Active	Non-active	Total	Total	Used
1991	13 356	7 387	11 312	18 699	46 7804	140 676
1992	13 181	8 844	9 609	18 453	465 494	161 257
1993	12 914	10 206	7 873	18 079	423 192	172 168
1994	12 609	11 567	6 138	17 705	380 890	183 079
1995	11 895	12 469	5 463	17 932	447 167	211 646
1996	11 827	13 076	5 298	18 374	458 868	237 605
1997	11 834	13 714	5 147	18 861	479 874	257 559
1998	11 394	14 626	3 951	18 577	457 282	253 671
1999	12 288	16 545	3 316	19 861	489 195	323 136
2000	12 838	17 451	3 045	20 496	508 609	342 208
2001	13 526	18 959	3 071	22 030	838 350	454 752
2002	14 519	20 566	3 159	23 725	857 376	628 144
2003	14 972	20 181	4 495	24 676	892 717	563 683
2004	15 668	20 615	5 298	25 913	922 924	505 499
2005	14 698	20 646	4 494	25 140	776 285	491 231

Source: Economic Affairs Sector (EAS) Ministry of Agriculture and Land Reclamation.

TABLE A2
Geographical distribution of broiler production capacity (1 000 birds) by size category, 2005

	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Alexandria	10 146.4	5 464	6 753	5 816	1 059.2	470.7	17 958.6	11 750.7
Behaira	11 463.44	7 618	33 500.26	20 843	2 685	1 682	47 648.7	30 143
Kafr El sheikh	2 933.5	2 120	1 7055	11 437.6	4 734	3 019.1	24 722.5	16 576.7
Dakahlia	21 190	7 666	78 516	47 284	5 716	3 135	10 5422	58 085
Damietta	10 792.205	5 754.025	14 017.87	83 66.009	2 143.1	1 068.363	26 953.175	15 188.397
Sharkia	22 119	15 063.6	90 242.75	47 088.2	11 708.3	6 369.75	124 070.05	68 521.55
Port Said	320	148	879	360	-	-	1 199	508
Ismailia	10 688	7 807	7 211	4 958	1 250	924	19 149	13 689
Suez	2 470	1 034	1 218	367.5	30	20	3 718	1 421.5
Ghrabia	14 042.79	10 438.525	63 487.64	60 552.16	9 958.08	8 691.32	87 488.51	79 682.005
Menoufia	9 701.934	5 196.85	22 366.534	8 762.7	1 332.58	678.74	33 401.048	14 638.29
Qalyoubia	8 425	5 815	75 350	59 760	8 575	4 550	92 350	70 125
Cairo	3 315	1 007.7	900	343.9	172	172	43 87	1 523.6
Lower Egypt	127 607.269	75 132.7	411 497.054	275 939.069	49 363.26	30 780.973	588 467.583	381 852.74
Giza	19 861.5	12 422	26 641	13 533	1 085	785	47 587.5	26 740
Beni Suef	2 199	1 599	5 829	2 921	1 883	1 883	9 911	6 403
Fayoum	4 948.8	2 919	10 198.75	7 013.6	1 276	1 276	16 423.55	1 1208.6
Menia	9 794	5 970	3 4712	19 531	6 526	2 955	51 032	28 456
Middle Egypt	36803.3	22 910	77 380.75	42 998.6	10 770	6 899	124 954.05	72 807.6
Assuit	875	455	5 126	2 624	667	378	6 668	3 457
Suhag	3 413	1 450.4	4 283	1 099	567	567	8 263	3 116.4
Qena	1 344	862.415	244	87.8	331	331	1 919	1 281.215
Luxor	-	-	-	-	1 230.898	902.907	1 230.898	902.907
Aswan	-	-	472	144.402	641.432	641.472	1 113.432	785.874

(Continued)

TABLE A2
(Continued)

	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Upper Egypt	5 632	2 767.815	10 125	3 955.202	3 437.33	2 820.379	19 194.33	9 543.396
Matruh	1 876.416	351	3 842.38	844.884	123.408	11.516	5 842.204	1 207.4
Noubaria	2 1943.7	16 419.5	5 908.6	6 697.8	975.6	864.6	28 827.9	23 981.9
North Sinai	105	31.3	5 253	846.5	876	402	6 234	1 279.8
Sinai South	-	-	315	28.4	-	-	315	28.4
New Valley	1 000	225	700	171	52	8	1 752	404
Red Sea	420	-	210	105	67.5	20.5	697.5	125.5
New and desert Land	25 345.116	17 026.8	16 228.98	8 693.584	2 094.508	1 306.616	43 668.604	2 7027
Grand Total	195 387.685	117 837.315	515 231.784	331 586.455	65 665.098	41 806.968	776 284.567	491 230.74

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A3
Geographical distribution of broiler production capacity (tonne) by size category, 2005

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Alexandria	15 219.600	8 196.000	10 129.500	8 724.000	1 588.800	706.050	26 937.900	17 626.050
Behaira	17 195.160	11 427.000	50 250.390	31 264.500	4 027.500	2523.000	71 473.050	45 214.500
Kafr El sheikh	4 400.250	3 180.000	25 582.500	17 156.400	7 101.000	4528.650	37 083.750	24 865.050
Dakahlia	31 785.000	11 499.000	117 774.000	70 926.000	8 574.000	4702.500	158 133.000	87 127.500
Damietta	16 188.308	8 631.038	21 026.805	12 549.014	3 214.650	1602.545	40 429.763	22 782.597
Sharkia	33 178.500	22 595.400	135 364.125	70 632.300	17 562.450	9 554.625	186 105.075	102 782.325
Port Said	480.000	222.000	1 318.500	540.000	-	-	1 798.500	762.000
Ismailia	16 032.000	11 710.500	10 816.500	7 437.000	1 875.000	1 386.000	28 723.500	20 533.500
Suez	3 705.000	1 551.000	1 827.000	551.250	45.000	30.000	5 577.000	2 132.250
Ghrabia	21 064.185	15 657.788	95 231.460	90 828.240	14 937.120	13 036.980	131 232.765	119 523.008
Menoufia	14 552.901	7 795.275	33 549.801	13 144.050	1 998.870	1 018.110	50 101.572	21 957.435
Qalyoubia	12 637.500	8 722.500	113 025.000	89 640.000	12 862.500	6 825.000	138 525.000	105 187.500
Cairo	4 972.500	1 511.550	1 350.000	515.850	258.000	258.000	6 580.500	2 285.400
Lower Egypt	191 410.904	112 699.051	617 245.581	413 908.604	74 044.890	46 171.460	882 701.375	572 779.115
Giza	29 792.250	18 633.000	39 961.500	20 299.500	1 627.500	1177.500	71 381.250	40 110.000
Beni Suef	3 298.500	2 398.500	8 743.500	4 381.500	2 824.500	2 824.500	14 866.500	9 604.500
Fayoum	7 423.200	4 378.500	15 298.125	10 520.400	1914.000	1 914.000	24 635.325	16 812.900
Menia	14 691.000	8 955.000	52 068.000	29 296.500	9 789.000	4 432.500	76 548.000	42 684.000
Middle Egypt	55 204.950	34 365.000	116 071.125	64 497.900	16 155.000	10 348.500	187 431.075	109 211.400
Assuit	1 312.500	682.500	7 689.000	3 936.000	1 000.500	567.000	10 002.000	5 185.500
Suhag	5 119.500	2 175.600	6 424.500	1 648.500	850.500	850.500	12 394.500	4 674.600
Qena	2 016.000	1 293.623	366.000	131.700	496.500	496.500	2 878.500	1 921.823
Luxor	-	-	-	-	1 846.347	1 354.361	1 846.347	1 354.361
Aswan	-	-	708.000	216.603	962.148	962.208	1 670.148	1 178.811

(Continued)

TABLE A3
(Continued)

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Upper Egypt	8 448.000	4 151.723	15 187.500	5 932.803	5 155.995	4 230.569	28 791.495	1 4315.095
Matruh	2 814.624	526.500	5 763.570	1 267.326	185.112	17.274	8 763.306	1811.100
Noubaria	32 915.550	24 629.250	8 862.900	10 046.700	1 463.400	1 296.900	43 241.850	35 972.850
North Sinai	157.500	46.950	7 879.500	1 269.750	1 314.000	603.000	9 351.000	1 919.700
Sinai South	-	-	472.500	42.600	-	-	472.500	42.600
New Valley	1 500.000	337.500	1 050.000	256.500	78.000	12.000	2 628.000	606.000
Red Sea	630.000	-	315.000	157.500	101.250	30.750	1 046.250	188.250
New and desert Land	38 017.674	25 540.200	24 343.470	13 040.376	3 141.762	1 959.924	65 502.906	40 540.500
Grand Total	293 081.528	176 755.974	772 847.676	497 379.683	98 497.647	62 710.453	1 164 426.851	736 846.110

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A4
Change rate of farm numbers, total capacity and used capacity for broiler chickens during the period 1991 to 2005

	Average	Regression coefficient	Change rate (%)
Number of farms	13 167.933	177.19	1.346
Total capacity	328 420.93	33 075.97	10.071
Used capacity	591 068.47	372 85.24	6.308

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A5
Distribution of broiler production capacity according to the size of the enterprise, 2005

	Enterprise scale	Large	Medium	Small	Total
Total capacity	Number of broilers (1 000)	195 387.685	515 231.784	65 665.100	776 284.57
	Capacity (tonne)	293 081.528	772 847.676	98 497.65	1 164 426.9
	Share of capacity (%)	25.17	66.37	8.46	100.00
Used capacity	Number of broilers (1 000)	117 837.315	331 586.455	41 806.97	491 230.74
	Capacity (tonne)	176 755.974	497 379.683	62 710.45	736 846.11
	Share of capacity (%)	23.99	67.50	8.51	100.00
Unused capacity	Number of broilers (1 000)	77 550.37	183 645.329	23 858.13	285 053.83
	Capacity (tonne)	116 325.554	275 467.993	35 787.19	427 580.74
	Share of capacity (%)	27.21	64.42	8.37	100.00

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

FIGURE A1
Total and used broiler production capacity according to scale of the enterprise

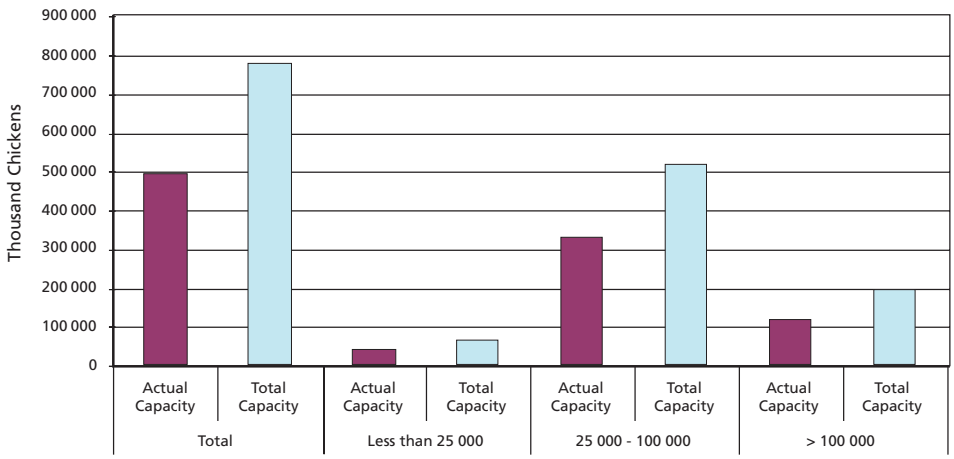


TABLE A6
Distribution of broiler chicken enterprises* according to management sector, 2005

Sector	Active enterprises			Non-active enterprises	
	Number of enterprises	Total capacity (1 000)	Used capacity (1 000)	Number of enterprises	Total capacity (1 000)
Private	871	140 623.779	96 652.65	136	20 725.656
Governmental	27	9 276.65	6 292.015	7	4 570
Cooperative	12	1 876.6	1 359.15	1	200
Investment	12	1 5815	13 595	2	1 800
Public works	2	500	108	-	-

* Enterprises of 100 000 or more birds.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A7
The geographical distribution of broiler chicken enterprises and houses, 2005

Governorate	Number of enterprises	Number of poultry houses		
		Active	Not active	Total
Alexandria	192	385	56	441
Behairah	721	1 408	321	1 729
Kafr El sheikh	455	650	73	723
Dakahlia	1 988	3 400	381	3 781
Damietta	324	727	176	903
Sharkia	2 962	3 334	750	4 084
Port Said	17	30	9	39
Ismailia	223	403	83	486
Suez	44	66	24	90
Ghrabia	1 787	2640	188	2 828
Menoufia	638	808	220	1 028
Qalyoubia	2 579	2 886	516	3 402
Cairo	35	52	46	98
Lower Egypt Total	11 965	16 789	2 843	19 632
Giza	698	1 102	529	1 631
Beni Suef	145	251	83	334
Fayoum	275	510	87	597
Menia	864	897	350	1 247
Middle Egypt Total	1 982	2 760	1049	3 809
Assuit	133	199	89	288
Suhag	129	147	280	427
Qena	8	24	8	32
Luxor	-	-	-	-
Aswan	11	15	32	47
Upper Egypt Total	281	385	409	794
Matruh	92	88	63	151
Noubaria	230	498	16	514
North Sinai	125	84	61	145
Sinai South	6	4	8	12
New Valley	12	35	28	63
Red Sea	5	3	17	20
New and Desert Land Total	470	712	193	905
Grand Total	14 698	20 646	4 494	25 140

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A8
Geographical distribution of broiler production capacity* of by size of the enterprise, 2005

Governorate		Large enterprises		Medium enterprises		Small enterprises		Total	
		Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Lower Egypt	No.	127 607.27	75 132.70	411 497.10	275 939.10	49 363.26	30 780.97	588 467.60	381 852.70
	%	65.31	63.76	79.87	83.22	75.17	73.63	75.81	77.73
Middle Egypt	No.	36 803.30	22 910.00	77 380.75	42 998.60	10 770.00	6 899.00	124 954.10	72 807.60
	%	18.84	19.44	15.02	12.97	16.40	16.50	16.10	14.82
Upper Egypt	No.	5 632.00	2 767.82	10 125.00	3 955.20	3 437.33	2 820.38	19 194.33	9 543.40
	%	2.88	2.35	1.97	1.19	5.23	6.75	2.47	1.94
New and Desert Land	No.	25 345.12	17 026.80	16 228.98	8 693.58	2 094.51	1 306.62	43 668.60	27 027.00
	%	12.97	14.45	3.15	2.62	3.19	3.13	5.63	5.50
Grand Total	No.	195 387.69	117 837.30	515 231.80	331 586.50	65 665.10	41 806.97	776 284.60	491 230.70
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*Number of broilers ×1 000
Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A9
Production capacity for layer chickens, 1991 to 2005

Year	Number of farms	Poultry houses			Total capacity (1 000)		Used capacity (1 000)	
		Active	Not active	Total	Chickens	Eggs	Chickens	Eggs
1991	?	642	2 191	2 833	29 116	6 454 874	12 931	2 453 911
1992	1 366	616	1 843	2 459	26 070	5 716 641	12 991	2 663 505
1993	1 635	1 023	1 948	2 971	22 961	5 307 019	12 487	2 557 034
1994	1 905	1 429	2 054	3 483	19 851	4 897 397	11 983	2 450 562
1995	1 445	1 227	1 457	2 684	22 324	4 956 175	12 507	2 457 072
1996	1 469	1 336	1 492	2 828	29 046	5 296 798	16 337	2 448 090
1997	1 340	1 374	1 375	2 749	22 365	5 648 732	14 543	2 551 622
1998	1 327	1 512	1 164	2 676	21 239	5 392 368	14 836	2 4433 032
1999	1 387	1 978	896	2 874	22 307	5 641 472	14 998	2 554 503
2000	1 331	2 057	860	2 917	22 285	5 658 035	15 499	2 944 410
2001	1 414	2 350	794	3 144	25 148	7 933 264	18 957	3 240 018
2002	1 361	2 273	677	2 950	24 737	7 802 900	19 412	5 117 889
2003	1 350	2 200	904	3 104	24 285	7 652 660	18 090	4 834 687
2004	1 461	2 415	978	3 393	28 256	8 922 352	18 529	4 015 516
2005	1 728	3 130	1 195	4 325	32 666	7 866 840	20 670	4 376 790

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A10
Geographical distribution of table egg enterprises, 2005

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Layer chickens (1 000)	Million eggs	Layer chickens (1 000)	Million eggs	Layer chickens (1 000)	Million eggs	Layer chickens (1 000)	Million eggs
Alexandria	309	73	634.92	163.16	100.52	25.62	1 044.44	261.78
Behairah	597	142	474.69	82.1	637	125.4	1 708.69	349.5
Kafr El sheikh	2 33.5	52	4.1	1	7.1	1.74	244.7	54.74
Dakahlia	1 020	248	752	185.9	21.4	5.23	1 793.4	439.13
Damietta	210	52.7	56	13.59	-	-	266	66.29
Sharkia	4 461	1 076.5	3 980	952.5	364.7	80.74	8 805.7	2 109.74
Port Said	-	-	29.97	5.2	-	-	29.97	5.2
Ismailia	230	57.5	163	40.75	26	6.5	419	104.75
Suez	75	15	34	8.64	7	1.05	116	24.69
Ghrabia	643	206.12	696.9	203.06	74.36	22.59	1 414.26	431.77
Menoufia	373.2	98.9	966.95	240.18	47	11.81	1 387.15	350.89
Qalyoubia	1 542	353	1 254.2	265.7	833	174.3	3 629.2	793
Cairo	467	115.8	246.8	58.78	3.5	0.91	717.3	175.49
Lower Egypt	10 160.7	2 490.52	9 293.53	2 220.56	2 121.58	455.89	21 575.81	5 166.97
Giza	5 258.3	1 303.65	1 832.6	451.1	18.3	4.51	7 109.2	1 759.26
Beni Suef	135	30	-	-	-	-	135	30
Fayoum	285	48	87.5	19.9	1.1	0.2	373.6	68.1
Menia	292	86	80	24	49.99	5	421.99	115
Middle Egypt	5 970.3	1 467.65	2 000.1	495	6 939	9.71	803 979	197 236
Assuit	144	26	28.67	4.76	950	170	1 122.67	200.76
Suhag	327	60	-	-	167	49	494	109
Qena	135	30	20	6.3	-	-	155	36.3
Luxor	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	97	14.55	97	14.55
Upper Egypt	606	116	4 867	11.06	1 214	233.55	1 868.67	360.61
Matruh	-	-	-	-	-	-	-	-
Noubaria	880	281.6	139.6	37.6	41.3	10.7	1 060.9	329.9
North Sinai	-	-	10	2	-	-	10	2
Sinai South	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-
Red Sea	-	-	111	35	-	-	111	35
New and Desert Land	880	281.6	260.6	74.6	41.3	10.7	1 181.9	366.9
Grand Total	17 617	4 355.77	11 602.9	2 801.22	3 446.27	709 85	32 666.17	7 866.84

Large: > 15 million eggs; Medium: 1million – 15 million eggs; Small: less than 1 million eggs.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A11
Change rate of poultry house numbers and production capacity for layer chickens, 1992 to 2005

	Average	Regression coefficient	Change rate (%)
Poultry house numbers	1 780.00	153.49	8.623
Total capacity (1 000 eggs)	6 335 189.50	276 714.36	4.368
Total capacity (1 000 layers	24 538.57	400.28	1.631
Used capacity (1 000 eggs)	4 760 337.86	135 512.80	2.847
Used capacity (1 000 layers)	15 845.64	627.94	3.963

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A12
Distribution of layer production capacity according to the size of the enterprise, 2005

	Enterprise scale	Large enterprises	Medium enterprises	Small enterprises	Total
Total capacity	Number of layers (1 000)	17 617	1 160.9	3 446.3	22 224.2
	Capacity (million eggs)	4 355.77	2 801.22	709.85	7 866.84
	Share of capacity (%)	55.369	35.608	9.023	100.000
Used capacity	Number of layers (1 000)	11 268	7 049	2 353	20 670
	Capacity (million eggs)	2 562.63	1 373	440.8	4 376.43
	Share of capacity (%)	58.555	31.373	10.072	100.000

Large: > 15 million eggs; Medium: 1 million – 15 million eggs; Small: less than 1 million eggs.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

FIGURE A2
Egg production capacity according to size of enterprise

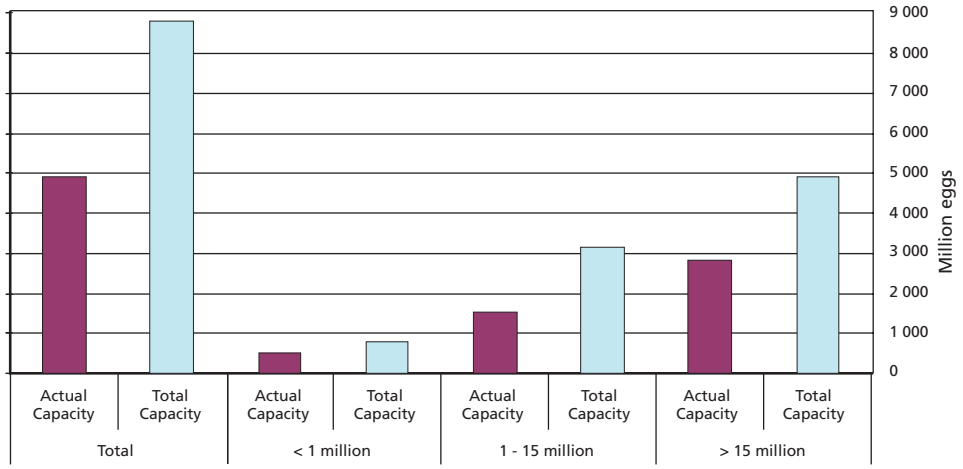


TABLE A13
Distribution of layer production capacity according to the size of the enterprise, 2005

Sector	Number of enterprises	Total capacity		Used capacity	
		Thousand layers	Million eggs	Thousand layers	Million eggs
Private	75	8 877.8	2 482.7	6862.9	1 530.70
Governmental	18	2 161	529.94	1 689 66	419.71
Cooperative	5	554.2	138.85	530.23	94.49
Investment	16	2774	663.2	2185	517.73

*Enterprises of 15 million eggs or more.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A14
The geographical distribution of layer chicken enterprises and houses, 2005

Governorate	Number enterprises		Number of poultry houses					
			Active		Not active		Total	
	Total	Large enterprises*	Total	Large enterprises*	Total	Large enterprises*	Total	Large enterprises*
Alexandria	93	3	111	13	49	-	160	13
Behaira	45	6	63	30	52	5	115	35
Kafr El sheikh	7	1	5	4	17	-	22	4
Dakahlia	68	9	131	47	73	-	204	47
Damietta	6	2	22	11	2	-	24	11
Sharkia	639	21	901	203	393	45	1 294	248
Port Said	1	-	7	-	-	-	7	-
Ismailia	21	2	23	8	23	-	46	8
Suez	8	1	8	3	3	-	11	3
Ghrabia	110	4	216	29	41	3	257	32
Menoufia	85	4	163	16	90	2	253	18
Qalyoubia	367	14	578	64	77	-	655	64
Cairo	26	4	50	12	16	-	66	12
Total for Lower Egypt	1 476	71	2 278	440	836	55	3 114	495
Giza	182	28	346	153	300	48	646	201
Beni Suef	1	1	6	6	-	-	6	6
Fayoum	7	1	22	6	8	2	30	8
Menia	6	2	23	7	7	-	30	7
Total for Middle Egypt	196	32	397	172	315	50	712	222
Assuit	4	1	184	6	7	-	191	6
Suhag	3	3	209	12	4	4	213	16
Qena	4	2	7	6	5	-	12	6
Luxor	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-
Total for Upper Egypt	11	6	400	24	16	4	416	28
Matruh	-	-	-	-	-	-	-	-
Noubaria	37	5	54	26	19	-	73	26
North Sinai	2	-	-	-	2	-	2	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-
Red Sea	6	-	1	-	7	-	8	-
Total for New and Desert Land	45	5	55	26	28	-	83	26
Grand Total	1 728	114	3 130	662	1 195	109	4 325	771

*Large enterprises: 15 million or more eggs per year.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A15
Geographical distribution of layer production capacity of by size of enterprise, 2005

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs
Alexandria	291.1	69	475.8	118.14	36.65	9.14	803.55	196.28
Behairah	411	104.4	185.5	26.79	54.3	10.86	650.8	142.05
Kafr El sheikh	67.5	14.37	4	0.9	-	-	71.5	15.27
Dakahlia	786	179.7	322	66.3	4.4	1.6	1 112.4	247.6
Damietta	196	47.04	32.65	7.84	-	-	228.65	54.88
Sharkia	2 620	587.9	2592	500.2	216.6	44.94	5 428.6	1 133.04
Port said	-	-	28.4	3.8	-	-	28.4	3.8
Ismailia	187	37.4	89	18.25	1	0.25	277	55.9
Suez	48	10.7	23.5	4.89	2	0.23	73.5	15.82
Ghrabia	258	142.3	652.4	115.2	43.2	7.89	953.6	265.39
Menoufia	294.53	61.67	404.47	69.77	22.12	3.26	721.12	134.7
Qalyoubia	1458	338.5	1 028.5	213.9	770.5	162	3257	714.4
Cairo	304.7	77.4	167.9	43.27	3.25	0.82	475.85	121.49
Total for Lower Egypt	6 921.83	1 670.38	6 006.12	1 189.25	1 154.02	240.99	14 081.97	3 100.62
Giza	2 673.2	536.8	739.1	119.1	18.05	2.66	3 430.35	658.56
Beni Suef	117.6	33.7	-	-	-	-	117.6	33.7
Fayoum	135	31.7	86.5	18.8	-	-	221.5	50.5
Menia	157.5	44	80	22	49.99	5	287.49	71
Total for Middle Egypt	3 083.3	646.2	905.6	159.9	68.04	7.66	4 056.94	813.76

(continued)

TABLE A15
(Continued)

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs
Assuit	72	20.73	5.5	1	850	150	927.5	171.73
Suhag	255	57	-	-	170	24.5	425	81.5
Qena	143.66	34.8	2.68	0.7	-	-	146.34	35.5
Luxor	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	97	14.55	97	14.55
Total for Upper Egypt	470.66	112.53	8.18	1.7	1 117	189.05	1 595.84	303.28
Matruh	-	-	-	-	-	-	-	-
Noubaria	792	133.52	100.2	16.01	13.9	3.1	906.1	152.63
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-
Red Sea	-	-	29	6.5	-	-	29	6.5
Total for New and Desert Land	792	133.52	129.2	22.51	13.9	3.1	935.1	159.13
Grand Total	11 267.79	2 562.63	7 049.1	1 373.36	2 352.96	440.8	20 669.85	4 376.79

Large: > 15 million eggs; Medium: 1 million – 15 million eggs; Small: less than 1 million eggs.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A16
Capacity for production of broiler breeders parents, 1991 to 2005

Year	Number of farms	Number of poultry houses			Total capacity (1 000)		Used capacity (1 000)	
		Active	Not active	Total	Chickens	Eggs	Chickens	Eggs
1991	10	52	10	62	3 348	647 821	3 071	472 118
1992	18	116	13	129	4 605	605 894	4 211	407 277
1993	62	411	20	431	4 635	569 149	4 115	217 167
1994	100	705	27	732	4 664	532 403	4 018	27 057
1995	231	1 536	88	1 624	5 815	672 891	5 034	491 632
1996	269	1 759	106	1 865	6 152	600 258	5 132	523 718
1997	239	1 323	224	1 547	6 351	857 239	5 662	481 153
1998	327	1 791	402	2 193	7 519	1 002 826	5 926	431 933
1999	335	2 022	198	2 220	8 122	1 099 707	7 316	580 319
2000	292	1 901	224	2 125	7 571	1 018 080	6 298	504 332
2001	378	2 097	147	2 244	7 969	1 275 394	7 232	661 448
2002	408	2 224	172	2 396	8 826	1 412 160	7 946	906 732
2003	406	2 122	259	2 381	9 736	1 557 760	7 722	847 885
2004	365	1 948	240	2 188	9 655	1 544 800	7 966	963 150
2005	435	2 189	169	2 358	9 793	1 552 315	8 369	942 022

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A17
Change rate of farm numbers and capacity for broiler breeder parent production, 1992 to 2005

	Average	Regression coefficient	Rate of change (%)
Number of farms	258.3	30.69	11.88
Number of poultry houses	1 479.73	154.46	10.44
Total capacity (1 000 eggs)	996 579.8	83 259.28	8.35
Total capacity (1 000 layers)	6 984.1	459.44	6.58
Used capacity (1 000 eggs)	563 862.9	49 523.92	8.8
Actual Capacity 1 000 layers)	6 001.2	371.23	6.19

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A18
Capacity for production of layer parent stock, 1991 to 2005

Year	Number of farms	Number of poultry houses			Total capacity (1 000)		Used capacity (1 000)	
		Active	Not active	Total	Chickens	Eggs	Chickens	Eggs
1991	30	95	53	148	1 039	164 602	545	76 333
1992	28	67	71	138	9 41	143 440	480	64 247
1993	21	64	39	103	6 19	95 118	342	45 664
1994	13	61	6	67	2 97	46 795	204	27 080
1995	19	97	9	106	379	55 048	347	44 792
1996	26	109	20	129	510	82 568	284	44 910
1997	30	130	16	146	759	127 418	410	41 992
1998	19	60	17	77	277	46 612	192	22 185
1999	23	70	33	103	687	115 312	324	42 070
2000	20	66	44	110	651	109 324	279	29 840
2001	21	57	45	102	619	104 573	244	24 347
2002	22	51	61	112	714	142 800	261	37 059
2003	22	47	69	116	736	147 200	277	34 701
2004	29	82	59	141	758	151 520	317	45 307
2005	42	112	45	157	543	99 606	340	41 646

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A19
Change rate of farm numbers and capacity for layer parent stock production, 1992 to 2005

	Average	Regression coefficient	Change rate (%)
Number of farms	24.33	0.42	1.73
Number of poultry houses	77.87	-0.65	-0.83
Total capacity (1 000 eggs)	108 795.73	1 528.28	-1.40
Total capacity (1 000 layers)	635.27	-4.90	-0.78
Used capacity (1 000 eggs)	41 478.2	-1 652.66	-3.98
Used capacity (1 000 layers)	323.07	-10.41	-3.22

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A20
Geographical distribution of chicken grandparent enterprises

Governorate	Number of enterprises	Number of poultry houses			Total capacity (million eggs)	Used capacity (million eggs)
		Active	Not active	Total		
Behaira	1	12	-	12	5.2	2.3
Middle Egypt	-	-	-	-	-	-
Upper Egypt	-	-	-	-	-	-
New and Desert Land	-	-	-	-	-	-
Total	1	12	-	12	5.2	2.3

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A21
Rabbit, duck and turkey production, 2001 to 2005

Year	Rabbit		Ducks		Turkey	
	Production	Index	Production	Index	Production	Index
2001	2 230 947	100.00	3 901 424	100.00	371 392	100.00
2002	2 480 597	111.19	4 602 444	117.97	626 804	168.77
2003	2 321 922	104.08	4 852 762	124.38	535 559	144.20
2004	2 910 725	130.47	5 047 419	129.37	610 331	164.34
2005	2 430 372	108.94	5 747 526	147.32	602 473	162.22

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A22
The geographical distribution of rabbit production capacity, 2005

Governorate	Total capacity		Used capacity		Unused capacity (parents)
	Number of parents	Number of offspring	Number of parents	Number of rabbits	
Alexandria	1 550	69 750	900	30 100	650
Behairah	9 805	357 050	8 990	233 195	815
Kafr El sheikh	700	30 500	234	9 850	466
Dakahlia	448	19 715	402	13 660	46
Damietta	498	19 920	425	14 875	73
Sharkia	1 2130	515 500	11 655	284 200	475
Port said	1 694	438 560	684	29 430	1 010
Ismailia	697	34 850	376	15 040	321
Suez	1 265	49 550	895	31 656	370
Ghrabia	770	36 376	250	8 734	520
Menoufia	100	4 800	40	1 200	60
Qalyoubia	9 819	490 950	8 280	163 300	1 539
Cairo	5 745	286 855	4 255	164 845	1 490
Lower Egypt	45 221	1 838 876	37 386	715 885	7 835
Giza	12 649	414 370	895	24 250	11 754
Beni Suef	11 137	156 427	8 060	162 232	3 077
Fayoum	1 146	47 826	1 001	38 151	145
Menia	9 060	434 880	8 747	305 245	313
Middle Egypt	33 992	1 053 503	18 703	529 878	15 289
Assuit	30 350	1 212 800	25 120	1 005 400	5 230
Suhag	-	-	-	-	-
Qena	500	25 000	424	19 080	76
Luxor	900	42 300	860	38 700	40
Aswan	11 648	66 212	11 203	48 412	445
Upper Egypt	43 398	1 346 312	37 607	1 111 592	5 791
Matruh	-	-	-	-	-
Noubaria	2 495	92 200	2 265	72 535	230
North Sinai	-	-	-	-	-
Sinai South	-	-	-	-	-
New Valley	350	14 800	130	482	220
Red Sea	-	-	-	-	-
New and Desert Land	2 845	107 000	2 395	73 017	450
Grand Total	125 456	4 345 691	96 091	2 430 372	29 365

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A23
Distribution of rabbit breeder enterprises* by management sector 2005

Sector	Active enterprises			Non-active enterprises	
	No. of enterprises	Total capacity	Used capacity	No. of enterprises	Total capacity
Private	93	1 487 266	560 581	58	291 732
Governmental	23	59 0175	340 274	20	47 776
Cooperative	3	7 200	262	1	2 592
Public business	-	-	-	1	8 950

*More than 10 parents
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A24
Geographical distribution of duck enterprises and capacity 2005

Governorate	Number of enterprises	Number of poultry houses			Capacity			
		Active	Not active	Total	Total capacity (number)	Used capacity (number)	Unused capacity (number)	Live weight of used capacity (tonnes)
Alexandria	3	6	2	8	25 500	6 108	19 392	15
Behairah	47	77	20	97	1 238 200	871 600	366 600	2 179
Kafr El sheikh	3	5	10	15	35 100	14 500	20 600	36
Dakahlia	16	18	-	18	128 880	59 235	69 645	148
Damietta	-	-	-	-	-	-	-	-
Sharkia	69	60	29	89	1 047 800	653 575	394 225	1 634
Port said	-	-	-	-	-	-	-	-
Ismailia	20	31	-	31	296 220	245 000	51 220	613
Suez	8	9	1	10	29 500	5 600	23 900	14
Ghrabia	117	114	18	132	1 154 190	896 400	257 790	2 241
Menoufia	3	-	3	3	20 740	-	20 740	-
Qalyoubia	193	242	36	278	3 336 000	1 727 000	1 609 000	4 318
Cairo	12	9	7	16	62 800	35 950	26 850	90
Lower Egypt	491	571	126	697	7 374 930	4 514 968	2 859 962	11 287
Giza	41	32	48	80	906 600	636 772	269 828	1 592
Beni Suef	18	21	16	37	430 000	119 900	310 100	300
Fayoum	6	7	4	11	62 600	22 100	40 500	55
Menia	8	5	3	8	26 400	10 900	15 500	27
Middle Egypt	73	65	71	136	1 425 600	789 672	635 928	1 974
Assuit	-	-	-	-	-	-	-	-
Suhag	6	5	9	14	31 820	17 230	14 590	43
Qena	6	5	4	9	82 800	59 000	23 800	148
Luxor	-	-	-	-	-	-	-	-
Aswan	6	8	5	13	32 750	1 155	31 595	3
Upper Egypt	18	18	18	36	147 370	77 385	69 985	193
Matruh	-	-	-	-	-	-	-	-
Noubaria	16	25	-	25	372 900	339 201	33 699	848
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	1	4	4	8	200 000	10 000	190 000	25
Red Sea	2	3	-	3	20 500	16 300	4 200	41
New and desert Land	19	32	4	36	593 400	365 501	227 899	914
Grand Total	601	686	219	905	9 541 300	5 747 526	3 793 774	14 369

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A25
Distribution of duck production enterprises according to management system, 2005

	Active enterprises			Non-active enterprises	
	No. of projects	Total capacity	Used capacity	No. of projects	Total capacity
Private sector	432	6 674 860	4 580 861	104	1 431 140
Governmental sector	37	892 150	709 893	19	247 650
Cooperative sector	7	269 500	451 772	1	16 000
Public business sector	1	10 000	5 000	-	-

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A26

The geographical distribution of Turkey enterprises and capacity 2005

Governorate	Number of enterprises	Number of poultry houses			Capacity			
		Active	Not active	Total	Total capacity (birds)	Used capacity (birds)	Unused capacity (birds)	Live weight of used capacity (tonnes)
Alexandria	-	-	-	-	-	-	-	-
Behairah	12	7	7	14	37 000	18 500	18 500	129.50
Kafr El sheikh	1	8	14	22	9 000	1 500	7 500	10.50
Dakahlia	3	2	1	3	4 300	1 050	3 250	7.35
Damietta	-	-	-	-	-	-	-	-
Sharkia	3	6	-	6	22 200	14 000	8 200	98.00
Port said	1	-	1	1	1 260	-	1 260	-
Ismailia	5	5	5	10	60 000	23 000	37 000	161.00
Suez	3	2	1	3	2 500	575	1 925	4.03
Ghrabia	6	7	3	10	123 432	72 000	51 432	504.00
Menoufia	3	2	3	5	27 500	600	26 900	4.20
Qalyoubia	6	3	4	7	175 000	3 600	171 400	25.20
Cairo	9	23	5	28	148 680	100 500	48 180	703.50
Lower Egypt	52	65	44	109	610 872	235 325	375 547	1 647.28
Giza	16	27	26	53	476 950	202 970	273 980	1 420.79
Beni Suef	6	6	11	17	118 000	43 600	74 400	305.20
Fayoum	4	9	-	9	30 700	27 400	3 300	191.80
Menia	17	17	2	19	27 750	19 108	8 642	133.76
Middle Egypt	43	59	39	98	653 400	293 078	360 322	2 051.55
Assuit	-	-	-	-	-	-	-	-
Suhag	-	-	-	-	-	-	-	-
Qena	3	2	2	4	39 000	31 800	7 200	222.60
Luxor	-	-	-	-	-	-	-	-
Aswan	6	7	2	9	4 760	3 000	1 760	21.00
Upper Egypt	9	9	4	13	43 760	34 800	8 960	243.60
Matruh	-	-	-	-	-	-	-	-
Noubaria	4	8	-	8	26 000	23 270	2 730	162.89
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	1	2	-	2	15 000	10 000	5 000	70.00
Red Sea	1	4	-	4	10 000	6 000	4 000	42.00
New and Desert Land	6	14	-	14	51 000	39 270	11 730	274.89
Grand Total	110	147	87	234	1 359 032	602 473	756 559	4 217.31

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A27
Distribution of turkey enterprises by management sector, 2005

Sector	Active enterprises			Non-active enterprises	
	Number of enterprises	Full capacity	Used capacity	Number of projects	Full capacity
Private	57	960 830	495 403	24	232 042
Governmental	18	100 410	71 070	7	14 350
Cooperative	1	19 200	16 000	-	-
Investment	2	30 000	18 000	-	-
Public business	1	2 200	2 000	-	-

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A28
Geographical distribution of ostrich enterprises and capacity 2005

Governorate	Number of enterprises	Total capacity		Used capacity			Unused capacity		
		Females	Males	Females	Males	Number of fattened birds	Number of enterprises	Females	Males
Behira	3	50	16	15	7	120	-	-	-
Dakahlia	1	340	160	102	48	50	-	-	-
Suez	2	37	3	11	2	21	-	-	-
Cairo	5	292	83	27	4	116	3	230	67
Lower Egypt	11	719	262	155	61	307	3	230	67
Middle Egypt	-	-	-	-	-	-	-	-	-
Upper Egypt	-	-	-	-	-	-	-	-	-
Matruh	1	66	34	17	17	53	-	-	-
Noubaria	1	448	224	400	200	1 700	-	-	-
Red Sea	1	400	100	10	40	50	-	-	-
New and Desert Land	3	914	358	427	257	1 803	-	-	-
Grand total	14	1 633	620	582	318	2 110	3	230	67

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A29
Distribution of quail enterprises and capacity, 2005

Governorate	Number of enterprises	Hutches	Total capacity (birds)	Used capacity (birds)
Dakahlia	1	120	44 600	34 000
Port Said	1	6 885	4 400 000	2 600 000
Lower Egypt	2	7 005	4 444 600	2 634 000
Giza	4	1 300	711 900	647 900
Middle Egypt	4	1 300	711 900	647 900
Upper Egypt	-	-	-	-
Noubaira	3	303	22 100	20 186
New and desert Land	3	303	22 100	20 186
Grand Total	9	8608	5 178 600	3 302 086

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A30

The geographical distribution of parent stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Number of chickens (1 000)			Hatching eggs (million)		
		Active	Not active	Total Capacity	Used capacity	Used capacity	Total capacity	Used capacity	Unused capacity
Alexandria	10	44	14	231.3	133.8	97.5	41.3	20.5	20.8
Behairah	39	193	31	912.2	630.24	281.96	146.98	67.79	7919
Kafr El sheikh	32	38	14	146.2	79.6	66.6	25.55	14.21	11.34
Dakahlia	56	263	29	1 128.5	872	256.5	218.96	154.16	64.8
Damietta	7	55	-	125.45	112.6	12.85	22.36	12.87	9.49
Sharkia	60	272	85	1 427.4	969.6	457.8	295.4	150.34	145.06
Port said	5	27	9	118.8	65.2	53.6	17	4.9	12.1
Ismailia	8	189	2	898	753	145	102.45	72.95	29.5
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	275	385	127	1 083.15	659.14	424.01	198.48	83.83	114.65
Menoufia	18	78	23	310.6	214.6	96	51.56	21.51	30.05
Qalyoubia	82	123	21	328.5	220.2	108.3	53.16	34.05	19.11
Cairo	13	23	23	174	76.2	97.8	40.38	7.34	33.04
Lower Egypt	605	1 690	378	6 884.1	4 786.18	2 097.92	1 213.58	644.45	569.13
Giza	47	125	75	568.8	284.2	284.6	89.2	49.4	39.8
Beni Suef	11	18	24	104.4	32.6	71.8	14.65	4.4	10.25
Fayoum	21	96	22	456.5	320.3	136.2	83.2	38.5	44.7
Menia	1	16	-	54	54	-	10.8	9.7	1.1
Middle Egypt	80	255	121	1 183.7	691.1	492.6	197.85	102	95.85
Assuit	2	4	3	65	18.7	46.3	10	3.4	6.6
Suhag	7	12	17	118	50.3	67.7	15.5	6.3	9.2
Qena	2	12	-	31	23.4	7.6	4.1	3.4	0.7
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	11	28	20	214	92.4	121.6	29.6	13.1	16.5
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	60	874	1	4 668.7	4 146	522.7	745.5	5 936	1 519
North Sinai	5	7	6	63	27.2	35.8	13	3.94	9.06
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	3	4	4	126.5	71	55.5	17.31	9.05	8.26
Red Sea	-	-	-	-	-	-	-	-	-
New and desert Land	68	885	11	4 858.2	4 244.2	614	775.81	60 659	16 922
Grand Total	764	2 858	530	1 3140	9 813.88	3 326.12	2 216.84	13 6614	8 507

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A31
Distribution of parent stock farms according to management system 2005

	Active enterprises			Non-active enterprises projects	
	No. of enterprises	Total capacity	Used capacity	No. of enterprises	Total capacity
Private sector	581	1 659.27	1 193.85	151	173.54
Governmental sector	14	85.52	38.84	4	75.65
The cooperative sector	2	10.70	8.80	-	-
Investment sector	11	187.66	124.65	1	24.50
Public business sector					

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A32
The distribution of parent stock farms according to Activity on year 2005

	Project No	Number of poultry houses		Chickens (1000)			Number of hatchings (million)		
		Active	Non active	Full capacity	Used capacity	Non-used capacity	Full capacity	Used capacity	Non-used capacity
Broiler parents	242	2 031	269	10 071.27	7 954.20	2 117.07	1 650.81	1 116.76	534.05
Layer parents	150	316	127	1 776.92	1 045.24	731.68	35179	157.74	1 9405
Duck parents	365	496	129	1 276.31	802.74	473.57	212.28	90.59	121.69
Turkey parents	7	15	5	15.5	11.7	3.8	1.96	1.05	0.91
Grand total	764	2 858	530	13 140	9 813.88	3 326.12	2 216.84	136 614	8 507

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A33
Geographical distribution of broiler parent stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Number of chickens (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Non-used capacity	Full capacity	Used capacity	Non-used capacity
Alexandria	10	44	14	231.30	133.80	97.50	41.30	20.50	20.80
Behairah	11	131	4	569.10	473.50	95.60	88.33	42.08	46.25
Kafr El sheikh	5	7	10	56.10	21.70	34.40	10.20	4.40	5.80
Dakahlia	39	240	27	1 041.00	804.00	237.00	203.90	143.65	60.25
Damietta	7	55	0	125.45	112.60	12.85	22.36	12.87	9.49
Sharkia	25	230	58	1 277.40	886.80	390.60	225.00	140.60	84.40
Port said	3	23	9	111.00	59.50	51.50	15.90	4.00	11.90
Ismailia	5	177	2	843.00	713.00	130.00	91.60	66.00	25.60
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	7	19	12	74.52	48.10	26.42	12.91	6.12	6.79
Menoufia	18	78	23	310.60	214.60	96.00	51.56	21.51	30.05
Qalyoubia	4	41	11	140.00	104.00	36.00	27.40	18.20	9.20
Cairo	12	22	23	172.50	74.90	97.60	40.20	7.19	33.01
Lower Egypt	146	1067	193	4 951.97	3 646.50	1 305.47	830.66	487.12	343.54
Giza	35	104	51	446.10	248.00	198.10	69.70	45.10	24.60
Beni Suef	5	8	15	78.00	20.00	58.00	11.75	3.00	8.75
Fayoum	8	24	0	70.40	65.30	5.10	13.40	11.70	1.70
Menia	1	16	0	54.00	54.00	0.00	10.80	9.70	1.10
Middle Egypt	49	152	66	648.50	387.30	261.20	105.65	69.50	36.15
Assuit	1	1	2	50.00	15.00	35.00	8.00	3.20	4.80
Suhag	2	8	2	44.00	25.80	18.20	4.60	2.60	2.00
Qena	1	8	0	24.00	16.40	7.60	3.00	2.50	0.50
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	4	17	4	118.00	57.20	60.80	15.60	8.30	7.30
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	38	788	0	4 289.80	3 836.00	453.80	685.90	547.90	138.00
North Sinai	5	7	6	63.00	27.20	35.80	13.00	3.94	9.06
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-	-
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	43	795	6	4 352.80	3 863.20	489.60	698.90	551.84	147.06
Grand Total	242	2031	269	10 071.27	7 954.20	2 117.07	1 650.81	1 116.76	534.05

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A34
Geographical distribution of layer parents stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Chickens (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Non-used capacity	Full capacity	Used capacity	Non-used capacity
Alexandria	-	-	-	-	-	-	-	-	-
Behairah	22	40	21	237.40	107.54	129.86	45.47	20.75	24.72
Kafr El sheikh	1	3	-	36.00	22.50	13.50	7.2	4.5	2.7
Dakahlia	-	-	-	-	-	-	-	-	-
Damietta	-	-	-	-	-	-	-	-	-
Sharkia	-	-	-	-	-	-	-	-	-
Port said	-	-	-	-	-	-	-	-	-
Ismailia	1	9	-	50.00	35.00	15.00	10	6.3	3.7
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	85	123	39	472.00	271.60	200.40	122.5	44.41	78.12
Menoufia	-	-	-	-	-	-	-	-	-
Qalyoubia	2	6	-	28.00	25.00	3.00	5.6	5	0.6
Cairo	-	-	-	-	-	-	-	-	-
Lower Egypt	111	181	60	823.40	461.64	361.76	190.8	80.96	109.84
Giza	8	7	24	101.82	16.00	85.82	16.99	2.68	14.31
Beni Suef	4	4	5	21.20	9.00	12.20	2.6	1.2	1.4
Fayoum	13	72	22	386.10	255.00	131.10	69.8	26.8	43
Menia	-	-	-	-	-	-	-	-	-
Middle Egypt	25	83	51	509.12	280.00	229.12	89.39	30.68	58.71
Assuit	1	3	1	15.00	3.70	11.30	2	0.2	1.8
Suhag	5	4	15	74.00	24.50	49.50	10.9	3.7	7.2
Qena	1	4	-	7.00	7.00	0.00	1.1	0.9	0.2
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	7	11	16	96.00	35.20	60.80	14	4.8	9.2
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	6	39	-	248.40	198.40	50.00	43.6	32.3	113
North Sinai	-	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	1	2	-	100.00	70.00	30.00	14	9	5
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	7	41	-	348.40	268.40	80.00	57.6	41.3	163
Grand Total	150	316	127	1 776.92	1 045.24	731.68	35 179	157.74	19 405

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A35
Geographical distribution of duck parent stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Ducks (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Unused capacity	Full capacity	Used capacity	Unused capacity
Alexandria	-	-	-	-	-	-	-	-	-
Behairah	6	22	6	105.70	49.20	56.50	13.18	4.96	8.22
Kafr El sheikh	26	28	4	54.10	35.40	18.70	8.15	5.31	2.84
Dakahlia	17	23	2	87.50	68.00	19.50	15.06	10.51	4.55
Damietta	-	-	-	-	-	-	-	-	-
Sharkia	35	42	27	150.00	82.80	67.20	70.40	9.74	60.66
Port said	2	4	-	7.80	5.70	2.10	1.10	0.90	0.20
Ismailia	2	3	-	5.00	5.00	-	0.85	0.65	0.20
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	183	243	76	536.63	339.44	197.19	63.04	33.30	29.74
Menoufia	-	-	-	-	-	-	-	-	-
Qalyoubia	76	76	10	160.50	91.20	69.30	20.16	10.85	9.31
Cairo	1	1	-	1.50	1.30	0.20	0.18	0.15	0.03
Lower Egypt	348	442	125	1 108.73	678.04	430.69	192.12	76.37	115.75
Giza	4	14	-	20.88	20.20	0.68	2.51	1.62	0.89
Beni Suef	-	-	-	-	-	-	-	-	-
Fayoum	-	-	-	-	-	-	-	-	-
Menia	-	-	-	-	-	-	-	-	-
Middle Egypt	4	14	-	20.88	20.20	0.68	2.51	1.62	0.89
Assuit	-	-	-	-	-	-	-	-	-
Suhag	-	-	-	-	-	-	-	-	-
Qena	-	-	-	-	-	-	-	-	-
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	-	-	-	-	-	-	-	-	-
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	12	40	-	121.70	104.50	17.20	14.40	12.60	1.80
North Sinai	-	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	1	-	4	25.00	-	25.00	3.25	-	3.25
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	13	40	4	146.70	104.50	42.20	17.65	12.60	5.05
Grand Total	365	496	129	1 276.31	802.74	473.57	212.28	90.59	121.69

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A36
The geographical distribution of Turkey Parents stock farms and actual capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Turkeys (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Unused capacity	Full capacity	Used capacity	Unused capacity
Lower Egypt	-	-	-	-	-	-	-	-	-
Giza	-	-	-	-	-	-	-	-	-
Beni Suef	2	6	4	5.2	3.6	1.6	0.3	0.2	0.1
Fayoum	-	-	-	-	-	-	-	-	-
Menia	-	-	-	-	-	-	-	-	-
Middle Egypt	2	6	4	5.2	3.6	1.6	0.3	0.2	0.1
Upper Egypt	-	-	-	-	-	-	-	-	-
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	4	7	1	8.8	7.1	1.7	1.6	0.8	0.8
North Sinai	-	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	1	2	-	1.5	1	0.5	0.06	0.05	0.01
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	5	9	1	10.3	8.1	2.2	1.66	0.85	0.81
Grand Total	7	15	5	15.5	11.7	3.8	1.96	1.05	0.91

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A37
Capacity of duck and turkey parent stock farms 2001 to 2005

Year	Duck parent stock farms				Turkey parent stock farms			
	Ducks		Hatching eggs		Turkeys		Hatching eggs	
	Production (1 000 ducks)	Index	Production (million eggs)	Index	Production (1 000 turkeys)	Index	Production (million eggs)	Index
2001	406	100	48.8	100	5	100	0.4	100
2002	484.9	119.43	59.69	122.32	14.2	284.00	0.7	175.00
2003	532.5	131.16	70.1	143.65	14	280.00	1.5	375.00
2004	556.18	136.99	72.95	149.49	10.2	204.00	0.65	162.50
2005	802.74	197.72	90.59	185.64	11.7	234.00	1.05	262.50

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A38
Geographical distribution of poultry feed plants and enterprises capacity 2005

Governorate	No. Enterprises	Enterprises		Capacity (tonnes)			Planned projects	
		Active	Non active	Full capacity	Used capacity	Unused capacity	Number	Capacity (tonnes)
Alexandria	3	2	1	153 000	7 452	145 548	1	20 000
Behairah	1	1	-	3 600	900	2 700	-	-
Kafr El sheikh	8	7	1	52 800	4 916	47 884	1	12 000
Dakahlia	83	50	33	678 200	48 581	629 619	33	157 200
Damietta	-	-	-	-	-	-	-	-
Sharkia	45	42	3	348 445	176 682	171 763	3	19 720
Port said	-	-	-	-	-	-	-	-
Ismailia	3	2	1	88 100	36 300	51 800	1	3 650
Suez	1	1	-	7 200	806	6 394	-	-
Ghrabia	13	4	9	184 800	11 470	173 330	9	134 400
Menoufia	19	16	3	189 459	23 587	165 872	3	39 000
Qalyoubia	12	5	7	227 328	15 750	211 578	7	149 328
Cairo	4	3	1	53 450	710	52 740	1	150
Lower Egypt	192	133	59	1 986 382	327 154	1 659 228	59	535 448
Giza	13	9	4	1 050 660	237 166	813 494	4	144 000
Beni Suef	5	4	1	17 340	835	16 505	1	1 920
Fayoum	2	2	-	8 160	2 589	5 571	-	-
Menia	16	14	2	148 993	67 536	81 457	2	6 520

(continued)

TABLE A38
(Continued)

Governorate	No. Enterprises	Enterprises		Capacity (tonnes)			Planned projects	
		Active	Non active	Full capacity	Used capacity	Unused capacity	Number	Capacity (tonnes)
Middle Egypt	36	29	7	1 225 153	308 126	917 027	7	152 440
Assuit	9	6	3	94 750	32 100	62 650	3	12 100
Suhag	3	1	2	50 000	400	49 600	2	25 000
Qena	1	-	1	4 800	-	4 800	1	4 800
Luxor	-	-	-	-	-	-	-	-
Aswan	3	3	-	43 400	142	43 258	-	-
Upper Egypt	16	10	6	192 950	32 642	160 308	6	41 900
Matruh	-	-	-	-	-	-	-	-
Noubaria	2	2	-	122 800	28 700	94 100	-	-
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	2	1	1	10 760	500	10 260	1	5 760
Red Sea	1	-	1	24 000	-	24 000	1	24 000
New and Desert Land	5	3	2	157 560	29 200	128 360	2	29 760
Grand Total	7	175	74	3 562 045	697 122	2 864 923	74	759 548

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A39
Distribution of poultry feed plants according to management sector, 2005

Sector	Active enterprises			Non-active enterprises	
	No. of enterprises	Full capacity (tonnes)	Used capacity (tonnes)	No. of projects	Capacity (tonnes)
Private	147	2 242 477	567 882	62	537 178
Governmental	10	146 460	9 405	9	186 720
Cooperative	7	80 400	31 161	-	-
Investment	9	297 160	84 738	3	35 650
General public business	2	36 000	3 936	-	-

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A40
Number and capacity of local hatcheries, 1991 to 2005

Year	No. of active hatcheries	Number of eggs	Number of chicks produced	Hatching rate (%)
1991	506	85 210 770	55 274 515	65
1992	520	87 367 845	55 681 142	64
1993	476	84 777 955	54 021 242	64
1994	482	86 656 737	55 588 603	64
1995	535	87 218 215	60 164 998	69
1996	533	87 917 030	54 038 720	62
1997	573	99 208 263	61 253 263	62
1998	570	104 171 640	56 243 278	54
1999	618	113 004 696	66 654 043	59
2000	661	99 061 769	68 402 078	69
2001	886	175 629 000	119 460 000	68
2002	992	17 234 000	133 724 000	75.5
2003	974	173 520 000	124 066 000	71.5
2004	964	156 333 000	120 696 000	77.2
2005	942	158 703 000	121 190 000	76.4

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A41
Number and capacity of industrial hatcheries, 1991 to 2005

Year	No. of active hatcheries	No. of eggs	No. of chicks produced	Hatching rate (%)
1991	118	283 036 625	213 321 417	76
1992	123	283 288 752	213 886 822	76
1993	116	304 986 498	224 399 741	74
1994	121	298 841 072	210 622 177	71
1995	115	297 146 842	221 070 561	74
1996	129	245 632 171	173 483 641	71
1997	126	291 742 972	213 599 303	73
1998	127	315 689 816	232 248 771	74
1999	96	350 121 283	259 878 897	74
2000	113	348 406 264	266 152 050	76
2001	150	626 846 000	499 038 000	796
2002	167	929 690 000	732 202 000	788
2003	162	894 351 000	656 984 000	731
2004	158	938 070 000	736 979 000	78.6
2005	169	755 752 000	599 964 000	79.4

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A42
Geographical distribution of automated poultry abattoirs, 2005

Governorate	Number of enterprises		Active			Non active
	Active	Non active	Total capacity (1 000 birds)	Used capacity (1 000 birds)	Unused capacity (1 000 birds)	Capacity (1 000 birds)
Alexandria	4	1	11 280	543	10 737	4 680
Behairah	-	-	-	-	-	-
Kafr El sheikh	-	-	-	-	-	-
Dakahlia	-	-	-	-	-	-
Damietta	-	-	-	-	-	-
Sharkia	10	0	27 927	13 921	14 006	-
Port said	-	-	-	-	-	-
Ismailia	1	-	6 300	2 400	3 900	-
Suez	-	1	36 000	-	36 000	36 000
Ghrabia	-	-	-	-	-	-
Menoufia	2	5	700	200	500	500
Qalyoubia	3	1	48 480	9 864	38 616	12 000
Cairo	0	1	43 200	-	43 200	43 200
Lower Egypt	20	9	173 887	26 928	146 959	96 380
Giza	1	-	3 000	1 995	1 005	-
Beni Suef	1	1	3 400	300	3 100	2 400
Fayoum	-	-	-	-	-	-
Menia	-	-	-	-	-	-
Middle Egypt	2	1	6 400	2 295	4 105	2 400
Assuit	1	-	36	30	6	-
Suhag	1	-	6 000	540	5 460	-
Qena	2	-	1 100	432	668	-
Luxor	-	-	-	-	-	-
Aswan	-	1	24 000	-	24 000	24 000
Upper Egypt	4	1	31 136	1 002	30 134	24 000
Matruh	-	-	-	-	-	-
Noubaria	-	1	135	-	135	135
North Sinai	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-
New Valley	-	1	1 560	-	1 560	1 560
Red Sea	-	1	180	-	180	180
New and Desert Land	-	3	1 875	-	1 875	1 875
Grand Total	26	14	213 298	30 225	183 073	124 655

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A43
Distribution of operational poultry automated abattoirs by management system 2005

Sector	Active enterprises			Non-active enterprises	
	No. of enterprises	Total capacity	Used capacity	No. of enterprises	Unused capacity
Private	16	30 971	13 320	7	17 215
Governmental	3	7 500	988	5	40 240
Cooperative	-	-	-	-	-
Investment	6	32 892	15 708	-	-
General public business	1	17 280	209	2	67 200
Total	26	88 643	30 225	14	124 655

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A44
Refrigerators used in refrigeration freezing process 2001 to 2005

Years	Volume of refrigerators		Actual storage	
	1 000 m^3	Index	1 000 tonne	Index
2001	2 255	100	1 389.6	100
2002	2 261	100.27	1 289.6	92.8
2003	2 282.70	101.23	1 365.92	98.3
2004	2 377.51	105.43	1 540.09	110.83
2005	2 469.11	109.5	1 769.1	127.31

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A45

Household poultry – number of animals and number of holdings (data from the last of comprehensive census of 1999/2000)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Cairo	2 901	52 810	401	2 352	2 228	19 165	802	7 050	3 009	100 055
Alexandria	25 981	419 595	4 348	24 275	22 734	230 174	11 071	105 403	5 998	95 089
Port Said	5 023	115 001	147	1 153	4 897	90 035	258	3 282	625	10 599
Suez	4 210	82 937	1 274	6 992	3 568	36 205	1 034	11 706	1 868	29 118
Damietta	47 111	821 663	8 548	46 276	44 454	560 357	10 809	111 382	47 744	1 680 074
Dakahlia	333 349	6 796 142	59 624	381 511	316 751	4 419 729	75 322	658 470	82 695	947 505
Sharkia	408 338	8 000 902	57 045	394 649	382 343	5 348 472	81 463	723 266	158 783	1 799 413
Qalyoubia	135 698	2 291 883	30 341	188 775	126 898	1 385 969	37 236	290 390	60 353	569 690
Kafr El sheikh	229 240	4 318 664	53 736	347 069	223 636	3 668 474	87 871	712 953	55 625	629 075
Ghrabia	222 648	3 722 007	45 375	268 146	208 494	2 484 138	54 584	445 908	58 811	577 140
Menoufia	232 634	3 467 105	55 166	336 175	215 465	2 286 499	55 028	425 415	103 095	918 827
Behara	326 667	5 429 844	61 706	412 625	315 260	4 516 124	128 355	1 119 070	123 393	1 321 125
Ismailia	45 313	1 115 362	7 346	49 846	42 229	640 794	7 419	72 813	17 630	281 919
Lower Egypt	2 019 113	36 633 915	385 057	2 459 844	1 908 957	25 686 135	551 252	4 687 108	719 629	8 959 629
Giza	127 275	2 127 764	20 637	122 484	103 838	980 568	43 257	383 444	49 662	462 380
Beni Suef	182 759	3 021 652	48 668	271 067	162 294	1 355 242	59 006	407 334	71 242	504 873
Fayoum	196 370	4 108 841	29 588	163 372	173 952	1 738 645	46 796	381 637	71 650	576 816
Menia	297 814	3 921 556	63 781	329 988	218 668	1 367 139	123 977	762 491	107 614	610 243

(continued)

TABLE A45
(Continued)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Assuit	266 512	3 647 136	41 556	196 750	181 058	1 174 416	120 643	794 272	204 084	1 602 436
Suhag	312 733	4 352 929	47 596	240 677	256 798	1 946 096	138 652	1 085 771	277 325	2 637 652
Qena	210 107	2 181 140	27 229	103 276	159 635	953 250	81 306	490 375	163 448	1 376 093
Luxor	19 669	254 120	1 604	7 404	12 069	85 197	4 398	27 350	11 389	122 294
Aswan	84 761	1 044 626	16 976	67 262	66 241	419 775	37 634	207 116	62 955	520 740
Upper Egypt	1 698 000	24 659 764	297 635	1 502 280	1 334 553	10 020 328	655 669	4 539 790	1 019 369	8 413 527
Red Sea	2 646	42 194	186	1 057	1 070	10 382	419	4 301	2 783	76 503
New Valley	14 100	211 262	6 355	20 964	12 825	100 333	5 919	44 773	12 573	172 669
Matruh	12 659	219 511	1 920	10 262	6 853	68 339	4 735	51 347	5 617	171 458
North Sinai	16 177	234 565	1 039	4 347	9 971	72 494	3 008	21 281	5 801	63 337
Sinai South	2 314	39 178	18	91	599	5 388	68	1 063	936	22 332
Desert Land	47 896	746 710	9 518	36 721	31 318	256 936	14 149	122 765	27 710	506 299
Grand Total	3 765 009	62 040 389	692 210	3 998 845	3 274 828	35 963 399	1 221 070	9 349 663	1 766 708	17 879 455

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A46
Household poultry – number of birds and number of holdings (data from 2004/2005 census)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Cairo	1 129	28 109	470	2 294	881	6 405	195	1 805	442	5 011
Alexandria	27 124	472 664	5 469	27 695	22 855	235 338	11 352	106 583	6 896	97 249
Port said	5 448	146 628	103	872	4 953	98 698	735	6 851	766	12 368
Suez	3 247	91 514	1 055	7 536	3 078	37 135	1 152	12 871	1 989	30 137
Damietta	47 359	909 347	6 565	36 405	44 720	563 356	6 100	59 232	27 589	1 151 912
Dakahlia	336 614	7 486 563	61 427	387 072	318 857	4 426 041	75 615	659 081	85 952	955 337
Sharkia	412 567	8 809 330	58 387	398 556	385 619	5 357 018	79 940	715 123	164 395	1 808 539
Qalyoubia	136 225	2 524 729	31 012	191 882	127 388	1 389 012	37 315	290 895	61 103	574 195
Kafr El sheikh	232 767	4 758 466	54 271	349 805	226 055	3 676 292	88 283	713 978	57 431	635 083
Ghrabia	237 188	4 119 783	46 815	275 115	211 653	2 501 567	55 737	447 101	65 168	581 905
Menoufia	235 683	3 823 311	56 270	340 211	218 941	2 293 848	52 698	419 849	104 172	923 151
Behara	328 983	5 981 147	62 602	417 303	316 292	4 523 065	125 924	1 105 251	124 975	1 326 548
Ismailia	47 155	1 236 147	7 522	50 841	40 539	615 911	7 448	73 018	18 221	283 524
Lower Egypt	2 051 489	40 387 738	391 968	2 485 587	1 921 831	25 723 686	542 494	4 611 638	719 099	8 384 959
Giza	133 108	2 347 845	22 089	125 929	104 456	985 589	43 643	386 419	50 119	465 425
Beni Suef	186 459	3 332 779	49 626	273 565	164 873	1 360 333	59 671	409 073	73 443	511 115
Fayoum	198 361	4 529 643	30 541	166 460	175 932	1 745 802	47 891	386 781	73 076	581 894
Menia	299 906	4 324 541	64 815	332 574	222 046	1 375 251	121 455	756 305	109 445	614 525

(continued)

TABLE A46
(Continued)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Assuit	269 743	4 022 039	42 191	198 769	182 901	1 179 482	120 740	794 764	206 208	1 607 671
Suhag	316 773	4 803 007	49 992	244 764	258 866	1 951 187	118 982	1 007 659	282 522	2 645 575
Qena	212 665	2 409 703	28 218	105 637	161 499	959 342	79 892	485 687	165 674	1 381 839
Luxor	19 976	282 753	1 797	9 231	13 283	87 610	4 857	29 156	11 833	125 313
Aswan	85 992	1 170 502	18 013	71 259	68 066	421 794	38 313	208 629	63 228	521 894
Upper Egypt	1 722 983	27 222 812	307 282	1 528 188	1 351 922	10 066 390	635 444	4 464 473	1 035 548	8 455 251
Red Sea	2 101	32 798	100	915	615	6 998	93	1 172	821	12 561
New Valley	15 895	237 033	8 626	23 165	13 120	109 526	6 414	45 564	13 431	176 396
Matruh	15 393	248 475	2 515	12 579	7 654	72 129	5 306	52 840	7 516	173 208
North Sinai	19 101	260 690	1 901	9 750	11 503	76 893	3 311	23 281	6 139	65 593
Sinai South	2 807	62 834	108	416	710	6 187	275	2 382	1 347	23 530
Desert Land	55 297	841 830	13 250	46 825	33 602	271 733	15 399	125 239	29 254	451 288
Grand Total	3 829 769	68 452 380	712 500	4 060 600	3 307 355	36 061 809	1 193 337	9 201 350	1 783 901	17 291 498

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A47
Geographical distribution of household poultry (data from 1999/2000 census)

Type	Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total	Share of total (%)
Chickens	36 633 915	24 659 764	746 710	62 040 389	48.01
Turkey	2 459 844	1 502 280	36 721	3 998 845	3.09
Geese and ducks	25 686 135	10 020 328	256 936	35 963 399	27.83
Rabbits	4 687 108	4 539 790	122 765	9 349 663	7.23
Pigeons	8 959 629	8 413 527	506 299	17 879 455	13.84
All household poultry	78 426 631	49 135 689	1 669 431	129 231 751	100.00
Share of household poultry (%)	60.69	38.02	1.29	100.00	

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

FIGURE A3
Geographical distribution of household poultry (data from 1999/200 census)

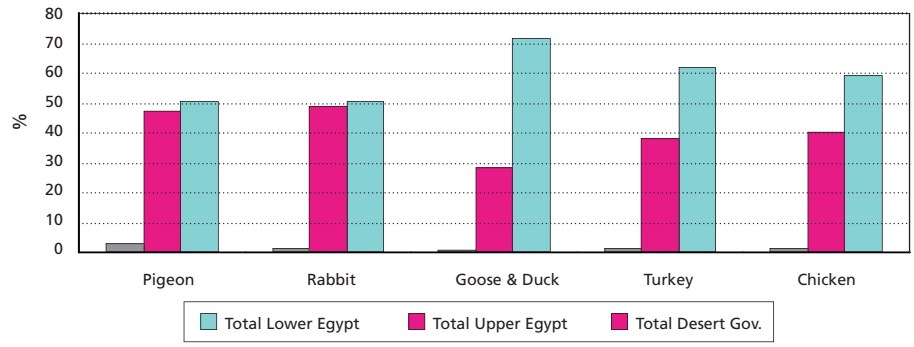


TABLE A48
Geographical distribution of household poultry (data from 2004/2005 census)

Type	Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total	Share (%)
Chickens	40 387 738	27 222 812	841 830	68 452 380	50.68
Turkey	2 485 587	1 528 188	46 825	4 060 600	3.01
Geese and ducks	25 723 686	10 066 390	271 733	36 061 809	26.70
Rabbits	4 611 638	4 464 473	125 239	9 201 350	6.81
Pigeons	8 384 959	8 455 251	451 288	17 291 498	12.80
All household poultry	81 593 608	51 737 114	1 736 915	135 067 637	100.00
Share of household poultry (%)	60.41	38.30	1.29	100.00	

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A49
Geographical distribution of household poultry holdings (data from 1999/2000 census)

Type		Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total
Chickens	Number of holdings	2 019 113	1 698 000	47 896	3 765 009
	Number of holdings (%)	53.63	45.10	1.27	100.00
	Number of chickens	36 633 915	24 659 764	746 710	62 040 389
	Number of chickens (%)	59.05	39.75	1.20	100.00
	Average of number of chickens per holding	18.14	14.52	15.59	16.48
Turkeys	Number of holdings	385 057	297 635	9 518	692 210
	Number of holdings (%)	55.63	43.00	1.38	100.00
	Number of turkeys	24 59 844	1 502 280	36 721	3 998 845
	Number of turkeys (%)	61.51	37.57	0.92	100.00
	Average of number of turkeys per holding	6.39	5.05	3.86	5.78
Geese and ducks	Number of holdings	1 908 957	1 334 553	31 318	3 274 828
	Number of holdings (%)	58.29	40.75	0.96	100.00
	Number of geese/ducks	25 686 135	10 020 328	256 936	35 963 399
	Number of geese/ducks (%)	71.42	27.86	0.71	100.00
	Average of number of geese/ducks per holding	13.46	7.51	8.20	10.98
Rabbits	Number of holdings	551 252	655 669	14 149	1 221 070
	Number of holdings (%)	45.14	53.70	1.16	100.00
	Number of rabbits	4 687 108	4 539 790	122 765	9 349 663
	Number of rabbits (%)	50.13	48.56	1.31	100.00
	Average of number of rabbits per holding	8.50	6.92	8.68	7.66
Pigeon	Number of holdings	719 629	1 019 369	27 710	1 766 708
	Number of holdings (%)	40.73	57.70	1.57	100.00
	Number of pigeons	8 959 629	8 413 527	506 299	17 879 455
	Number of pigeons (%)	50.11	47.06	2.83	100.00
	Average of number of pigeons per holding	12.45	8.25	18.27	10.12

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A50
Regional distribution of household poultry (data from 2004/2005 census)

Type		Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total
Chickens	Number of holdings	2 051 489	1 722 983	55 297	3 829 769
	Number of holdings (%)	53.57	44.99	1.44	100.00
	Number of chickens	40 387 738	27 222 812	841 830	68 452 380
	Number of chickens (%)	59.00	39.77	1.23	100.00
	Average of number of chickens per holding	19.69	15.80	15.22	17.87
Turkeys	Number of holdings	391 968	307 282	13 250	712 500
	Number of holdings (%)	55.01	43.13	1.86	100.00
	Number of turkeys	2 485 587	1 528 188	46 825	4 060 600
	Number of turkeys (%)	61.21	37.63	1.15	100.00
	Average of number of turkeys per holding	6.34	4.97	3.53	5.70
Geese and ducks	Number of holdings	1 921 831	1 351 922	33 602	3 307 355
	Number of holdings (%)	58.11	40.88	1.02	100.00
	Number of geese/ducks	25 723 686	10 066 390	271 733	36 061 809
	Number of geese/ducks (%)	71.33	27.91	0.75	100.00
	Average of number of geese/ducks per holding	13.38	7.45	8.09	10.90
Rabbits	Number of holdings	542 494	635 444	15 399	1 193 337
	Number of holdings (%)	45.46	53.25	1.29	100.00
	Number of rabbits	4 611 638	4 464 473	125 239	9 201 350
	Number of rabbits (%)	50.12	48.52	1.36	100.00
	Average of number of rabbits per holding	8.50	7.03	8.13	7.71
Pigeons	Number of holdings	719 099	1 035 548	29254	1 783 901
	Number of holdings (%)	40.31	58.05	1.64	100.00
	Number of pigeons	8 384 959	8 455 251	451 288	17 291 498
	Number of pigeons (%)	48.49	48.90	2.61	100.00
	Average of number of pigeons per holding	11.66	8.17	15.43	9.69

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A51
Total and Actual capacity for Broiler production and for slaughtering in surplus governorates

Governorates	Total capacity for Broiler	Actual capacity for Broiler	Total capacity for Slaughters	Actual capacity for Slaughters	Shortage of Slaughters
Behairah	66 432,33	51 125,67	1350	417	49 775,67
Gharbia	115 745,33	93 478	0	0	9 3478
Dakahlia	145 977	91 485,33	0	0	91 485,33
Damietta	32 578,33	19 871,33	0	0	19 871,33
Sharkia	178 292,67	107 111,33	25 660	13 852	81 451,33
Ismailia	28 951	14 048	6 300	14 222	7 748
Qalyoubia	99 051,33	63 426,33	48 480	7 252	14 946,33
Matrouh	5 899	2 953,67	0	0	2 953,67

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A51
Estimating Variables used for Suitable Distribution for Slaughters in Egypt (2002/2004)

Governorates	Population No. 1 000	Production (Tonnes)*	Demand (Tonnes)	Balance (Tonnes)	Total capacity for Slaughters (Tonnes)*	Actual capacity for Slaughters (Tonnes)
Alexandria	3 693	21 043	51 000.33	-29 957.3	11 280	2 239
Behairah	4 516	112 886	62 365.96	50 520.04	1 350	417
Gharbia	3 792	137 503.6	52 367.52	85 136.08	0	0
Kafr El sheikh	2 494	32 306.6	34 442.14	-2 135.54	0	0
Dakahlia	4 748	133 539.9	65 569.88	67 970	0	0
Damietta	1 035	29 215.7	14 293.35	14 922.35	0	0
Sharkia	4 905	155 931.9	67738.05	88 193.85	25 660	13 852
Ismailia	826	21 017.5	11 407.06	9 610.44	6 300	1 422
Port Said	522	1 047	7 208.82	-6 161.82	0	0
Suez	469	2 558	6 476.89	-3 918.89	600	567
Menoufia	3 112	40 118.6	42 976.72	-2 858.12	430	228
Qalyoubia	3 732	90 876.7	51 538.92	39 337.78	48 480	7 252
Cairo	7 505	2 685.7	103 644.1	-100 958	8 333	1 892
Lower Egypt	41 349	780 730.2	571 029.7	209 700.5	102 433	27 869
Giza	5 425	52 326.7	74 919.25	-22 592.6	3 000	2 402
Beni Suef	2 161	9 797.6	29 843.41	20 045.8	2 400	0
Fayoum	2 319	15 720.2	32 025.39	-16 305.2	0	0
Menia	3 872	31 540.5	53 472.32	-21 931.8	0	0
Middle Egypt	13 777	109 385	190 260.4	-40 783.8	5 400	2 402
Assuit	3 278	16 261.5	45 269.18	-29 007.7	36	26
Suhag	3 655	10 660.8	50 475.55	-39 814.8	6 000	416
Qena	2 819	2 715.3	38 930.39	-36 215.1	1 117	591
Luxor	407	605.6	5 620.67	-5 015.07	0	0
Aswan	1 078	79.3	14 887.18	-14 807.9	1 600	399
Upper Egypt	11 237	30 322.5	155 183	-124 860	8 753	1 432
North Sinai	295	3 532.5	4 073.95	-541.45	0	0
South Sina	62	112.4	856.22	743.82	0	0
Matrouh	255	4 430.5	3 521.55	908.95	0	0
New Valley	163	966.8	2 251.03	-1 284.24	1 560	0
Red Sea South	179	168.6	2 471.99	-2 303.39	180	0
New and desert	954	9 210.8	13 174.74	-3 963.94	3 090	0
Grand Total	67 317	938 859.3	942 822.6	-3 963.26	121 416	31 703

* Meat poultry production includes broiler, spent-layers, improved baladi (produced in the commercial sector) and baladi (produced in traditional sector) chicken.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

Future trends and developments in poultry nutrition

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SUMMARY

This paper gives recognition to the recent rapid technological, scientific and industrial changes that have taken place in the poultry sector, and uses these as a baseline for the prediction of future trends in nutrition. It is predicted that elevated levels of poultry feed will be required, in the fast-developing poultry sectors of Asia in particular, to meet the burgeoning consumer demand for poultry products. This significant migration of feed demand from west to east will be associated with increased outputs of formulated compound feeds. Globally, relatively few protein and energy ingredients are used in the manufacture of poultry feed for landless and large-scale commercial operations, with a significant reliance on soybean and traditional cereal grains to achieve nutrient supply and balance. The feed versus fuel debate over cereal usage is set to continue, accompanied by uncertainty as to the likely impact on feed and livestock production levels, and on feed-industry dynamics. Further refinements of technologies used for the production of ethanol by-products with desirable nutritional characteristics – for example, dried distillers' grains with solubles (DDGS) – will be necessary in the future, parallel to the economic evaluation and justification of such products with respect to competitor feed ingredients.

Additional legislation will affect most aspects of the feed sector, including those pertaining to environmental protection, feed hygiene, and those linked to food-safety issues throughout the poultry supply chain. Parallel to the continued inclusion and utilization of traditional feed ingredients in the poultry industries of both developed and developing countries, will be the ongoing requirement for nutritional evaluation of more locally grown and novel indigenous crop sources, which may have the potential to offer reasonable (alternative) protein and energy yields. The future use of a greater diversity of protein feeds in formulations, despite the fact that they may contain less than optimal natural amino acid profiles, will be assisted by the increasing availability of relatively cheaply manufactured synthetic forms of essential amino acids, which will facilitate the dietary creation of "ideal" protein. There will be continued selection for genetically improved and more location/climate-tolerant plant cultivars that have potential nutritional value and widen the feed options for more countries.

Greater accuracy in dietary macronutrient and micronutrient provision not only results in enhanced bird performance characteristics, but also reduces the likelihood of nutrient waste posing a pollution threat to the environment, which will be an increasingly important issue in the future in an increasing number of countries. Manipulation of voluntary feed intake (VFI) in birds is key to the control of nutrient intake levels, and therefore ultimate

performance and productivity; the factors influencing VFI will merit further scientific and commercial evaluation in the future, particularly with the prospect of climate change and the effect of elevated temperatures and other climatic variables on appetite.

The genetic selection emphasis of recent times linked to nutrition, that of feed conversion efficiency and maximal growth, is likely to change in favour of traits associated with bird welfare, meat and egg quality, and "robustness" of genotypes or strains of bird capable of adapting to, and being productive in, a range of commercial environments. There is already recognition of the potential of indigenous poultry breeds and their adaptive role in more suitably converting locally available feed resources into sustainable production, albeit on a smaller scale.

Husbandry practices which support effective immune response in chickens are vital. Two perspectives have influenced the focus of research in recent years on this subject: firstly, determining the most appropriate nutrient feeding strategies to optimize the immune response; and secondly, the study of the influence of immune response on the growth and nutrient requirements of the bird. The maintenance of immunocompetence and optimal health status in birds in a range of husbandry situations will remain a priority. Such physiological well-being can be challenged by a number of anti-nutritional factors (ANF) in feeds, and by mycotoxin presence in the birds' environment. The latter, if ingested or inhaled over a sustained period, has the potential to cause varying degrees of mycotoxicosis in poultry, with the associated negative effects on growth and reproductive performance. With regard to the presence of feed ANF, a significant number of research results, in which a range of exogenous enzyme treatments have been applied and evaluated, have indicated success in ameliorating the negative effects which such compounds have on feed digestibility and palatability. As far as mycotoxin contamination is concerned, surveys from around the world indicate that protein sources such as rapeseed meal, groundnut cake, sunflower meal, copra meal and palm kernel meal, for example, are more susceptible to mycotoxin contamination than are conventional raw materials such as soybean meal.

A successful poultry production system, irrespective of scale and sophistication, requires a continuous enterprise cycle, which can be better achieved by embracing the important elements of sustainability both physical and financial. Systems of the future, in the context of poultry nutrition, will need to apply greater focus on "resource sufficiency" not scarcity, which will necessitate the constant consideration and evaluation of alternative protein and other nutrient input sources, for example a reduced reliance on the traditional proteins – fishmeal and soybean – in broiler and layer diets. There will remain the need to achieve and exploit efficiencies throughout the system, particularly opportunities for further feed conversion economies through improved general flock management. A more holistic and integrated approach to the development of feeding programmes will assist the poultry industries and individual producers of chicken products to pursue their goals of enhanced production within a sustainability context. Endemic and local occurrence of infectious diseases will remain an omnipresent threat, and on occasion will stifle the progress achieved in bird performance through the adoption of improved nutrition strategies.

Key words: poultry, future, feed.

1 CHARACTERIZATION OF THE FEED INDUSTRY

1.1 Subject emphasis

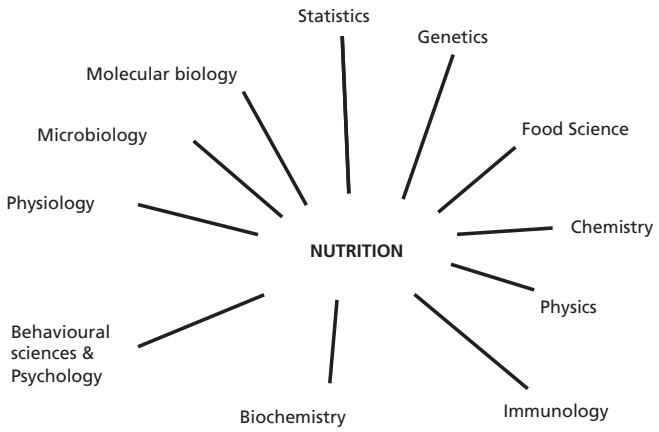
The livestock feed industry, irrespective of scale and size, is an integral and growing segment of the food supply chain. It supplies the feed ingredients needed to promote health and productivity in birds which, in turn, provide a growing global human population with essential dietary protein and energy sources. The title of this paper gives recognition to the recent rapid technological, scientific and industrial changes which have taken place in the poultry sector, and uses these as a baseline for the prediction of future trends in nutrition. The latter subject, together with general quality management and breeding, continue to be the central themes of livestock production. Adequate, physiologically balanced nutrition is vital to the health, fertility and optimal performance of birds. As vital links in the food chain, the feed manufacturer and producer, alike, are having to give due consideration to changing social and economic climates. The significant proportion of costs of production attributable to feed now has to be considered alongside bird welfare, food safety and environmental protection concerns which have attracted increasing volumes of legislation, particularly in the European Union (EU). Such issues are now having an impact globally, as reviewed thoroughly recently by Steinfeld *et al.* (in FAO, 2006).

Over the last century, there has been considerable research endeavour, and important milestones, in poultry nutrition science. These have been documented by Larbier and Leclercq (1994) – from the discovery of vitamin A, through to the commercial manufacture and development of synthetic amino acids. Feeding, which is a major factor in controlling profitability, has evolved and progressed both in terms of understanding the physiology and metabolism of the bird, and in the more precise evaluation of the quality of dietary raw materials. The science of nutrition, applied to both meat and egg production sectors, has changed its emphasis from the effect of feed on the whole animal to the impact of (individual) nutrients on selected organs and tissues. Thus, the emphasis in research today is less on outcomes, and more on mechanisms investigated at the cellular level. This is likely to be the immediate future scenario, with more efficient and focused use of financial resources.

The importance of nutrition as a science in its own right has been the focus of much researcher discussion, and the science of poultry nutrition is very much a multidisciplinary subject. A key feature of the study of nutrition is its absolute reliance on other, more fundamental, sciences (Figure 1). The relationships depicted are, nevertheless, oversimplified; each discipline can influence nutrition in several ways.

For example, the science of microbiology is important because of the large indigenous microbial population in the gastro-intestinal tract. These organisms intercept nutrients, thereby enhancing or detracting from the host's nutrition. Microbiology also interacts with nutrition in that infections may influence appetite, and therefore food intake, as well as the animal's ability to metabolize nutrients. Although most studies have been carried out on large bird populations and under experimental protocol conditions, it is the application of such results and the dissemination of scientific findings to both the large and small producer, perhaps through extension services, which is of paramount importance to facilitating improvements in bird productivity at the practical husbandry level.

FIGURE 1
Nutrition – A Multi Disciplinary Science

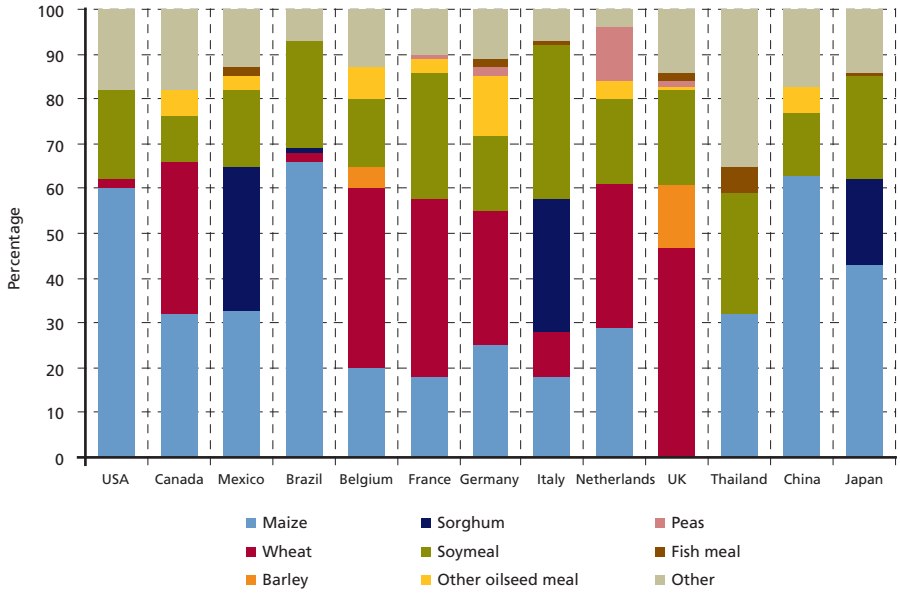


1.2 Poultry feed industry dynamics

The global demand for livestock commodities, namely milk, meat and eggs, has seen significant growth globally, the drivers of change being improved incomes, growing populations and urbanization (FAO, 2004a; Steinfeld *et al.*, in FAO, 2006). At the forefront of consumer demand is poultry, and in particular broiler meat. There is a shift in developing countries towards monogastric production, with poultry and pigs accounting for 77 percent of the expansion – this in contrast to the consolidation and relative stagnation of poultry activity within the EU (Geers and Madec, 2006). To support such a large increase, there is a need for significantly elevated levels of poultry feed, both raw materials and, particularly, concentrate compound forms. The concern remains, therefore, that the booming poultry industries will pose feed demands that will far exceed supplies (Steinfeld *et al.*, in FAO, 2006). There are regional differences, with the strongest growth being in Asia. Gilbert (in FAO, 2004b) estimates the global production of animal feed annually to be in the region of 1 000 million tonnes, 60 percent of which is compound; poultry account for the greatest tonnage produced. The growth in large, industrial-scale, vertically integrated poultry operations, the so-called landless systems, tends to be associated with, and mainly responsible for, the increased demand for purchased compound feed products.

International trade in raw materials is the key to the dynamics of the global feed industry. The economics of accessing the industry's products present a challenge for small-scale production in developing countries. Traditional poultry production was (and still is) based on the availability of local (indigenous) feed resources, with access to markets, appropriate infrastructure, land price, labour and transport issues being important determinants of poultry locations (Steinfeld *et al.*, in FAO, 2006). FAO (2003) document a projected increased demand for grains up to 2030 of 1 billion tonnes, and for maize a projected rise from 625 to 964 million tonnes for the period 2002 to 2030. Traditionally, there has been a

FIGURE 2
Relative composition of chicken feed ration in selected countries (by weight)



Source: Steinfeld *et al.* (in FAO, 2006).

high reliance on cereal grains as the main energy source in poultry diets, irrespective of the country concerned, as can be seen in Figure 2. The demand for cereals globally is balanced by the popularity of soybean as the major protein source (Figure 2).

Fish production is an increasing competitor for the compound feed market. Others have recently reviewed the growing importance of aquaculture and implications for feed manufacturers (Morris, 2005). Gill (2006) comments that aquafeed continues to be the fastest growing sector of feed production on an industrial scale, although this trend is not predicted to continue indefinitely. Clearly, the poultry-feed sector has other competing species with respect to feed raw material usage. Both monogastric industries are intensive operations which require similar high-quality protein resources. One of the reasons for an increased demand for soymeal in other animal diets is the elevated use of fishmeal to sustain the aquaculture sector, the latter being more dependent on fishmeal than are terrestrial animals (Steinfeld *et al.*, in FAO, 2006).

1.3 Feed manufacturing technology and regulatory constraints

Much technological sophistication and innovation has been applied in the feed manufacturing sector in recent years. In addition to catering for large-volume outputs of an increasingly diverse range of products, the milling business and industries across the world also face increasing competition. More than 80 percent of the world's feed is now produced by as few as 3 800 mills (Gilbert, in FAO, 2004b). This consolidation of feed manufacturing

capacity has resulted in the adoption of state of the art engineered equipment to produce high-quality and safe products, which from a food-chain perspective, provide the consumer with greater confidence and the birds with the opportunity to maximize their performance potential. It is imperative that high-volume outputs are combined with safeguarding quality in terms of the end product, and comply with various official directives (Van der Bunt and West, 2006).

Today, most poultry feed is manufactured by employing a combination of technologies – grinding or rolling, heat moisture and pressure by pelleting, expanding or extruding, and applying heat via anaerobic pasteurizing conditioners. The range of raw materials incorporated into modern poultry diets is continually changing over time due to a number of factors, which were identified by Kersten *et al.* (2005) as price changes and fluctuations, component price dynamics, availability of raw materials, government regulatory permissions, and customer supply and demand. Many advantages can be attributed to feed processing – improved availability of protein and energy, destruction of inhibitors and toxins, facilitation of the use of a wide range of raw materials in diet formulations, production of hygienic compounds, and reduction of feed wastage. There have been some informative reviews on aspects of emerging feed-processing technologies, and some of the potential problems involved in achieving feed end-product quality (van der Barneveld, 2001; Thomas and var der Poel 2001; Kersten *et al*, 2005).

A major concern in the feed industry is that of ensuring food safety. There is a direct link between animal-feed quality and hygiene issues and the safety of foods of animal origin when consumed. It follows, therefore, that feed production and manufacture should be considered as an integral part of the food production chain (Tielen, 2005), and that it should therefore be subject to quality assurance and food safety systems (Manning *et al.*, 2006a ; Manning *et al.*, 2007). The quantity of legislation, regulations, recommendations and guidelines that the feed industry has to comply with or take note of is increasing; much originates in Brussels with the purpose of being applied across the European Union (EU) member states (currently 27). Detail relating to the specifics of such regulatory frameworks is provided in two recent papers (Millar, 2006; Nelson *et al.*, 2006). The legislation considered includes issues such as feed-additive and hygiene regulations, organic feed legislation, ingredient declaration, labelling and by-product definitions. It can be expected that this steady stream of animal feed regulations will continue, and that the principle of Hazard Analysis and Critical Control Points (HACCP) will be implemented rigidly throughout the food production chain (Manning *et al.*, 2006b). Clearly, countries engaged in trading poultry products with EU member states will have to give due consideration to existing legal frameworks and standards.

1.4 Country focus

The levels of sophistication which characterize the so-called feed industry sectors in different countries are very much determined by the scale of poultry production, both meat and eggs. This ranges from highly industrialized landless intensive systems as defined by Devendra (2007) to family poultry production with modest feed-sourcing requirements. The latter remains important in low-income food-deficit countries (FAO, 2004c; Guèye, 2002). Within individual countries, there is significant regional variation and contrast with

respect to the scale and complexities of the poultry-feed manufacturing sectors. An example of this is found in Asia, a region which in general has seen rapid development in feed production technology linked to, and in support of, improvements in commercial poultry performance.

Meggison (2005) predicts increasing opportunities in the future in the Far East for feed and feed-related companies linked to the "shift" from west to east of the production and consumption of livestock products. China is singled out in terms of future influence – it produces more compound feed than the rest of Asia together. The growth of compound feed production is predicted to exceed 10 percent *per annum* for the foreseeable future. It is worth noting, however, that most Asian countries rely on the net import of unsubsidized grains and pay world market prices to complement locally grown feed raw material commodities. Bootwalla (2005) provides statistics on the magnitudes of poultry feed production in South Asia, the total is estimated at 19 million tonnes (India, 13.2, Pakistan 3.7, Bangladesh 1.45, Sri Lanka 0.6 and Nepal 0.25 million tonnes *per annum*, respectively). The same author comments on the continued growth of vertical integration and ownership consolidation among feed companies, a trend which is set to continue. Integration embraces improvements in technology, particularly in laboratory raw material evaluation and least-cost ration formulation techniques.

The introduction of high-density pelletized feed operations in India has resulted in much improved production efficiency in the poultry sector. This is a country which has made significant progress towards modernization of its livestock industry, and poultry in particular, in recent years. The 1990s were associated with advances in integration, automation and feed production. Such developments help to underpin and support a very significant broiler and egg industry, but the commercial progress tends to be focused mainly in the south. Availability of raw materials has increased in recent years due to elevated production levels of grains and oilseeds and, currently, the improved cultivation of maize varieties (Balakrishnan in FAO, 2004d).

In contrast, however, and despite the success in commercialization of the organized feed sector, many rural households continue to rely on backyard subsistence poultry rearing, which contributes substantially to the nutritional requirements of the individual family unit. This small-scale and modest poultry enterprise system is characteristic in many countries in Asia, including Viet Nam in the southeast. Dinh Tu (2002) estimates that 75 percent of the poultry population in Viet Nam is kept in small households. The productivity of such birds is low, as would be expected given the less than optimal nutrient intake, and they are viewed essentially as having a scavenging role and existence. Supplementary feeds of a higher quality may be offered, but these are very much dependent on the family's economic situation and circumstances. Some improvements in conservation and storage technology have brought improvement in chicken diets even at this level – including earthworm production and preservation methods for increasing the shelf life, and therefore quality, of paddy rice, maize and peanuts. As with many of the countries of this region, improvements in the nutrition of indigenous birds are countered by the presence of endemic diseases such as Newcastle disease.

Climate extremes are a complicating factor in the poultry economics of South Africa (Shane, 2002), where rainfall (or lack of) influences the yield of maize and domestic pric-

ing and, together with extremes of humidity, can impair bird performance and predispose stored crops to mould development. Mugga (2007) reporting on another African country, Uganda, comments on the significant move in recent times towards self-sufficiency in maize production and improved quality in commercial feeds, brought about mainly by adopting improved milling expertise. However, a shortage of grain-storage facilities means that the country has to export a substantial amount of maize at unfavourable prices. Clearly, there are a number of challenges confronting the poultry-feed industries in various countries, with constraints at production level and in terms of product quality requiring particular attention in the future.

2 ESTABLISHING NUTRIENT REQUIREMENTS

2.1 Feed intake predictability

Applying accuracy and a degree of precision in diet (ration) formulation requires an intimate knowledge of the bird, its daily nutrient requirements, and a more comprehensive understanding of the ability of the selected feeds to provide the most desirable nutrient status. The ingestion of the optimal level of dietary nutrients, whether for birds involved in egg or boiler meat production, is very much dependent on the level of feed intake. In the case of poultry in most commercial situations ad libitum provision of feed is practised, in which the bird is permitted to give expression to its appetite (or voluntary feed intake [VFI]). The level of consumption observed in practical commercial situations, the actual feed intake (AFI), is often lower than the bird's potential feed intake (PFI) (the quantity of feed required to fulfil all the nutrient requirements) due to physical or physiological constraints and/or negative interaction with environmental situations.

The complexities of the factors which determine nutrient intakes and causative reasons and hypotheses for under- or over-consumption, have been reviewed extensively by others (Forbes, 1995; van der Heide *et al.*, 1999; Forbes, 2006). Birds have precise requirements for nutrients, both macro and micro, and energy-yielding components. Therefore, knowledge of their feed-intake capacity is essential if dietary concentrations are to be appropriate. A bird's daily consumption of feed ultimately governs its health, development and potential for reproduction. Diets are usually formulated on the basis of specific expectations for feed intake; alternatively, in special circumstances, we may dictate the level of intake through controlled feeding systems. An understanding of the complexities and interacting mechanisms that control feed intake is, therefore, essential in designing nutritional programmes and production systems. Figure 3 illustrates the range of variables that can act either as VFI stimulators or constraints. A "cascade" of feedback signals regulates and modifies nutrient supply to the tissues.

Aspects such as the sight and smell of the feed, its taste (flavour), gastric and intestinal effects, and liver and blood metabolite parameters appear to be likely feedback mechanisms. The latter can be used to create learned associations that can be employed to influence feed consumption in situations where the bird is allowed to be discriminatory in feed selection.

Clearly, the anticipated level of productivity from birds will be dependent on the scale and commercial intensity of the enterprise, and on whether it is characterized by the high-input, high-output production associated with large-scale vertically integrated systems or

by the modest expectations for egg or meat output typical for a family backyard operation. However, the principle of VFI relationships remains the same regardless of the context. If VFI is too low, productivity may be compromised, making the requirements for maintenance nutrients a relatively large proportion of the total. The converse is true in the event of excessive nutrient intake or imbalance, in which case undesirable partitioning of nutrients into carcass fat deposition may occur or there may be a potential environmental pollution threat. The optimal level of production in a given situation depends to a large extent on the relative costs of different types of feed, their nutritional values and the anticipated production response to changes in feed quality. Under most practical feeding situations the energy level of the diet is the major factor influencing feed intake. Figure 4 identifies the range of factors which are associated with the regulatory effect of energy in various dietary scenarios, and which have often been evaluated in experimental situations.

The choice of dietary energy level in commercial poultry businesses is often based on economic decisions, and this contributes to the range of different energy concentrations used worldwide. In areas of the world where high-energy grains and feed-grade fats are relatively inexpensive, high-energy diets are often the most economical (i.e. the lowest-feed cost per unit of product). Conversely, in areas where lower-energy grains and by-products are less expensive, low-energy diets are often the most economical. The effect of the environment, particularly climatic variables should not be overlooked in terms of modifying effects on feed consumption levels (Figure 3). Chickens, being homeotherms, have to maintain their body temperature irrespective of fluctuating environmental circumstances.

FIGURE 3
The physiological and production components involved in the determination of voluntary feed intake in birds

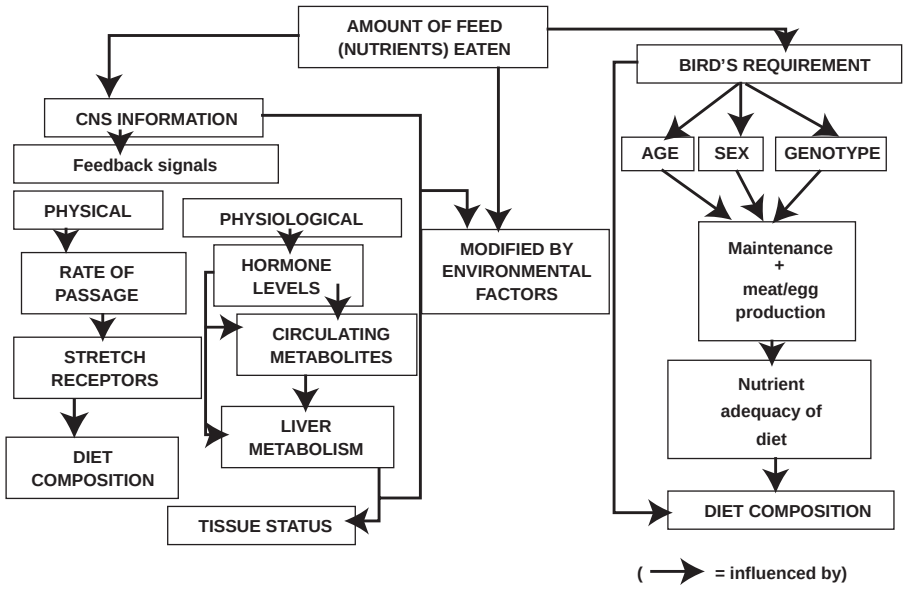
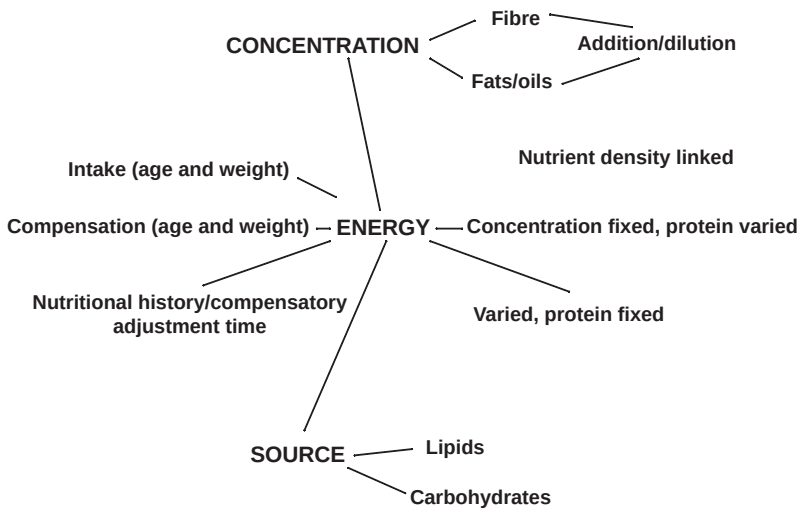


FIGURE 4
Potential dietry energy status scenarios



Temperatures and humidity deviations below or above the thermoneutral zone for the bird will prompt an adjustment in feed intake (NRC, 1994; Leeson and Summers, 2001; Gous 2007). Feed intake, therefore, with its multifunctional complexity and importance in economic terms, also has a fundamental role as a variable in the interpretation of nutritional responses. To this end, predicting the responses of poultry to various nutrient input scenarios has engaged researchers and scientists in recent times, and is likely to do so for the foreseeable future as computer modelling becomes a more popular predictive tool. Various authors including Ferguson (2006), Gous and Berhe (2006), Gous (2006) and Gous (2007) have documented the significant ongoing progress in the development of simulation models – not only for predicting VFI, but also for layer and broiler feeding programmes.

2.2 Critical nutrient relationships

In order to maximize performance, poultry diets must contain the correct balance of the essential nutrients required to meet the nutritional needs of various categories of bird. Much research effort has been directed over recent times into establishing the optimal inclusion levels for these nutrients to promote desirable, commercially important, outcomes such as maximizing VFI, and improving feed conversion and lean tissue deposition. The ability to create diets with such a degree of precision is made relatively easy by the availability of computer linear programming procedures, which access the nutrient profiles of large feed databases. At the industrial and commercial level, such formulation techniques are commonplace. However, in country situations where the array of raw materials for dietary inclusion is restricted, the ability to ensure precise nutrient balance and availability is inevi-

tably compromised; this would certainly be true for village or backyard-scale production and basic feeding scenarios. Greater accuracy in dietary nutrient provision not only results in enhanced bird performance characteristics, but also reduces the likelihood of nutrient waste and the threat of environmental pollution – an increasingly important issue for the future in an increasing number of countries.

An example of the important associations that exist between nutrients is that of the balanced essential amino acid (EAA) profiles embraced within the concept of the ideal protein. This is linked to the definition of protein quality with respect to the feed source and the extent to which it can meet the EAA needs of birds, for which (along with other monogastrics) these nutrients are indispensable.

The provision of quality protein devoid of any EAA deficiency is particularly critical in the early nutrition of young poultry (Dibner, 2006; Noy, 2006). There has been and continues to be research interest regarding the most deficient (limiting) amino acid in the diet and the quality of the protein mixture from which it is supplied. This has arisen from a recognition of the diversity of protein feed sources used throughout the world, concern about nitrogen in effluents from poultry enterprises, and argument about the validity of empirical methods used to measure the amino acid requirements of poultry. Amino acids represent the most costly feature of poultry diets and therefore continued studies to establish more precise nutrient requirements are merited (Wijtten *et al.*, 2004). The formulation of diets appropriately balanced in EAA sequences has been much assisted by the availability of synthetic and crystalline forms, particularly of lysine, methionine and threonine. Their use is likely to increase in the future as manufacturing costs decline in a growing international industry. Most commonly, the use of synthetic forms is associated with economic factors, and their trade price tends to shadow the major protein (amino acid) source worldwide, which is soybean. Many experiments have sought to elucidate the efficiency with which EAA are utilized by the bird to support improved levels of egg, meat and broiler breeder production (Gous, 2006; Ciftci and Ceylan 2004; Kidd *et al.*, 2004).

Other important nutrient inter-relationships have been identified (Leeson and Summers, 2001), which are important with regard to the nutritional integrity of diets, and which can have negative effects on poultry performance if ignored. Such relationships include various interactions between vitamins, between vitamins and minerals, and between minerals, particularly trace elements. Many relate to the effects of imbalances and antagonisms. Research focus has recently been on the dynamics of calcium utilization by laying hens (Lichovnikara, 2007) and the importance and role of selenium in the maintenance of bird health (McCartney, 2006) and broiler-breeder fertility (Renema and Robinson, 2006).

Another important association is that of the dietary energy:protein ratio. Protein deposition in the bird is an energy-demanding process and, therefore, may only proceed if adequate dietary energy is provided (assuming other nutrient adequacy). This fundamental relationship can be incorporated into the dietary association of energy and lysine, where the latter is used as the reference EAA, as in the concept of ideal protein. The ratio has been further explored recently by Wiseman (2006), in research which considered the consequences, particularly on broiler carcass tissue components, of changing energy:protein ratio under a variety of circumstances. Clearly, in countries and poultry management situations where the sourcing of protein, energy and micronutrient feed is difficult, and the choice

limited, such precision and choice of formulation strategies will also be limited. However, the principles of achieving correct nutrient associations should be adhered to whenever possible in the cause of improved efficiency and bird performance.

2.3 Genotype–nutrient interactions

Laying hen and broiler chicken performance capabilities and phenotypic manifestations in industrial, commercial and backyard situations will be determined by the effects of a combination of genetic and environmental factors. Both are associated with degrees of variation in commercially important traits that are usually observed in chicken populations irrespective of flock size. In poultry production, more so than other livestock systems, nutritional progress is intimately linked with genetic developments – correct nutrition giving opportunity for full expression of genetic potential, and thus complementing the process of genetic selection.

The majority of nutritionists accept the fact that different types of poultry have different nutrient requirements. In commercial production, for example, diet specifications for boilers versus laying hens are deliberately differentiated. However, it has been shown experimentally that avian species have fairly similar requirements for the essential nutrients. Certainly, while birds have changed somewhat genetically over time, their digestive anatomy and physiological function has not. That said, it is obvious that for layers and meat-producing birds there must, of necessity, be a different selection emphasis in terms of commercially important traits. It follows, therefore, that there is genetic variance related to the need for nutrients, which does create an interesting opportunity for selecting birds that can survive and perform well on lower planes of nutrition, particularly in the context of parts of the world where feed resources are scarce.

For a farmer to get the most out of the genetic potential of his or her birds, it is vital that due consideration is given to nutrition and general good management practice, particularly hygiene and disease minimization. There needs to be recognition of the biological limits to the gains achievable through classical selection practices. Breeding goals globally are now inextricably linked to ultimate safe food production, and represent an important aspect of the multidisciplinary approach to poultry production. Genetic potential cannot be viewed in isolation. The theory of feed intake and growth proposed by Emmans (1989) was based on the premise that birds attempt to grow to meet their genetic potential, which would imply that they would attempt to eat as much of a given feed as necessary to support such growth rates.

Change has certainly been witnessed over time, with present-day commercial poultry breeds and strains appearing more efficient in utilizing nutrients, and the current commercially prepared feeds being better formulated to meet the nutrient requirements of modern-day genotypes. In terms of the future direction of genetics linked to nutrition, costs of feed will remain a factor in the economics of production, and therefore the optimization of feed utilization by birds will remain a priority to geneticists in making economic decisions (Hoste, 2007). The same author predicts a breeding focus on other traits which will indirectly have nutritional management consequences and implications, such as selection for the characteristics of "robustness", environmental sensitivity and disease resistance.

Dawson (2006) has also reported on the future benefit of nutrigenomics, studies which

will enable a better understanding of the interaction between genes and nutrition at the molecular level, to (in the context of the paper) evaluate the effects of nutrition on fertility. By way of contrast, in developing countries genetic and breeding upgrading in local bird populations continues in a modest and more conventional way. Development initiatives in the past have emphasized genetic improvement, normally through the introduction of exotic genes, arguing that improved feed (nutrition) would have no effect on indigenous birds of low genetic potential. There is a growing awareness of the need to balance the rate of genetic improvement with improvement in feed availability, health care and general management. There is also an increased recognition of the potential of indigenous breeds and their role in converting locally available feed resources into sustainable production.

2.4 Nutrient support of immunocompetence

One of the possible consequences of intensive genetic selection in recent years, both in the layer and the broiler sectors of the poultry industry, is that such selection pressures for high-performance traits are associated with an increased susceptibility to infectious diseases and compromised health status. Health and disease control should constantly remain a high priority in the management of industrial, commercial and backyard-scale poultry enterprises. Various aspects of poultry husbandry can impact bird health in addition to genetics – including environment, vaccination programmes, prophylactic and therapeutic medication, feed additives, sanitation and farm biosecurity. In addition, there is an important relationship between the nutrition of the bird and the maintenance of health status in the flock. Suboptimal provision in terms of nutrient balance in the diet can compromise the immunocompetence of the bird.

The contribution that nutrition makes to disease resistance should not be underestimated, and both under provision and imbalanced provision of nutrients should be avoided. Such scenarios render the bird more susceptible to viral and bacterial pathogen overload. Husbandry practices which support effective immune responses are therefore vital. Two perspectives have influenced the focus of recent research on this subject: first, determining the most appropriate nutrient feeding strategies to optimize the immune response; and second, the study of the influence of immune response on the growth and nutrient requirements of the bird (Klasing *et al.*, 1999). The latter authors also comment on the important difference that can exist between the sanitation standards found in experimental situations and the less-controlled standards prevailing at the farm level. Immunological stressors resulting from poor sanitation, whether individual or multiple, are associated with, and manifested by, inferior growth rates, substandard feed conversion efficiency and modulated nutrient requirements; an infection usually results in a reduction in feed intake.

Koutsos and Klasing (2006) and Meijer (2006) have produced recent research review papers which comprehensively deal with interactions between the immune system, nutrition and livestock productivity. The consequence of immunosuppression in terms of altered metabolism and requirements for a range of individual macro- (energy-yielding, protein) and micro- (vitamins and minerals) nutrients is considerable. Nutrient demand associated with a challenged immune system is a component of the maintenance "costs" of a bird. As a system, it competes (for nutrients) with other commercially important productive processes. This repartitioning and diversion of nutrients away from production in favour of sup-

porting immune-related functions is not efficient or desirable. It goes without saying that although quality nutrition in poultry is an important component of management efforts to promote disease resistance, there is no substitute for good general management practice, embracing high standards of hygiene at the farm level.

3 FEED DIVERSITY AND CHARACTERIZATION

3.1 Desirable nutritional properties

A diverse range of raw materials with potential to supply nutrients to poultry has been identified over the years. However (and perhaps surprisingly) poultry diet formulations across the world, particularly at the commercial level, are characterized by relatively few feed ingredients (see Figure 2). Having established the nutrient requirement of a bird, the remaining part of the formulation procedure is to identify a mix of feeds which most (cost-) effectively supplies the essential nutrients in the right balance. The ability to achieve this is dependent on the nutritional properties and quality of the raw materials, and on the ability of the formulator to acquire the most appropriate feeds to support and maximize muscle growth or egg production. Variability in the nutritional value of feed raw materials is not surprising, as most are of plant origin and will have been subjected to many husbandry and climatic variables during production, harvesting and storage.

The true nutritive value of any feedstuff is influenced by its chemical composition, and the degree to which the bird fed is able to digest, absorb and utilize these components. Maize and soybean (meal) are the two crops that (when processed appropriately) form the main basis of most poultry diet formulations – representing 70 to 80 percent of the components of a compound feed. The use of other ingredients and substitutes for these two key energy and protein sources, respectively, will depend on availability. To ascertain with accuracy and speed the actual nutrient profile of individual raw materials and the final compounded nutrient status, the use of near infrared spectrometry techniques have helped considerably, particularly at the commercial production level where the scale of operation is sufficient to justify the cost (Bertrand, 2001).

For convenience, individual feeds are often categorized by adopting a set of criteria which allows a judgement to be made regarding their nutritional significance or emphasis. An example of such a classification would be: cereals, cereal by-products, vegetable proteins and animal protein. Such a grouping is, however, over simplistic in terms of reflecting the more precise nutrient quality, balance and availability of each type of feed. For example, cereal grains are primarily an energy-yielding feed component and are recognized as such, although cereals, particularly wheat, also make a contribution to the crude protein (nitrogen) balance of the overall feed. The presence of soybean meal or fishmeal in the diet of broilers or laying hens is commonly the chosen way to include a major protein source. Again, such feeds also have a significant metabolizable energy contribution to make. The largest of these suggested categories in terms of potential alternatives is the "vegetable protein" group, which is most able to appreciably contribute to a rise in the overall protein specification. As far as poultry feeds are concerned, fishmeal as a quality protein (amino acid) source, tends now to be the sole representative of the category "animal protein". This is mainly due to the withdrawal of meat and bone meal and carcass products from use by the feed industries of many (but not all) countries. Substituting the latter, with its com-

mendable balance and profile of essential nutrients, has not been easy and will continue to represent a loss to diet formulators. Most of the feeds mentioned here can be traded internationally, assuming that this is financially feasible for the countries concerned and that movement of such materials can be logistically facilitated. If this is not the case, then the use of alternative indigenous protein and energy-yielding feed ingredient sources need to be considered (Chadd *et al.*, in FAO, 2004e) and evaluated for the local poultry sector.

3.2 International research perspectives

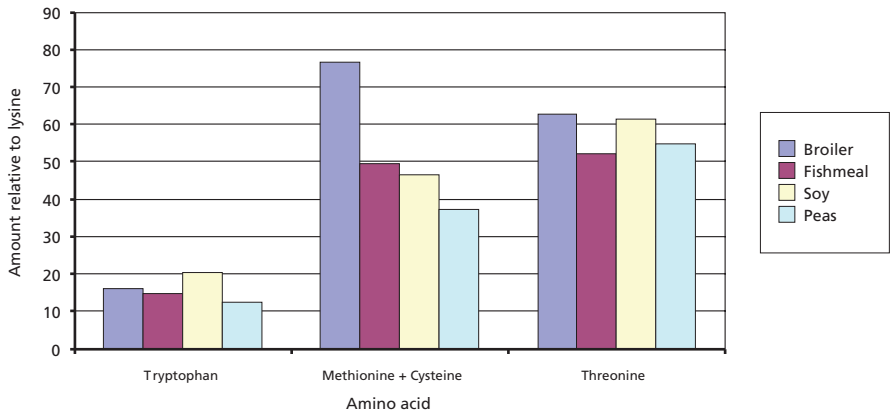
There have been efforts by a number of international researchers not only to give further consideration to the nutritional evaluation of the familiar components of poultry diets, but also to examine alternatives. Wheat continues to be the staple starch energy-providing ingredient for many poultry birds across many countries (Figure 2). Some time ago, Wiseman and Inborr (1999), however, drew attention to the variability in broiler performance which, it was hypothesized, could have been due to variability in batches of wheat over time and consequent variations in nutrient levels. The husbandry and climatic conditions which are associated with crop growth and harvest are considered to have a particular influence on the nutritional value of the grain. Results pointed to variability in the apparent metabolizable energy of wheat fed to young broilers, but also indicated that this was linked to differences between birds in terms of their ability to digest and utilize high-wheat diets (ibid.). More recently an English study conducted by Pirgozliev *et al.* (2003) addressed similar concerns – nutritive variability in wheat – by evaluating different wheat cultivators over three harvest years; it was concluded that there was an association between the endosperm hardness and ash content of grains and the observed variability in growth rate, feed intake and feed conversion efficiency. Such an understanding could assist plant breeders in selecting and breeding new wheat cultivars that enhance rather than detract from bird performance.

In a further study involving wheat, Norwegian researchers, Svitius *et al.* (2004), compared the feeding of whole wheat grains to broiler chicks with wheat in a ground form. The motivation for the study was the inconsistent results obtained for such comparisons in other studies. Feeding whole grains has the advantage of reduced handling and processing costs. Results suggested that benefits in bird performance associated with feeding whole grains were due to increased pancreatic and liver secretory activity which facilitated improved digestion overall.

The importance of EAA status in cereal grains generally, and the production of a high-lysine maize variety in particular, is reported by Vassal (in FAO, 2004f) in relation to plant breeding work carried out at the International Maize and Wheat Improvement Centre (CIMMYT), Mexico. It is well established that feeds offered to poultry have, as individual components, deficiencies in EAAs (Figure 5). However, although crop manipulation in the interests of improvements in poultry nutrition is feasible, given the relative ease of availability of synthetic forms of EAA, and particularly those classically limiting in the diets of layers and broilers, such efforts may be questionable.

Alternatives to maize as a key energy ingredient have been considered and reported on in recent times. A number of millet types were evaluated by Rao *et al.* (2006a) in India, and their potential investigated as substitute feeds. For example, foxtail millet (*Sevaria*

FIGURE 5
Amino acid balance of three raw materials relative to that required by the young broiler



Source: Wiseman (2000).

italica) is grown in Asia, Africa and some parts of Europe, and has superior protein, oil, sugars, lysine and methionine content compared to maize. The metabolizable energy content of the millet was slightly lower than that of maize (2 915 to 3 304 kcal/kg, respectively) (ibid.). Performance of boiler birds fed millet as an energy basis, compared very favourably with control birds fed on a conventional maize ration, especially when offered in a pellet form.

The nutritional potential of another potential energy source in broiler diets, sorghum, has been investigated recently by Nyannor *et al.* (2007) in work done at Purdue University. The background to this work is the ever-increasing diversion of demand for maize from use as feed into ethanol production, and therefore the need to consider alternatives. Results indicated that weight gain, VFI and feed conversion efficiency were not too dissimilar in chicks fed a sorghum–soybean diet compared to those fed on conventional maize–soybean diets. The use of sorghum across the world has its appeal, as it is a drought tolerant crop and is able to withstand a wide range of environmental conditions. However, improved cultivars – providing digestibility comparable or superior to that characteristic of other grains – would be welcome.

The growth of the ethanol industries will bring with it the opportunity to explore the production of co-products which have potential as poultry feed. One such is distillers dried grains with solubles (DDGS). Essentially, this product is the dried residue remaining after the starch fraction of maize is fermented with selected yeasts and enzymes to produce ethanol and CO_2. Refinements of new technologies are now capable of producing a product suitable for inclusion in discrete amounts (approximately 10 percent maximum) in poultry diets, which can offer energy, digestible amino acids and available phosphorus (Gibson and Karges, 2007).

Rice by-products are another potential energy source; their use in the context of the Sri Lankan poultry industry is described by Mellor (2004). This provides an example of a country which, rather than relying on expensive import commodities, has focused on the evaluation of local cheaper energy sources. The report expands on the use and application of enzyme technologies (phytase or xylanase) to rice to release greater nutritional potential. Cuba has been evaluating a by-product from its considerable sugar-cane processing sector – high-test molasses (sugar cane juice). Valdivie (2003) commented on its utilization in poultry feed as providing total or partial substitution for cereals, which would represent a substantial import-cost saving. Performance results derived from some basic experimental substitution trials for both broilers and layers indicate a favourable outcome.

In many developing countries, the opportunity to switch protein sources from the traditional use of soybean meal would be welcome because of import pricing structures, and also because of the feed-hygiene risks associated with animal protein sources. To this end, recent studies in India conducted by Rao *et al.* (2006b) have looked at the extent to which soybean meal can be safely replaced with sunflower seed meal. There had previously been some concern regarding the higher fibre, and low energy and lysine values of the sunflower alternative. However, it was concluded from this study that sunflower can replace up to two-thirds of soybean in the diet, corresponding to an inclusion of 345 and 296 grams per kg for starter and finisher phases in broiler diets, respectively. In another Indian study, peanut and sunflower meal were combined successfully in poultry diets – reinforcing the opportunity for utilizing home-grown alternatives and making significant economies without compromising bird performance.

Allymehr *et al.* (2007) considered the nutritional potential of rapeseed derived from biofuel production. Approximately 80 percent of the biofuel in the EU is produced from rapeseed. Although there is a significant amount of scientific evaluation of conventional oil-extracted rapeseed, there is a dearth of information on rapeseed meal derived in this alternative way. Results were promising particularly when exogenous enzyme treatments were applied – especially those that would degrade the non-starch polysaccharide (NSP) fraction.

Peas and beans are also regarded as relatively well-balanced nutrient providers including respectable amino-acid profiles and energy-yielding capability. The main constraint to their use is the well-documented presence of anti-nutritional factors (ANF) inherent in their biochemistry (Crèpon, 2007). These include resistant starches, refractory proteins, tannins and trypsin inhibitors. However, with appropriate treatments and technologies applied at the point of processing, such negative influences on their potential nutritive value for layers and broiler chickens can be minimized. Chadd *et al.* (in FAO, 2004e) reported on other indigenous legumes with potential for inclusion in layer diets in Australia – including mungbean, chickpea and cowpea; the consideration of such ingredients in diet formulations would help reverse the trend of increasing soybean imports.

Clearly, the alternative options for poultry-feed ingredients mentioned above are those that can be considered in the future compilation of diet specifications for poultry operations and enterprises at the commercial level, where high-quality diet specifications are achievable. Many challenges remain, however, to provide adequate nutrients to birds at the level of family, backyard systems in developing country situations, where there is a heavy reliance on scavenged resources. Under such circumstances, particularly in times

of drought, the initial challenge remains that of offering nutrition at a level that exceeds maintenance. A well-balanced diet is difficult to achieve with poor or unpredictable, availability and/or lack of diversity in raw material resources. The provision of minerals, so vital in egg production, is particularly difficult, and alternative local mineral sources have to be utilized in place of commercial premixes (FAO, 2004c). The latter publication lists potential substitutes for expensive commercially formulated feeds. The principles of calculating nutritional requirements remain the same irrespective of the system of poultry keeping, but will need to be modified to take into account the level of productivity expected and the genetic capability of the birds to meet these requirements.

3.3 Anti- and pro-nutritional factors

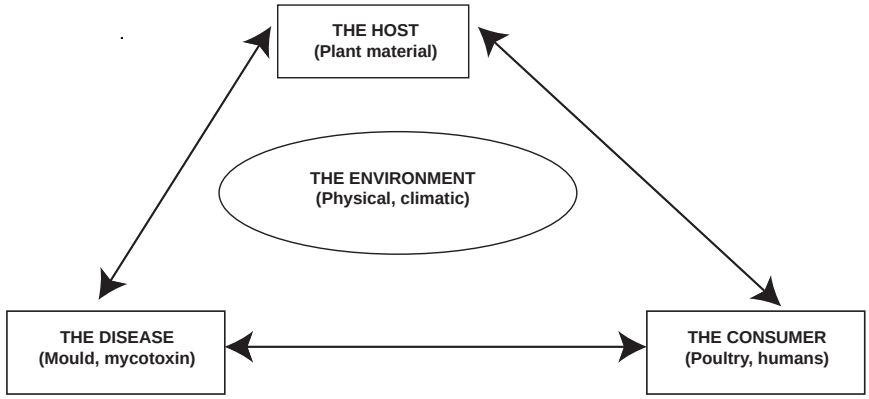
In the future, major improvements in poultry nutrition are far from likely to come from the discovery of new nutrients or even the refining of nutrient requirements; rather, improvements in production efficiency, a desirable objective commercially, must depend on achieving maximum nutrient utilization from feedstuffs. This would also enable the use of a larger range of feed ingredients, including those currently considered to be nutritionally inferior for one reason or another. It is recognized within the feed industry that a proportion of the nutrient content of feeds is not subjected to effective digestion and absorption by poultry. Certain feed commodities are overlooked or underutilized due to inferior nutrient availability, high levels of NSPs and/or the presence of undesirable anti-nutritional fractions. A varied number of anti-nutritional and/or potentially toxic compounds are located integrally in cereal grains, seeds of legumes, and other feeds of plant origin used in the manufacture of poultry diets. Most of these substances are naturally occurring constituents of varying chemical composition (e.g. proteins, alkaloids, glycosides and fatty acids). Such compounds can be relatively easily inactivated by subjecting them to washing, soaking and heating processes. Care in the application of such processes is needed to avoid further spoiling of the nutrient profile or the inadvertent creation of further toxic compounds. The detailed characterization of the many commonly found ANFs and their (negative) interaction with feed nutrient supply and livestock host are provided in the literature (de Lange *et al.*, 2000).

One subject receiving much attention from researchers at present is that of mycotoxicity. It is an issue which has important implications for the global feed industry, bird performance and potential negative consequences for the food chain. The prospect of elevated temperatures, and other climatic variables, resulting from climate change means that study of the subject will continue to be of paramount importance in the future.

Mycotoxins are a structurally diverse group of secondary metabolites produced by different genera of toxigenic fungi (Chadd, 2004). Aflatoxins, deoxynivalenol, zearalenone, fumonisin, T-2 toxin and ochratoxin A are toxins of importance worldwide, which are produced by fungi on pre- and post-harvest food and feeds (Fokunang *et al.*, 2006). Figure 6 highlights the complexity involved in the study of the subject, and in the prevention and solution of contamination, resulting from the interaction between the host, the toxin properties and the consumer of the product in question.

Of particular concern is that mycotoxin surveys from around the world indicate that protein sources such as rapeseed meal, groundnut cake, sunflower meal, copra meal and palm kernel meal, for example, are more susceptible to mycotoxin contamination than

FIGURE 6
The multifactorial challenge of mycotoxin contamination



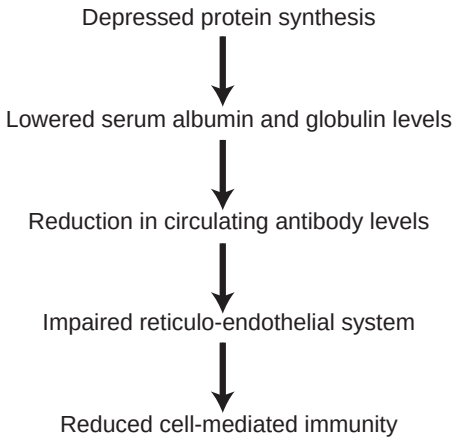
conventional raw materials such as soybean meal. Due to cost implications, the move by the feed industries of different countries to seek alternatives to soybean will only serve to exacerbate the situation and the degree of risk.

The cost of maize has also reinforced the need to assess other "vulnerable" energy sources including by-products such as rice bran, wheat bran and screenings. The additional concern here is that many of the mycotoxins are concentrated in the outer covering of the seeds. The toxicological effects on poultry and the mode of action associated with such toxins are varied, but the extent of mycotoxicosis manifest in chickens will depend on factors such as duration of exposure to toxins either ingested or inhaled, breed type, age and physiological status (Chadd, 2004).

In addition to disrupting the normal metabolism of nutrients, the presence of such a toxin in the chicken can have the overall effect of compromising immune-system function, and thereby negatively affecting bird performance. Devegowda *et al.*, (1997) in their study of the immunosuppressive effect of aflatoxins in poultry, linked compromised protein synthesis with a cascade "knock on" effect, the consequence of which is that normal body immune status can be breached (Figure 7).

With a significant number of industries and organizations involved in feed and food production and technologies employed to improve efficiency, it is imperative that in the future more integrated (including regulatory) approaches to prevention and control of mycotoxin occurrence are considered and adopted. Bhatnagar *et al.* (2004) identified a twin approach to priorities for future research. First, an emphasis on devising more rapid procedures for detecting the presence of fungal and toxin contamination of crops, raw feed materials and manufactured products, which have greater sensitivity and accuracy; and, second, the recommendation that more effective strategies be employed through demonstrating good agricultural practice, controlling contamination prior to harvest, and decontamination of commodities post-harvest. Hygienic storage conditions particularly in tropical climates are imperative.

FIGURE 7
A cascade of immunosuppression effects in aflatoxin-challenged poultry



Source: adapted from Devegowda *et al.* (1997).

In contrast to factors that exert a negative influence on poultry production, other developments and technologies current and emerging, are offering opportunities to enhance the quality of feed, improve utilization by birds and promote optimal health status. One reason for the expansion of interest in exploiting new technologies and product creation is the recent demise of the use of antibiotics as growth-promoting agents in the poultry industry (mainly in Europe). One alternative "pro-nutrient" is the use of exogenous enzymes in poultry diets (Rosen, 2006). Exogenous enzymes added to the feed or used during feedstuff processing, have the potential to improve feed efficiency, reduce pollution associated with poultry manure, and increase the use of low-cost feed ingredients. One important development, now widespread in the poultry feed sector, is the use of exogenous phytases (Touchburn *et al.*, 2006). Despite the significant volume of literature on the ability of phytase to increase phosphorus availability and reduce pollution, this latter benefit is only of economic value in regions where phosphorus concentrations in the diet and/or manure are associated with a disposal cost.

Fibre (NSP)-degrading enzymes increase digestibility of the entire ration through the degradation of anti-nutrients (arabinoxylans in wheat and B-glucans in barley) and enable the feed compounder to utilize more cereal and less fat and/or protein supplements, thus enabling potential economies in formulation. Looking to the future, it is to be hoped that in many countries new technologies will provide solutions which will increase the benefits derived from enzyme use and increase the size of the global market in which they are used. An example of this would be further exploitation of the advantages that solid-state fermentation technology has to offer, as described recently by Purser (2007).

There are many other natural alternatives to antimicrobial growth-promoting agents which merit continued research and development attention in the coming years. These

include, pre- and probiotics, organic acids, herbs and spices (plant extracts), yeast cultures, oligosaccharides and flavourings. The purposes and claimed benefits of these alternatives are several. First, providing the bird with more available nutrients; second, reducing the metabolic demands for maintaining the absorptive and immunological function of the gastro-intestinal tract; and, third, reducing the susceptibility of the bird to enteric disorders. However, the mode of action of the various products can be quite diverse. The common objective is, in addition to providing improved nutrient balance in the diet, to exploit the full health-enhancing properties of feeds. This is implicit in the concept of "total nutrition" and the term "neutraceuticals", as discussed at length by Adams (2001).

There are many natural components of feed, the so-called "nutricines", that have valuable and beneficial effects and which relate health to nutrition. In most countries, attention is increasingly given to the whole food chain – whether associated with egg or meat production – in relation to bird welfare, protection of the environment and the pursuit of higher standards of food safety for the consumer. On the theme of consumer acceptability, and as the genetic modification (GM) "debate" continues (Horlick-Jones *et al.*, 2007), there is little doubt that genetic modification of both crops and poultry genotypes will contribute to nutrient availability and utilization, and offer particular desirable commercial applications to developing countries. Hard (in FAO, 2004g) discusses the value of pursuing controlled GM of crops for feed purposes in parallel to both conventional breeding approaches and other biotechnologies. The prediction is made that the next wave of genetically improved crops will focus on "output" traits providing enhanced feed values to benefit poultry productivity – for example, protein quality (amino acid balance) and improved digestibility (particularly fibre and starch). Aumaitre (2001) provides a thorough review of challenges and successes in the transgenetics of crops and of future opportunities to extend the variety and diversity of genetically, and thereby nutritionally, "customized" feeds available for dietary inclusion.

3.4 Redefining the systems approach

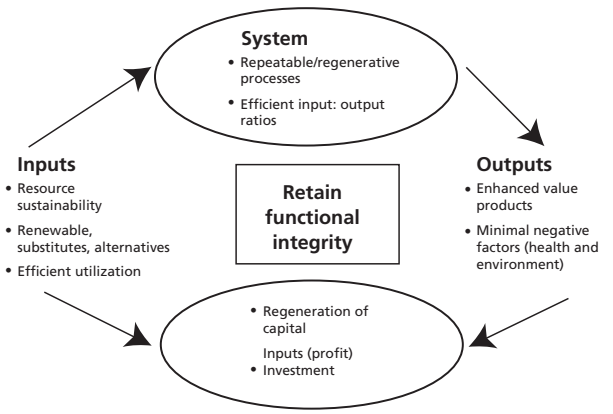
The familiar and now well-established model which enables analysis of the role of essential inputs and the effectiveness of their conversion by the bird into a defined output has become increasingly important for researchers and the feed industry (see Section 2.1). At the commercial level, the farmer is also able to manipulate the biological (including nutritional), technical and social factors of input in order to enhance the chicken's ability to transform these into a saleable commodity. The model, therefore, can be considered at the level of the individual bird, the flock or the farm system, and is a useful management tool. Scientists and nutrition researchers are interested in the fundamental and biological mechanisms and limits to the conversion of a nutrient or nutrients, and their consequences for output (quantity and quality). Such a conventional model appears rather basic and oversimplified; it does not take into account, the need (increasingly important in current and future poultry production) to apply a "sustainability dimension". Figure 8 illustrates a model which includes a continuous enterprise cycle embracing the important elements of sustainability – both physical and financial.

The model assumes a greater focus in the future on "resource sufficiency" not scarcity, which will necessitate the constant consideration and evaluation of alternative protein and

other nutrient input sources, for example, a reduced reliance on the traditional proteins fishmeal and soybean in poultry diets. A continued objective will need to be to achieve and exploit efficiencies throughout the system, particularly opportunities for further feed conversion economies. On the output side, the future expectation is that the whole food chain, and its quality assurance, will be considered from the perspective of consumer acceptance. This is an increasing requirement for poultry production practices in developed countries and, increasingly, globally. From the perspective of the maintenance of an economic livelihood, a measure of investment back into the system is vital. A sustainable system, therefore, has to retain "functional integrity" (Thompson, 1997) whether high-input, high-output as in the case of industrial scale production, or low input–modest output expectations as is usually the case for small-scale production.

Such a theoretical approach to (and examination of) the importance of feed costs and quality in a system, involves the association of such inputs with the type of production enterprise and the management system used. In the EU there has been, for environmental and welfare reasons, a shift from intensive (high input resources) to more extensive systems (Guy and Edwards, 2006). Despite major improvements in bird performance, and in particular feed conversion efficiency, in recent years, brought about through improved breeding and nutrition management strategies (i.e. phased feeding), advances in exploiting the biological potential of the chicken are likely to be slower in the future (Steinfeld *et al.*, in FAO, 2006) with greater focus on more sustainable practices. The development of alternative production systems in the tropics and developing countries, using locally available feed resources, must start with knowledge of the impact on nutritional requirements of using new feed resources, which are often rich in sugars, lipids and fibre, in contrast to the starch-rich feeds used in temperate countries. A more holistic approach to the development of feeding programmes will assist the poultry industries and individual producers of chicken products to pursue the goal of enhanced production within a sustainability context.

FIGURE 8
A system's approach embracing sustainability



4 CONCLUSION

This paper has given recognition to recent rapid technological, scientific and industrial changes that have taken place in the global poultry sector, with focus on nutrition, and has used these as a baseline to predict likely future trends and developments. The size and dynamics of the feed industries in different countries reflects the significant level of growth in demand by consumers for poultry products, particularly meat. Regional differences indicate the continuation of a strong demand for poultry feed in Asia, while the manufacturing output from European countries remains fairly static, reflecting industry consolidation. Various "drivers of change" will exert increasing influence in the future on the practical feeding of poultry, whether kept for broiler meat or egg production. For example, feed costs as a proportion of the variable costs for producers of poultry products will remain high, in particular, the protein sources included in diet formulations.

Additional legislation will affect many aspects of the feed sector including regulations associated with environmental protection, and hygiene and food safety issues throughout the poultry food chain. There will be challenges to the continued popular use and dietary inclusion of the traditional protein and energy-yielding ingredients – soybean meal and maize cereal, respectively. Due to cost and environmental reasons, developing poultry production sectors will not be able to sustain soybean imports, and will have to consider alternative oilseed or legume feed options. Likewise, the likely diversion of cereals such as maize into ethanol production will require a switch to viable substitutes.

There is ongoing scientific evaluation of locally grown indigenous crop sources that can offer reasonable protein and energy yields. The future use of alternative protein feeds in formulations, despite the fact that they contain less than favourable natural amino-acid profiles, will be assisted by the increasing availability of relatively cheap synthetic forms of EAA. Even the growth of the ethanol industries will be accompanied by opportunities to explore the production of co-products with some nutritional merit for poultry rations.

The focus of poultry nutrition research in the future will be increasingly dependent on commercial sponsorship, and very much applied to the practical scenarios and challenges of commercial poultry farming. Manipulation of VFI in birds is key to the control of nutrient intake levels, and therefore ultimate performance and productivity, and the factors influencing VFI will merit further scientific and commercial evaluation in the future, particularly with the prospect of climate change and the effect of elevated temperatures and other climatic variables on appetite.

The genetic selection emphasis of recent times linked to nutrition, that of feed conversion efficiency and maximal growth, is likely to change in favour of traits associated with bird welfare, meat and egg quality, and "robustness" of genotypes or strains of bird capable of adapting to, and being productive in, a range of commercial environments. Production prediction models will increase in sophistication and remain a valuable tool for research purposes and formulation of practical diet solutions. The maintenance of immunocompetence and optimal health status in birds in a range of husbandry situations will remain a priority. A shift towards alternative, less-conventional feeds which are subject to established manufacturing processes may mean that birds' diets contain chemical elements that can be identified as ANF. The latter can compromise immune status, and adversely affect performance. The presence of mycotoxins in poultry feed also compromises immune status and

an increased level of vigilance will be required by farmers in the future to identify, prevent and control such situations. Good agricultural practice and management, particularly of stored feeds in hot climates, is vital. There is likely to be continued interest in the value and nutritional "virtue" of the range of "natural" pro-nutrients, and the advancement and application of the "holistic" approach to poultry nutrition. Future poultry production systems globally will need to embrace and incorporate sustainable practices in pursuit of business viability at the commercial level and to address the scarcity of feed-resource inputs often associated with subsistence farming.

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Future trends for poultry genetic resources

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SUMMARY

Local breeds make up most of the world's poultry genetic diversity, and are still very important in developing countries where they represent up to 95 percent of the total poultry population. These local breeds, which are well-adapted to extensive husbandry systems and suitable for resource-poor poultry farmers endowed with very limited means, should be thoroughly studied as a basis for enhancing their use and conservation.

There is evidence to show that there is considerable scope for improving the performance of local breeds. However, these breeds cannot compete with highly selected commercial hybrids. Thus, a breeding programme involving local breeds should identify alternative breeding goals, and capitalize on the breeds' specific attributes. Commercial laying hens can produce as many as 325 eggs per year, and broilers can reach 2.5 kg in 42 days. This is the result of long, structured and intensive selection, which also focused on feed efficiency and product quality. A handful of breeding companies account for most of the genetic improvement that is currently taking place; the products of this improvement process reach the world market through multiplication and distribution networks. Most of these breeding companies are located in temperate regions, while their products are marketed all over the world – including tropical, semi-arid and arid regions where conditions are challenging in terms of climate, husbandry, feeds and feeding practices. To account for genotype by environment interaction, these companies either test their animals across a range of environments or establish satellite breeding programmes in various locations. The use of specific genotypes, such as homozygote or heterozygote naked-neck or featherless birds, could be another option for hot climates.

In the developed world, food production is changing from being producer driven to consumer driven. The consumer is increasingly concerned about health, environment, ethics and animal welfare, and demands for certified products such as a free or organic meat and eggs have emerged. This trend is supported by new regulations, especially in Europe. Breeders have adjusted their programmes to include welfare-related traits. No direct actions have yet been taken to address environmental issues and the use of resources. However, it is argued that benefits are obtained indirectly, through genetic progress in growth and feed conversion ratio.

In the developing world, the production of local chickens is consumer-driven, with

demand for quality, typical products and cultural uses; industrialized meat and egg production is still producer driven.

Technology, especially genomics, has evolved very fast and expectations are high. Yet, these developments are costly and out of reach of most developing countries. Without doubt, major breeding companies will use them to select for disease resistance and robustness. If they succeed, local indigenous breeds will be at higher risk of erosion, unless actions are taken to apply genomics also to the characterization and conservation of local populations and to increase awareness among policy-makers and the international community of the importance of these breeds. *The State of World's Animal Genetic Resources for Food and Agriculture* contributed to raising awareness, and the *Global Plan of Action for Animal Genetic Resources* adopted through *Interlaken Declaration* provides, for the first time, an agreed international framework for the management of these resources.

Key words: genetics, poultry, future

1 POULTRY GENETIC RESOURCES

Generally speaking, two poultry production systems coexist: a commercial production system, with varying levels of integration and industrialization, and a village or backyard system. These two systems use different breeds of poultry. Commercial hybrids are used by the commercial system, while the village system makes use of indigenous or local breeds.

The companies providing the commercial hybrids keep their breeding information secret. There is, therefore, no information available on the provenance of these strains. In the case of chickens, most strains appear to be derived from the White Leghorn, Rhode Island Red, Plymouth Rock, New Hampshire and White Cornish breeds. Commercial turkeys are derived mainly from Black, Bronze and White Holland. The latter is the ancestor of the Broad-Breasted White, the commercial turkey of choice for the turkey industry and the most commonly produced. Commercial duck strains are mainly derived from Indian Runner, Khaki Campbell and Pekin. In geese, the major commercial strains are White Toulouse, Emden and Chinese. These breeds are relatively well-documented.

According to *The State of the World's Animal Genetic Resources for Food and Agriculture* recently published by FAO (FAO, 2007), there are 1 644 local, 85 regional transboundary and 157 international transboundary avian breeds reported in the Domestic Animal Diversity Information System (DAD-IS). The latter group includes the above-mentioned commercial breeds. These figures clearly indicate that local or indigenous breeds make up most of the world's poultry genetic diversity. As shown in Figure 1, chicken breeds make up the vast majority (63 percent) of the total number of avian breeds, followed by ducks (11 percent – excluding Muscovy ducks), geese (9 percent) and turkeys (5 percent).

1.1 Regional distribution of avian breeds

The Europe and the Caucasus region accounts for 52 percent of the world's local avian breeds. Asia accounts for 25 percent, Africa for 9 percent, and Latin America and the Caribbean for 8 percent. North America accounts for less than 2 percent of the total (FAO, 2007). The large number of breeds in Europe and Caucasus is partly a result of the fact that in this region breeds are more likely to be recognized as separate entities. It also reflects the more advanced state of breed recording and characterization in this region. Molecular

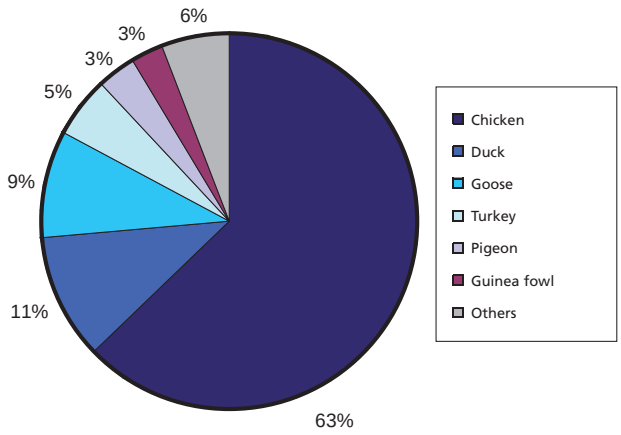
studies of European chicken breeds show they are not particularly closely related; they are genetically distinct, but harbour moderate to low within-breed diversity, because the populations are of limited genetic size.

Indigenous chicken breeds are widely distributed, but their contribution varies between regions: very limited in the developed world (Europe and North America), but still important in the developing world. In many of the developing countries of Africa and Asia, the estimated average proportion of indigenous birds in the population is close to 80 percent (Guèye, 1998). Given the level of productivity of indigenous birds, their relative contribution to meat and egg production is, however, likely to be very much lower than their numerical contribution. Predictions of the extent of this contribution are subject to a high degree of error. The very approximate estimates produced by Pym *et al.* (2006) suggest that the contribution of indigenous genotypes to egg production is probably quite low in most countries, but that the contribution to meat production is likely to be quite substantial.

Ducks are also found in all regions; however, they are less numerous and show a less even distribution than chickens. Domestic ducks have a long history of domestication, and were kept in ancient Egypt, Mesopotamia, China and the Roman Empire. However, production is now concentrated in China, which has 70 percent of the world's domestic duck population. Other major producers are Viet Nam, Indonesia, India, Thailand and other countries in Southeast Asia. Among European countries, France and Ukraine have large numbers of ducks. The Muscovy or Barbary duck (or Criollo duck in Latin America) is a unique duck species that belongs to a group of waterfowl that can reproduce without water.

Geese and turkeys have a relatively narrow distribution. This can be explained by tradition and consumer preferences rather than by agro-ecological conditions. Nearly 90 percent of the world's domestic geese are found in China. Turkeys originated in Central America,

FIGURE 1
Distribution of the world's avian breeds by species



Note: Avian species with more than 50 recorded breeds are displayed separately; the remaining avian species are aggregated as others.
Source: FAO (2007).

and were brought to Europe shortly after their discovery by colonists; many breeds were developed in the latter region.

Most of the examples and developments described in the following sections are related to chickens – despite our efforts to cover all major poultry species. The chicken not only accounts for the vast majority of poultry genetic diversity, but is also the economically dominant species.

2 PAST DEVELOPMENTS IN POULTRY BREEDING

2.1 Attempted breeding programmes for indigenous poultry

Most breeding programmes aimed at improving the productivity of indigenous chickens have used cross-breeding. This approach has provided significantly higher productivity, but has resulted in a loss or dilution of the indigenous birds' morphological characters and instinct for broodiness. For example, the system used in Bangladesh for a number of years, and often referred to as the Bangladesh model (Jensen and Dolberg, 2002), which was designed to alleviate poverty among vulnerable people, was based on a cross between Fayoumi and Rhode Island Red chickens. The cross-bred chicken, known as the Sonali, turned out to be a high-yielding breed combination under semi-scavenging conditions (Rahman *et al.*, 1997). The Sonali is quite popular where it is kept, and it has a good reputation among Bangladeshi smallholders. However, its production faces a major obstacle in that new parent stocks are not readily available. In addition, smallholders' acceptance declined when they discovered that they had no success in reproducing Sonalis. The Central Avian Research Institute in India has produced various types of cross-breeds by crossing Rhode Island Red birds with local breeds (Singh *et al.*, 2004). However, when these birds were distributed, villagers complained about the dilution of morphological characters. They also found it difficult to market the eggs.

Experience has made it clear that the structure of such programmes was too complex for village conditions, where crucial inputs such as feed and medication were not readily available. The need for periodic re-supply of cross-bred chicks to the villagers presents a challenge. This has to be carried out either by an NGO or by a government agency, which has to maintain the pure lines of the indigenous birds as well as of the exotic birds on an appropriate selection programme. A mechanism for re-supplying the birds, providing minimum inputs, and marketing the eggs and culled birds has to be put in place in order to achieve success with programmes of this type.

Another cross-breeding strategy which has been practised for many years in some African countries is the cockerel exchange programme (FAO, 2004). This type of scheme involves distributing cocks of improved breeds to smallholders. However, several reports have concluded that this type of improvement has not changed the basic populations, except for contributing to a larger variation in plumage colour.

2.2 Development and trends in organized poultry breeding

Concentration in the breeding sector

In the 1960s, there were literally hundreds of breeders with significant market influence. Slowly, the breeders started expanding into more distant markets, including overseas. Only those who could cater for different market requirements and those who had efficient

production and delivery systems survived. The rest disappeared. By 1980, only 12 layer breeding companies and 13 broiler breeding companies survived. Poultry breeding is an international industry. Survival in such a highly competitive industry is dependent on a number of factors:

- Primary breeders must have well-structured and efficiently operated breeding programmes to maximize genetic gains per unit of time in traits that are relevant in a given market or markets.
- Primary breeders must have efficient schemes for the multiplication of commercial products to meet market demands for quality and quantity in a timely manner.
- Breeders are also expected to provide technical recommendations and service support to ensure that customers achieve the genetic potential of the product provided.

A primary breeding company may have taken care of all the three above-mentioned requirements and still fail, if the geneticist conducting the breeding programme pursues an inappropriate goal. There is a long (four to five year) timeline from selection of pedigree stock to realization of results in the field. Once the geneticist realizes that the goal he or she pursued is not helping the company in the market, it will take a minimum of four years before any correction will be seen in the market. By that time, market will have been lost, and regaining the confidence of the customers may take months or years and require much effort.

Product performance is generally evaluated in relative terms, with competitors' products serving as a benchmark for all the attributes desired by the customer. Thus, it is important for product performance to be superior to that of the competitors as market requirements change. Breeding companies that could not foresee, or did not acknowledge, forthcoming changes in the market place, and did not modify their once-successful breeding programmes, have either vanished or been relegated from first or second to fourth or fifth place in terms of market share, despite having most of the ingredients needed to run a successful breeding business.

By the year 2000, layer breeding companies achieved more than 300 eggs per hen housed for 72 weeks, with a peak of lay of more than 95 percent. This means that the majority of birds were laying to their biological limit. Similarly, the broiler farmers were getting almost 2.5 kg body weight at 42 days of age with 1.75 feed conversion ratio. In other words, broilers were also approaching their biological limit. In order to obtain further genetic gains in production, feed efficiency or liveability, more sophisticated technologies were adopted by the breeding companies:

- Information and communication technologies – in order to estimate breeding values more efficiently, the breeding companies had to use best linear unbiased prediction (BLUP) methods, which require more sophisticated computers and state of the art software.
- With the approach of biological limits, breeding companies had to use larger populations per line, with a wider sire base in order to find minor differences between sire and dam families and between individual birds.
- With the advent of a global market, the breeding companies had to have efficient distribution channels throughout the world. The companies had to place not only grandparents, but also great grandparents, in different countries and continents.

All these developments strained the profitability of the breeding companies. Some could not cope in terms of finance and human resources. These companies became prey to the big multinational pharmaceutical or holding companies. By 2001, nine major layer breeding companies had been acquired by only three holding companies. By 2006, all nine were owned by only two companies – Hendrix Genetics and Erich Wesjohann (Table 1). Similarly, eight broiler breeding companies from the year 2000 are now owned by only four companies – Aviagen, Cobb, Hubbard and Hybro.

Impact of concentration in the poultry breeding sector on breeding programmes and the use of genetic resources

Two major concerns have been expressed regarding the concentration of the poultry breeding sector in a few hands:

1. The main concern expressed by many is the loss of genetic resources (lines) due to mergers and acquisition of breeding companies. It is feared that the breeding companies will keep only those lines that in their opinion are useful at present in product formulation or have potential to be used in the future. Economics could compel the companies to discard lines perceived not to be useful. Once the line is discarded it is gone for ever. Due to the proprietary nature of the lines, there is no information available as to how many lines have been discarded. This trend is definitely going to reduce the available gene pool across the breeding companies.

TABLE 1
Layer breeders and ownership since 1991

Breeders	1991 Location	1991 Ownership	2001 Ownership	2006 Ownership
Babcock	Ithaca, United States of America	Rhone/Merieux	Merial	Hendrix Genetics
Bovans	Ospel, Netherlands	Hendrix	Hendrix/Nutreco	Hendrix Genetics
Dekalb	Dekalb, United States of America	Dekalb Genetics	Hendrix/Nutreco	Hendrix Genetics
Hisex	Boxmeer, Netherlands	BP Nutrition	Hendrix/Nutreco	Hendrix Genetics
H & N	Redmond, United States of America	Lohmann	Erich Wesjohann	Erich Wesjohann
Hy-line	Des Moines, United States of America	Lohmann	Erich Wesjohann	Erich Wesjohann
ISA	Lyon, France	Rhone/Merieux	Merial	Hendrix Genetics
Lohmann	Cuxhaven, Germany	Lohmann	Erich Wesjohann	Erich Wesjohann

Source: adapted from Albers and Van Sambeek (2002).

2. The reduced number of breeding companies has raised concerns about reduced competition and associated reduction in the potential for innovative research and development (Sheldon, 2000). However, competition among the remaining breeders is more intense than it has ever been. Consumer demands are much more diverse on a global scale than they ever were. This means that the breeding companies are required to supply products that are much more diverse than those of the recent past. The few remaining layer breeding companies are increasing their range of products rather than decreasing them. As the remaining breeders have access to a much larger market share, they have more income and their spending in the research is far greater today than it has ever been.

2.3 Selection criteria

Indigenous populations

The village chicken is invariably a coloured bird. The colour can be brown, yellow, black or a mixture of these. According to farmers, multiple colours serve as camouflage against aerial predators. The village chicken is very alert and has long shanks with which to run away from predators. If necessary, they even fight with predators to safeguard their chicks. Hens can incubate their eggs and brood their chicks. This enables them to reproduce without any assistance.

Indigenous chickens appear to have an inherent scavenging and nesting habit. Years of natural selection, under scavenging conditions, has made them robust and resistant to various diseases, especially to those caused by bacteria, and protozoa and other internal and external parasites; they have better survival than the commercial hybrid strains under village production conditions (Minga *et al.*, 2004; Sonaiya *et al.*, 1999). However, the village chicken is a poor egg producer, laying on average 40 to 60 eggs per year in three or four clutches, with an average egg weight around 35–45 grams (Guèye, 1998). They generally have small body size; for various African chicken breeds, mature body weight varies between 1.3 and 1.9 kg for males and between 1.0 and 1.4 kg for females (Musharaf, 1990; Shanawany and Banerjee, 1991). Egyptian breeds seem to be somewhat heavier: around 2 kg for the males and 1.7 kg for the females. Village chickens require very little attention from the farmer, but closer management could improve production.

The challenge with respect to improving the productivity of indigenous chickens is to conserve the above-mentioned attributes, which are appreciated by the villagers. The best way to improve productivity without altering any of the morphological characters is to select for production traits within a given population. In terms of rate of improvement, this is a slow process compared to cross breeding. Iyer (1950) conducted selection in a non-descript flock of Indian deshi fowl and was able to increase the annual egg production from 116 eggs to about 140 eggs per hen through six generations of selection. The average egg weight of the flock also increased from 43 to 49 grams. It would be particularly interesting to identify selection criteria related to adaptation or disease resistance features, which are often reported but not precisely described.

Commercial lines

Laying hens

From the early twentieth century, the selection of egg-type chickens led to tremendous improvements in their productivity. The number of eggs per hen per year improved from 170 eggs in 1925 to as many as 325 eggs in 2006.

The primary objective of breeding programmes is to maximize the return on investment of different stakeholders in the layer business. In order to achieve this, a layer geneticist has to consider the following selection objectives: number of saleable eggs per hen housed per year, efficiency of converting feed into eggs, external and internal egg quality.

Egg production, which determines the overall returns on investment to the layer farmer, is tested in cross-lines and pure-lines, with emphasis on production during the later part of the laying cycle – known as "persistency of lay". Feed efficiency is generally defined in terms of the kilograms of feed required to produce one kilogram of eggs. In the early 1980s, the concept of residual feed consumption – the deviation from calculated demand to satisfy maintenance and production requirements – was introduced in commercial breeding programmes as a fine measure of efficiency.

The most important external egg-quality criteria are shell strength and egg weight. As shell strength decreases with the age of the hen, it is measured as late as possible in the laying cycle, and selection is based on these measurements. For egg weight, the objective is to select towards an intermediate optimum, which helps to maximize the percentage of eggs in the preferred weight range. Shell colour is also receiving attention, especially in brown-egg stocks, in response to consumer preferences for uniform, dark brown eggs. Traditional internal quality criteria are albumen height, and incidence of blood and meat spots (which are to be minimized). With increasing use of eggs for further processing, selection for higher yolk percentage and dry matter, and strength of vitelline membrane has become more important in recent years. However, it is difficult to select for these traits within line as there is very little variation among the hens within a line. The best way to improve them is by replacing or crossing different lines. Fertility and hatchability are traits that are best handled by eliminating the worst individuals for these traits (Gowe *et al.*, 1993).

Broilers

During the last 50 years, there has been tremendous improvement in broiler traits like growth rate, feed efficiency, liveability and yield. Poultry meat production developed from numerous small broiler farms into a well-defined global broiler industry. The world broiler industry can be divided into three broad market segments.

Live broiler market

In most Asian and African countries, broilers are sold on a live-weight basis. In this type of market, a producer buys day-old chicks from a hatchery, grows the broilers and sells them after the required market weight is attained. In this scenario, the broiler producer and the hatchery are two independent entities. Thus, there are two distinct profit centres: 1) the hatchery operator who owns the parent breeder and the hatchery and supplies the day-old broiler chicks to broiler farmers; and 2) the broiler farmer who grows the broilers and sells them to wholesalers and retailers. The broiler farmer's profitability is dependent on: age at

market weight (growth rate); feed conversion ratio; and mortality. The hatchery operator's profitability depends mainly on the number of chicks obtained per breeder housed. Knowing that reproductive traits and broiler traits have negative correlation, geneticists in this segment of the market have to strike a balance between the two.

Live broiler/processed broiler integration

Here the breeders themselves grow and sell the broilers, either live or dressed. There is only one profit centre. Shortfall in any one of the breeder traits, say egg production or fertility, can be compensated by incremental gain in broiler traits, such as feed efficiency or growth rate. In this scenario, in addition to the traits mentioned with respect to live broilers, dressed yield also becomes important if the producer is selling dressed whole chicken or cut ups.

De-boned meat

In North America, western Europe and some other countries, almost 50 percent of broilers are sold as deboned meat. In these countries, the broiler industry is completely vertically integrated; the producers keep breeders, grow broilers either by themselves or through contract, process the broilers, and sell primarily deboned meat or processed chicken products. In this context, meat yield, especially the breast meat yield, becomes profit determinant, as breast meat fetches a premium over leg meat. Low-price cuts are often exported to developing countries – affecting their local industry.

Relative selection pressures applied by geneticists to develop products for the three different market segments are shown in Table 2.

TABLE 2
Relative selection pressure for various traits in different broiler-market scenarios

Selection trait	Relative selection pressure for different markets		
	Live broiler market	Live/dress broiler marker with one profit centre	Deboned meat market with one profit centre
Hatching egg production	+++	++	+
Fertility/ hatchability	++	+	+
Growth rate	+++	+++	++
Feed efficiency	++	+++	+++
Meat yield traits	+	++	+++
Liveability	++	++	++
Leg and skeletal strength	+	+	++
Plant condemnation	-	+	++

Economic performance is not the only criteria used by breeders/broiler producers when deciding which breed/product to buy. For example, mortality during the later part of the growing period, which requires the producer to remove dead birds daily, is disliked even when in economic terms the product could still be relatively profitable. Similarly, producers like to maintain a certain level of egg production in the breeders, even in the deboned yield market, despite the fact that a 1 percent increase in yield could economically balance as many as 20 to 25 eggs.

It should always be remembered that improvement of performance in industrial birds has been contemporary with improvements in management conditions.

3 CURRENT AND FUTURE CHALLENGES

3.1 Increasing demand for poultry products

Poultry consumption in developing countries is projected to grow at 3.4 percent *per annum* to 2030, followed by beef at 2.2 percent and ovine meat at 2.1 percent. In the world as a whole, poultry consumption is projected to grow at 2.5 percent *per annum* to 2030, with other meats growing at 1.7 percent or less (FAO, 2007). The increasing demand for poultry meat and eggs in many parts of the developing world favours the industrialization of production systems. The poultry sector is the most industrialized of all forms of livestock production, and large-scale production is now widespread in many developing countries.

Industrialization and globalization imply stricter requirements for product uniformity and food safety, which limit the range of marketable livestock products and restrict the production conditions under which poultry are kept. This, in turn, favours the use of a narrow range of genetic resources that are highly productive under these conditions. While this process is a threat to the diversity of poultry genetic resources, it has also contributed greatly to increasing the supply of food of animal origin in the face of rapidly growing demand.

Industrial systems, in which environmental stresses are removed by keeping animals in closed systems and intensive use of veterinary inputs, have allowed a greater focus on efficiency, maximizing benefit per animal place, and quality traits (see above), with less focus on adaptation to local environments or disease resistance or tolerance. However, consumers' demands are changing; they are increasingly concerned by health, environmental, ethical and animal welfare issues; new demands for certified products, such as free range or organic meat and eggs, have emerged. These issues also have an important influence on global costs, such as waste management, building costs and environmental taxes.

3.2 Increased threat of disease epidemics

Transboundary zoonotic diseases are serious threats to human health and the poultry economy. Outbreaks provoke concerted control efforts, including large-scale culling programmes, surveillance, vaccination and controls on the movement of animals. The highly pathogenic avian influenza (HPAI) outbreak in 2003/2004 in Thailand resulted in the loss of around 30 million birds (Ministry of Agriculture and Cooperatives, 2005). Approximately 43 million birds were destroyed in Viet Nam in 2003/2004, and 16 million in Indonesia – roughly equivalent to 17 percent and 6 percent of the respective national populations (Rushton *et al.*, 2005).

Non-transboundary (zoonotic or otherwise) diseases also significantly affect the econo-

my of the poultry sector. Salmonellosis, campylobacter, Marek's disease, Newcastle disease and infectious bursal disease are among major diseases of this category. They are more or less kept under control in the commercial sector though disease control strategies which include chemotherapy, vaccination, control of disease vectors and appropriate management methods. However, there are constraints to the sustainability of such strategies. Problems include the evolution of parasite resistance to the treatments applied, such as virus resistance to vaccines (Marek's disease virus) or bacterial resistance to antibiotics. There are also concerns regarding residues in the food chain and the implications for human health of the emergence of antibiotic-resistant micro-organisms. Another issue is the affordability and accessibility of treatments to poorer livestock keepers. Outbreaks of Newcastle disease and infectious bursal disease frequently devastate village chicken flocks, and farmers have had to live with these losses.

For commercial production systems, the major impact of disease epidemics, such as the HPAI outbreak, is market shock and ban on international trade. With respect to backyard poultry production systems, changes to management practices and cultural activities may be introduced. For example, the raising of multiple species like keeping ducks or geese alongside chickens has been prohibited in some Southeast Asian countries; cultural and social events involving the mixing of birds (for example cock fighting or the exhibition of songbirds) may be banned. Such measures could result in a future poultry sector which has fewer backyard producers (FAO, 2007). Small-scale commercial poultry producers (who largely keep imported breeds) also face great difficulties in responding to the threat of HPAI, and their future may also be in doubt.

It is generally difficult to quantify the impact of disease epidemics on poultry genetic diversity – mortality data are rarely broken down by breed. However, it is clear that large numbers of birds can be lost, and that it is often culling rather than the disease itself that accounts for the largest number of deaths and poses the greatest risk for poultry genetic resources. It is only recently that threats to local genetic resources have been given any consideration in the planning of disease control measures. Limited steps to address this issue have been taken in Europe, but the potential for conflict between animal health and breed conservation objectives remains considerable.

3.3 Environmental issues and climate change

There is a double challenge; the first is the effect of the poultry industry on the environment, and the second is the effect of climate change on the poultry sector in general and poultry genetic resources in particular.

The industrialization of poultry production and the rapid genetic progress made in growth rates and reproduction have had both positive and negative influences on the environment. These processes have been accompanied by major positive effects on the use of resources. On the negative side, people living near poultry units may be affected by odour and increased fly populations. There is also the problem of manure disposal. In areas with a high density of livestock production, excess nitrogen and phosphorus often enters local water courses; poultry production contributes to this problem. Ammonia produced by bacteria in the litter is ventilated into the atmosphere, which also adversely affects the environment.

Climate change is likely to have significant impact on the world's environment. Climatic zones could shift towards the poles, and vertically – affecting forests, deserts, rangelands and other ecosystems (FAO, 2007). Climate change has the potential both to gradually affect the distribution and characteristics of production systems, and to increase the frequency of weather-related disasters such as droughts, floods and hurricanes. Hydrometeorological and geophysical disasters became, respectively, 68 percent and 62 percent more frequent over the decade between 1994 and 2003 (IFRCS, 2004). The occurrence of disasters is relatively unpredictable, at least in terms of the intensity of their impact and the specific locations that are affected. Hence, foreseeing their effects on poultry genetic resources presents a difficult challenge.

It is likely that intensively managed livestock systems such as the commercial poultry industry, which depend less on local resources, will more easily adapt to climate change than extensive production systems. The question is at what cost?

The poor and disadvantaged will be the most vulnerable to the negative consequences of climate change. These are the poultry keepers who keep indigenous and local breeds. A breed population whose numbers and range have declined as the result of gradual changes to the production systems in which it is kept is more vulnerable to being wiped out by an acute disaster. Restocking after disasters could also be a threat to poultry genetic diversity if it is not well-planned and carefully implemented.

3.4 Increased competition for feed resources

Domestically and internationally traded concentrate feeds are increasingly important. In 2004, a total of 690 million tonnes of cereals were fed to livestock (34 percent of the global cereal harvest) and another 18 million tonnes of oilseeds (mainly soy). Poultry, along with pigs, are the biggest user of feed cereals.

In developing countries, especially in the densely populated rural areas of Asia, poultry is in direct competition with humans for feed resources. In addition, the growing use of cereals and oilseed to produce ethanol and biodiesel will increase the pressure on the land area used for agriculture – already high as a result of increased population size and urbanization. This will inevitably lead to higher crop prices and subsequently to higher feed costs.

In high cereal producing regions or countries (e.g. Brazil and the United States of America), poultry will continue to be a profitable business. Where the grain:meat/egg price ratio is high, typically in developing countries, feeding grain will be more difficult. This may lead to movement of production to the high cereal producing regions; indeed, the process has already started.

The higher cost of concentrate feed may present an opportunity for local birds, which may be less disadvantaged when fed on locally available feed resources such as crop residues and unconsumed household food. The balance between all inputs and outputs should be the decisive criterion when comparing breeds and/or production systems (i.e. not only output should be considered).

3.5 Erosion of poultry genetic resources

According to FAO (2007), Europe and the Caucasus, and North America are the regions with the highest proportion of their breeds classified as at risk – 49 percent and 79 per-

cent of avian breeds, respectively. These are also the regions where the highest numbers of breed extinctions have been recorded. These regions have the most highly specialized poultry industry. The high proportion of at-risk breeds in these regions may also relate to the greater levels of breed recording that have taken place there. In Africa, for example, population size has not been reported for over two-thirds of breed populations. Besides missing population data, a big weakness of the current monitoring of breed erosion is that it does not capture genetic dilution of local breeds by uncontrolled cross-breeding.

As noted in Section 2.1, various cross-breeding efforts have been undertaken in many developing countries. Often, they were conducted by NGOs with the support of local authorities – an example being the Bangladesh poultry model. In addition, the supply of hybrid males by large private hatcheries to neighbouring smallholders leads to indiscriminate cross-breeding with the imported stock, often without significant gains in production levels. The genetic impact of these formal and informal cross-breeding schemes and practices is unknown. As a consequence, the identification of poultry as indigenous may be merely a matter of convenient labelling, as there has been at least one attempt at cross-breeding in most developing countries.

The loss of poultry genetic resources is also happening in the breeding sector as a consequence of the merger and acquisition of breeding companies (see above). Besides this loss, there has also been planned and unplanned loss of stock kept as a resource population in the public sector (Pisenti *et al.*, 2001). Some of the lost stock was developed over a period of many years; its loss reduces the scope of future research.

4 CURRENT AND FUTURE DEVELOPMENTS FOR POULTRY GENETIC RESOURCES

4.1 Developments based on current technologies

Niche market or alternative systems

Food production is changing from being producer-driven to consumer-driven. Consumer confidence in the livestock industry has broken down in many countries (Lamb, 2001). Fears about the quality and safety of animal products have been heightened in recent years by various crises in developed countries: bovine spongiform encephalopathy, dioxin, and more recently, avian influenza. At the same time, the majority of consumers in developed countries have become less connected to the countryside and know less about farming. In short, there is a growing demand for "natural", "ethical" or "ecological" production, but often without a clear description of what this should encompass.

Welfare issues

Welfare has become an important element of consumers' perception of product quality. Special welfare-driven brands have been established in some European countries, and even fast-food chains in the United States of America are introducing minimum cage-space requirements for the laying hens kept by their egg suppliers. It is expected that similar developments for poultry meat production will follow.

The main welfare issues for laying hens are related to the limited space and the restriction of natural behavioural expression associated with conventional cages. Based on the European Union's Directive on the Welfare of Laying Hens (1999), conventional cages will

be banned in 2012; during the transition period more space has to be given to birds housed in conventional cages. In the future, hens may be housed in so-called enriched or furnished cages, barn systems or aviaries, which may be combined with access to free-range areas. Production costs are likely to increase significantly as a consequence of these changes; this may affect the future of poultry production in Europe as compared to that in other continents.

While changing from conventional to enriched cages should have no consequences for layer breeding, the change to non-cage management systems requires effective control of feather pecking and cannibalism, for both of which there are differences between breeds. Breeders are selecting against these two behavioural problems, which are more difficult to control in floor management (large groups) than in cages (small groups). This will require many generations, while specific management tools such as beak trimming, control of light intensity and balanced nutrition can help in the short term. Issues like nesting behaviour, floor eggs and resistance to a range of infectious diseases will also become more important in floor systems. Conversely, increased space and enriched environment stimulate birds' activity and reduce the problem of weak bones (osteoporosis) which has been identified as a cause of bone breakage in spent hens.

The main welfare issues in broilers are cardio-vascular insufficiency (sudden death syndrome and ascites) and leg disorders. Selection for body weight gain, intensive feeding and some management procedures contribute to these problems. The locomotive activity of commercial broilers is very low compared to slow growing-poultry breeds. The lack of exercise increases the incidence of leg problems and may cause foot lesions, hock burns and dermatitis under unfavourable climatic conditions and in wet litter. Turkeys are more active, but periodically leg problems appear, often associated with digestive upsets to which the turkey is prone. Breeders of broilers and turkeys are selecting against the incidence of leg disorders and malfunction of the cardio-vascular system. Until these causes of mortality and potential suffering are effectively reduced by selection, they can be alleviated to some extent by improved management.

Environmental issues

Genetic improvements and technological advances have had a positive effect on the use of resources. In 1977, 20 kg of feed was required to produce 1 kg of chicken breast meat; now, it takes only 6.5 kg (Mckay, 2005). Similar improvements can be quoted for other meat-type poultry (turkeys and ducks) or laying hens. Genetic improvements in productivity will continue to indirectly improve the use of resources such as feed and energy. Furthermore, there is a need to genetically improve the efficiency of digestion of amino acids and phosphorus. However, in the short term, the greatest potential for reduced nutrient load is offered by improved feed additives such as enzymes and acids.

Developments for hot climates and challenging conditions

Most of the world's leading poultry breeding companies are located in temperate regions (Europe and North America) while their products are marketed all over the world, including tropical, semi-arid or arid areas, where conditions are challenging in terms of climate, husbandry, feeds and feeding practices. Poultry production under such conditions leads to

a general depression in performance, which may not be uniform in all genotypes, revealing significant genotype by environment interactions (termed GxE). A number of authors have reported strain by location or housing-system interactions for traits such as egg production and mortality in layers (Muir, 1985; Besbes, 2004), body weight gain, feed conversion and liveability in broilers (Hartmann, 1990; Cahaner, 1990).

The question for poultry breeders is whether selection should be carried out under favourable environmental conditions that allow maximum expression of the genotype, or should be carried out in the environment where the genotype is actually designated to live. Layer breeders select based on information collected in both environments. Pure-line pedigreed birds in breeding farms are housed in single-bird cages to measure individual egg production and quality traits. Under these controlled conditions, there is no competition between birds, and mortality is very low. However, commercial birds are housed in multiple-bird cages or in large pens. These conditions may be stressful and can result in injuries due to aggression, flightiness and cannibalism, leading to high mortality and depression of egg production. To select birds that cope with these conditions, layer breeders conduct several tests representative of field conditions in different geographical regions. The assumption behind these tests is that the effects of housing type on animal welfare cannot be isolated and studied independently from the effects of nutrition, management, local environmental conditions, etc.

Some poultry-meat breeders have chosen to establish satellite breeding programmes in various locations. This could be viewed as a safety measure against unknown GxE interactions which might affect the programme. In most cases, however, the establishment of satellite programmes seems to be more a commercial choice inspired by logistic considerations and business partnerships than a technical matter (Albers *et al.*, 2002). However, the appropriateness of such a strategy is illustrated by the example of an Indian breeding company which started 27 years ago to select and breed chickens under Indian environmental conditions and for Indian market requirements. Its locally bred broilers and layers have, in general, outperformed those based on imported grandparents in traits of economic importance (Jain, 2004).

To overcome unfavourable effects caused by GxE interactions, breeding companies may advise poultry farmers to install specific devices to control temperature, humidity and air flow. This advice is given to ensure that conditions in the broiler/layer houses are close to the environment in which the birds have been selected. For small-scale poultry farmers in developing regions, this is an expensive proposal and usually impracticable due to the high cost of electricity and frequent power breakdowns. Moreover, the depressed broiler growth or reduced egg production caused by high temperature cannot be completely alleviated by such measures (Cahaner and Leenstra, 1992).

Under hot conditions, fast-growing broilers cannot dissipate all the heat they generate, resulting in lower feed intake, and consequently lower growth and, even, higher mortality. Heat dissipation is hindered by the insulation provided by the feathers. The introduction of genes that reduce feather coverage has been suggested as a means to improve heat dissipation in fast-growing broilers. The "naked-neck" (Na) gene, which is quite common in rural and commercial chicken breeds in hot regions and also in Europe, reduces feather coverage by about 15–20 percent in heterozygous (Na/na) and 30–40 percent in homozygous

(Na/Na) chickens. Compared to their normally feathered counterparts, naked-neck broilers have been shown to have a higher rate of heat dissipation and better thermoregulation in hot conditions; consequently their growth rate is less depressed. A series of studies conducted under artificially hot conditions and in hot climates (Egypt, Israel, Turkey and Viet Nam) have demonstrated the advantage of naked-neck broilers over their normally-feathered counterparts. However, although less affected than normally-feathered broilers, the naked neck chickens also suffer under heat stress. This observation led to the hypothesis that total elimination of feathers might maximize heat-tolerance among fast-growing broilers under hot conditions. Featherless broilers are being produced by an Israeli team. However, despite the apparent advantages exhibited by such birds, they face difficulties in terms of acceptance by the market.

Developments for better poultry health

The physical health of commercial poultry has been improved continuously, along with the ongoing development of modern production systems. All parties involved in poultry production worldwide have contributed to this process, but breeding companies have played a critical role. They have eradicated vertically transmitted poultry diseases such as *Salmonella* spp, *Mycoplasma* spp, avian leucosis and egg drop syndrome, and using the pyramidal multiplication structure of the industries, they have rendered the vast majority of production flocks virtually free from these diseases. This has been achieved mainly by biosecurity measure, as to our knowledge, no breeder has, as yet, a formal programme to directly select for resistance to a specific disease, although some breeders have for a long time been screening for major histocompatibility complex, known as the B locus, in their lines.

Increased production potential in conjunction with improvements in nutrition, health care and general bird management have increased production levels per bird to all time highs. This, in itself, has increased the vulnerability of poultry populations to a number of diseases and defects if any part of the system fails.

Breeding for resistance to a specific disease caused by micro-organisms involves exposure of the birds to disease-causing microbes in controlled conditions. Obviously, this can not be done on a pedigree farm. For this reason, disease challenge is sometimes carried out at an isolated location, using the siblings or progeny of the birds under selection. Selection is based on the relative susceptibility of the families. The identification of genetic markers for resistance to a particular disease will enable more focused selection, which does not require the evaluation of breeding stock through welfare-unfriendly challenge experiments.

Developments in information technologies

Animal breeding requires extensive data collection. The availability of robust portable computers that can be used in harsh environmental conditions (dust, temperature, humidity) has greatly facilitated data collection. The size of computerized files has very much increased with the development of breeding-value estimation using mixed model methodology and animal models. These have been routinely applied in poultry since the early 1990s. However, computer capacity has also greatly progressed, so that very large data files can now be handled relatively easily. Most software for genetic evaluation and inbreeding

calculation are in the public domain, but those designed for the management of small populations are still expensive.

Electronic identification has been available for large animals for several years. In the case of poultry, the cost of an individual device was too high relative to the economic value of individual birds. However, the situation has now changed, with electronic identification having been described for a commercial breeding programme in laying hens (Thurner *et al.*, 2006). In combination with electronic devices such as egg captors and electronic scales, electronic identification makes it possible to measure individual performance (body weight, egg laying) without directly handling the animal. This renders individual measurement in extensive production systems possible, thus contributing to the adaptation of breeding programmes to new environmental conditions.

4.2 Developments based on new biotechnologies

Characterization and study of genetic diversity

The most recent progress in the characterization of poultry resources has been based on the use of molecular markers. The European project AvianDiv (1998–2000) provided the first large-scale study of genetic diversity in domestic chickens using microsatellite markers (Hillel *et al.*, 2003). The project included 5 types of population, the wild ancestor, unselected populations, standardized breeds, commercial lines and inbred lines. The range of heterozygosity varied from 10 percent to 65 percent. Among commercial lines, broilers exhibited the highest level of variation, brown-egg layers showed moderate values (below 50 percent) and white-egg layers showed the lowest values (35 percent). The unselected populations were generally among the most variable, but the standardized breeds exhibited a wide range – from 20 to 65 percent depending on population history and population size. It was clear that molecular tools were available to study the genetic structure of a wide range of populations, to quantify the genetic variability at the genome level, to reconstruct scenarios for population history, and to propose new management programmes. Since 2000, molecular studies of poultry genetic resources have developed across countries and continents, including China (Qu *et al.*, 2004) and Africa (Mwacharo *et al.*, 2007).

A pilot study (Hillel *et al.*, 2007) compared the use of single nucleotide polymorphisms (SNPs) to the use of microsatellite markers as a means to characterize diversity. This study showed the need for a high number of SNPs (in the order of thousands) to study the fine structure of the genome and identify chromosomal segments showing selection signatures. This is because SNPs are biallelic markers, with a low level of information content as compared to microsatellites, which are multi-allelic and informative in most cases.

In addition to the characterization of genome variability, molecular markers allowed individuals to be assigned to a breed with a success rate above 95 percent for most of the breeds studied within the AvianDiv project (Rosenberg *et al.*, 2001). Thus, it could be possible to confirm the breed origin of an animal, provided that a reference data set has been defined for the breed. This shows that breed traceability as well as breed definition for conservation issues may benefit from the use of molecular markers.

It is generally necessary to complement molecular study with population data, using a field survey to describe the main socio-economic features of the population as well as phenotypes. Georeferencing is a quite useful tool for providing an accurate view of the

geographic distribution of local populations. Furthermore, it allows overlay of further biophysical data from the environment (climate, soil, vegetation cover, water availability, type and level of disease challenges) with the morphological or performance data. Collecting these data on local populations would benefit from the use of portable computers and electronic devices, provided that power supply is available.

QTL detection, gene identification and transgenics

Microsatellite markers have been used for quantitative trait locus (QTL) detection in several programmes involving chickens, turkeys, ducks and quails in various parts of the world (Hocking, 2005). These programmes were set up in commercial and experimental lines. The aim was to identify chromosomal regions likely to control performance traits such as growth rate, egg production, behaviour and disease resistance. Such chromosomal regions can, thus, be proposed for an approach focused on functional diversity. This functional approach is all the more useful in that candidate genes are identified within the chromosomal region and their polymorphism can be readily compared across populations. Investigating the polymorphism of a candidate gene across various populations has been quite efficient in identifying causal mutations for morphological traits, such as feather colour, that are controlled by a major gene. This has been illustrated successfully in the case of the silver locus (Gunnarson *et al.*, 2007).

Large-scale studies of gene expression with microarrays have been used to identify candidate genes within QTL regions, as genes differentially expressed between genotypes differing at the QTL are good candidates to explain the QTL effect. This has been illustrated for Marek's disease resistance (Liu *et al.*, 2001). The approach raises a number of questions, regarding the tissue to be sampled and the stage of sampling; furthermore it may require slaughtering animals in order to get the tissue needed for the function to be studied.

The use of transgenesis has been mainly investigated for the production of high-value therapeutic proteins, with the chicken, and particularly the laying hen, being considered as a bioreactor (van de Lavoir, 2006; Lillico *et al.*, 2007).

Cryopreservation and gene banks

Sperm freezing is currently the only cryopreservation technology that can be used routinely in chickens. However, the rate of success, estimated by fertility with thawed semen, still exhibits large variability between individuals. Thus, it is difficult to guarantee that the whole range of genetic variability of a given population will be preserved; only a subset of males may be suitable sources of semen for freezing. In addition, neither the W chromosome nor mitochondrial genes can be preserved using this technology. This may not be a major limitation for population performance, but it will prevent any further study of population history through the female pathway.

To date, a few cryobanks have been set up in Europe and in the United States of America, housing collections of frozen semen for chicken breeds or experimental lines (Blackburn, 2006; Blesbois *et al.*, 2007). A simulation study has shown that a large number of straws (a few hundreds) are necessary to restore a breed that would otherwise have totally disappeared (Blesbois *et al.*, 2007). In Canada, a set of experimental lines were saved in the 1990s by freezing blastodermal cells from early embryos.

5 GAPS, OPPORTUNITIES AND EXPECTATIONS

5.1 Characterization and study of poultry genetic diversity

Poultry genetic diversity and options for its utilization are usually discussed in terms of breeds. "Breeds" are cultural concepts rather than physical entities, and the concept differs from country to country. This makes characterization at the genetic level very difficult. Furthermore, genetic diversity needs to be considered and understood at the species level, between breeds, and within breeds. This should be taken into account when defining indicators for animal genetic diversity.

Data on production systems, phenotypes and molecular markers should be used together in an integrated approach to characterization. A comprehensive description of production environments is needed in order to better understand the comparative adaptive fitness of specific animal genetic resources. In addition, defence mechanisms against pathogens should be a priority, given the significance of the threats posed by epidemics and climate change. Field and on-station phenotypic characterization is therefore needed.

The need to characterize the specific traits of local populations is quite urgent, and genomics may facilitate the search for genetic variants. This could be easier than recording phenotypes for adaptive traits, which are not well defined. A more accurate characterization of these populations will support their development and could lead to monitored cross-breeding strategies – avoiding uncontrolled absorption which might result in the loss of the local resource. The number of populations studied should be increased, particularly in Africa, South America and Asia. However, marker analysis may detect cases in which local populations have already been subject to introgression from imported lines. In such cases, it may be concluded that the local population is no longer "local" or is at least a mixture of genetic resources from different countries.

In the short term, microsatellite markers are likely to remain the first choice for the assessment of genetic diversity and population structure. However, isolated studies that do not share a sufficient number of markers in common with the FAO recommended set will not contribute to a global view of chicken genetic resource diversity. The use of a reference set of markers is, therefore, highly recommended. Such a reference set has been developed for chickens; similar developments should also be considered for other poultry species such as ducks and geese (particularly in Asia), guinea fowl, turkeys, quails or even pigeons. Laboratory procedures need to be standardized in order to merge data sets; the distribution of reference samples is a prerequisite for the calibration of genotyping across laboratories. Within a country, or even a region, it would be advisable to concentrate all typing work in a common reference laboratory.

The characterization of functional diversity will benefit from the progress in gene identification, comparing populations for genes associated with a known phenotype – provided that such genes are not patented. In fact, the issue of property rights becomes more important the longer specific gene effects are studied.

A large-scale functional diversity approach using microarrays can be used in order to search for specific adaptive metabolic traits. An interesting example was provided in salmon, where gene expression patterns appeared to correlate better to environmental conditions than to population history established with microsatellite markers (Giger *et al.*, 2006). Functional genomics also requires specific technology and extensive capacity-building, as

pitfalls and statistical errors may occur even more easily than with the approach based on DNA markers, in which common software are available to estimate the usual parameters of populations genetics.

5.2 Sustainable use and development of poultry genetic resources

The utilization of poultry genetic resources is the best means to ensure that they remain available for future generations. To be sustainable, this utilization must efficiently meet current economic and social objectives without compromising the natural environment and resources. The situation varies greatly between the commercial populations kept in high-input production system and the indigenous populations kept in subsistence-oriented and low–input systems.

For indigenous populations, the challenge is to improve the survival rate, especially of chicks, through simple and applicable biosecurity measures, and to ensure access to markets. Genetic improvement of these populations is a challenging but not impossible task. Guidelines for the design and implementation of improvement programmes need to be developed. But, perhaps the most urgent task is to increase awareness of the values of these populations, especially among policy-makers.

For commercial populations, the balance between animal health and welfare on the one hand, and production efficiency on the other, is very delicate. With high and ever-increasing efficiencies and highly specific product requirements, it will be increasingly difficult to maintain this balance. However, probably the most obvious risks for the poultry industry are related to diseases; viral or bacterial disease agents may spread vertically or horizontally. The concentration of primary breeding, suggests that the risk of new disease variants combined with international distribution could become a major hazard. However, the remaining large companies are investing heavily in new biotechnologies to help them cope with these new challenges.

It is likely that SNPs will be used by breeding companies for selection purpose. Although this technology may be less costly per unit of information provided than the use of microsatellites, it is designed for large-scale studies, and so the total cost is still high. With high-throughput sequencing, it should be possible, within few years, to have a draft genome sequence for one chicken within a few days. Of course, utilizing this technology will require extensive capacity-building in bioinformatics and data analysis, but it may completely change the structure of breeding programmes. Indeed, phenotype recording could become focused on a few crucial steps, in which close association between genome polymorphism and performance is established and remains valid over a few generations within a given population. A reliable association can be achieved only with a very high density of markers all over the genome; thus, whole-genome sequencing will be more efficient than the genotyping of thousands of SNPs. This could be very useful for disease-resistance traits, which require challenge tests and tailored procedures that are not easy to implement in routine breeding programmes. The use of genomics in commercial lines may help to define criteria for improving their adaptation to environments other than the standard intensive and protected production system.

5.3 Conservation of poultry genetic resources

There is a need to establish a comprehensive conservation strategy for poultry genetic resources in the face of global trends and growing uncertainties. Securing poultry genetic resources is best carried out proactively, giving time for the development of effective *in situ* or *ex situ in vivo* conservation schemes wherever possible. Where this is not the case, cryoconservation and gene banks could be an alternative.

Sperm freezing is currently the only technology that can be used routinely to cryoconserve genetic material from chickens. The technology has to be adapted to the biology of the sperm cell in each species of bird; thus sperm freezing is not yet a routine procedure for most species – see the review by Blesbois (2007). However, it is preferable to start implementing conservation measures immediately, utilizing current best practice, rather than delay and leave genetic resources unsecured and at risk.

To be useful, the material stored in gene banks must be described. Thus, characterization and cryopreservation should be connected. Furthermore, a gene bank should be safe from animal diseases. This issue is a major problem for cryobanking local populations. Thus, improvement of health conditions among in situ populations should be a priority for local authorities. This requires capacity-building in developing countries, and recurrent support in developed countries. Moreover, current sperm freezing technology is not easy to implement in the field; this means that current cryobanks include experimental lines and some commercial lines, but very few indigenous populations.

The possibility of setting up a gene bank based on embryonic cells could be appealing, as it requires only the collection of fertile eggs, and the provision of a centralized incubation and cell culture facility. Moreover, saving totipotent cells would allow the restoration of an extinct breed more efficiently than would storing frozen semen. Nonetheless, decisions will depend on the efficiency rate and operating costs of each procedure. As this method produces chimaeric chickens during one stage of the procedure, it should be used only if the donor genome can be distinguished from the recipient genome – which can be done using molecular markers. Currently, there is no routine system of this type set up in any developed country.

Somatic cloning would represent the most convenient and appealing method, as there would be no intermediate stage involving chimaeras. However, considering the difficulty involved in manipulating the avian ovocyte, this approach is not likely to be developed in the short term or even the medium term.

Finally, coordination of gene banks through multilateral or bilateral agreements will be needed. In this context, there is a need to resolve how cryoconserved material can be stored in duplicate (or more) locations, to reduce the risk of catastrophic failure in an individual gene bank; how access and use can be made timely and traceable, with appropriate security to manage pathogens; and how replenishment of gene banks can be achieved after access and use. These aspects are discussed in the relevant FAO guidelines (FAO, 1998).

6 CONCLUDING REMARKS

Economic development and globalization, changing market demands, environmental impacts including climate change, and trends in science and technology are the major drivers of change influencing the management of poultry genetic resources. Globalization

favours intensive production systems and the use of a narrow range of genetic resources. Market demands are changing, mainly in the developed world; this could constitute an opportunity for local poultry populations. Changes to the climate will tend to affect extensive production systems (and hence local poultry populations) more than intensive production systems, as the latter depend less on local resources. Advances in science and technology constitute the driver that will probably have the greatest influence on the future management of poultry genetic resources. The trends in commercial populations will differ from those in indigenous populations.

Selection of commercial lines is likely to benefit from the use of new genomic tools, which could be particularly profitable for disease resistance. Gene identification is likely to make impressive progress in the near future, meaning that functional diversity will be much more fully studied. Transfer of knowledge from one animal population to another will be easier for known genes than for QTL.

However, new technologies are costly, and substantial investments are needed. The breeding sector has already undergone strong concentration; thus, a few big companies will compete in the use of genomics. The quality of the phenotypes to be correlated with genomic information will determine future success. Considering the diversification of markets and production conditions, breeders may be interested in robust animals, which can maintain a good level of production across a range of environments. If breeding companies succeed in providing such genotypes, able to produce much better than local populations in harsh environments, then indigenous genetic resources are likely to disappear rapidly, or in the best-case scenario local commercial chickens would drive the local indigenous ones out of the market.

Yet, it should be recalled that local chickens not only provide meat, but are also maintained for their cultural values. Their survival will depend on future changes in rural societies; this raises the global issue of how development will be managed in countries where village chickens are still numerous. Moreover, developing countries may consider that they should not depend on a few international companies for the supply of chicken meat and eggs. If these countries invest in new technologies to better characterize their local populations and to design tailored breeding programmes, then chicken diversity may be maintained, in line with the diversity of climatic conditions and social uses of chickens. Genomic tools will benefit the management of genetic resources, provided that the information obtained through research is made available worldwide. Thus, capacity-building and access to knowledge are major issues that will determine the impact of genomics on the future of chicken breeding.

In the field of conservation biology, prospects are unfortunately not so promising. Techniques have not evolved as far as those in the field of genomics. This may well become the limiting factor in global strategies. Both fundamental research and technological research are needed here. Storing cells or gametes in a gene bank should always include two steps: complete documentation of the sample (genetic origin, performance, specific features) and a sanitary check to avoid storing material that will be impossible to use in the future because of sanitary restrictions.

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Perspectives on the global markets for poultry products

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SUMMARY

In the long term, poultry consumption is expected to grow at 2 to 3 percent per year. Highly pathogenic avian influenza (HPAI) H5N1 will remain a threat to animal health, poultry supply chains and poultry. The major exporters are strengthening HPAI prevention, control and response, while zoning (regionalization) and compartmentalization protocols are being used to minimize risks. Production will expand in developing and low-cost producing regions, and stagnate in higher-cost developed regions, while short-term trade interruptions will increase largely due to sanitary concerns. Brazil will continue to strengthen its position in world meat and poultry trade, and Thailand will continue to grow as an important source of cooked products; opportunities will increase for new countries to emerge as exporters in the long term. The industry has to look at issues like global warming and use of feed stocks.

Key words: poultry, global, future, warming

1 INTRODUCTION – MARKETS

A wide array of "markets" for poultry products exists across the globe. These range from local exchanges in traditional agrarian societies to international trading relationships geared to balance global supply and demand. Thus, "perspectives" on the world's poultry markets are greatly influenced by the development status of a society, its extent of urbanization and its openness to trade. Different perspectives should not be viewed as competing visions of how poultry production and marketing systems should operate. Rather, these various food systems are the result of divergent evolutionary paths. Each system developed to meet the needs of different societies – all attempt to optimize production based on available resources, cultural norms and market demand.

2 PROJECTED MEAT DEMAND AND LOCATION

Global demand for dietary animal protein is rapidly increasing, largely due to increased prosperity and urban population growth in developing and transition economies. Because of favourable nutrient conversion efficiency relative to beef and pork, global poultry production is projected to double by the year 2030 to meet this demand. The vast majority of the global demand for poultry products will be in the form of chicken meat. Production to meet the regional demand for duck and goose will remain centred in Asia.

Using global meat demand during the years 1997–1999 as a base, it is estimated that by 2030, demand will increase by 45 percent, 57 percent and 106 percent for bovine, pork

TABLE 1
Distribution of poultry production

Species	Location
Chicken	Global
Turkey	92% North America and Europe
Duck	83% Asia
Goose	93% Asia

and poultry meat, respectively. The present distribution of poultry production is presented in Table 1.

3 GLOBAL TRADE IN CHICKEN PRODUCTS

While produced across the globe, 13 percent of chicken products consumed globally are currently traded across national boundaries. The United States of America and Brazil, combined, represent 76 percent of global exports in 2005, and they are expected to be the future big exporters. This trade in chicken products is expected to increase due to the higher demand in developing economies, many of which lack adequate resources and conditions needed for cost-effective poultry production. Additionally, the relatively high production costs in many developed nations will provide market opportunities for more competitive poultry-production regions. As tariffs decline, countries with abundant grain production, such as Brazil, are positioned to expand production further, as they offer a favourable value proposition to global customers.

4 MARKET COMPETITIVENESS AND DRIVERS

While trade disruptions due to animal health concerns are a prominent feature of the meat-trading landscape of today, countries and their animal industries are adapting to the new reality of emerging diseases by adopting various risk-mitigation strategies recognized by the World Organisation for Animal Health (OIE). Tools such as zoning and compartmentalization will minimize supply-chain disruptions when appropriately applied within a country and recognized by its trading partners. Other strategies recognized by the OIE, such as pre-cooking poultry products, will be employed to prevent trade disruptions, as evidenced by the re-emergence of Thailand's poultry-meat export industry despite being situated in a region of the world with endemic H5N1 avian influenza. Overall, the traditional and emerging factors that will drive competition can be summarized as in Table 2.

5 NOT SUPPLY CHAINS, BUT FOOD SYSTEMS

There is much talk about the supply chain, but it would be more correct to talk about food systems – in plural form. There will be not one but many models of production around the world. "Feel-good" food will not go away, and large-scale (sectors 1 and 2) production will shift closer to "feel-good" production to fill niche markets. This can already be seen in the United Kingdom, with branded birds that are raised at lower stocking densities and

TABLE 2
Market competitiveness – drivers

Traditional	Emerging
Feed quality and cost	Regulatory competency
Housing and capital cost	Capacity and capability of animal health services
Domestic market profile	Trust with trading partners
Climate	Freshwater availability
Growers' margin	Environmental footprint
Talent and cost of labour	Citizenship issues
Co-product values	
Exchange rates	

take longer to grow to market size. This is the "happy hens" concept. It is predicted that commercial production will look more at these types of production methods because niche markets are growing. It would be desirable to have "principle-based" production systems. Big industry has a responsibility to do things right in terms of environmental impact, animal health, good biosafety practices and disease surveillance. Over the long term it is predicted that there will be more sector 1 and sector 4 production and fewer sector 2 and 3 production systems.

6 CONCLUSION

The industry needs to start looking at issues such as global warming and use of feed stocks. Cargill raised the issue of the use of feed stocks over two years ago and argued for caution.

Global feed issues affecting the Asian poultry industry

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SUMMARY

The global poultry industries have traditionally faced competition for feed ingredients from other animal industries such as pork and aquaculture. To this should be added the prospect of future competition from ethanol production. This situation gives rise to a need to search for alternative feed ingredients. In this paper it is argued that the use of by-products, and in particular the use of fibre, as an energy source in poultry diets will be an important means to meet future feed requirements. Technologies such as solid state fermentation complex enzyme systems hold the key to closing the feed-availability gap and providing the additional feed ingredients much needed by the poultry industry.

Key words: poultry, feed, competition, future, technologies

1 INTRODUCTION

Will ethanol displace gasoline or simply take food off our plates and feed from our animals? That was the question posed by Dr Lyons (Alltech President) to delegates at a recent feed industry symposium. To all involved in the poultry industry, this question has great significance and should perhaps sound a few alarm bells. Competition for feed ingredients will become even more pressing given the already increasing pressures that poultry industries globally are encountering from other animal industries such as pork and aquaculture, which in many cases are vying for the very same feed ingredients. In this paper we look at meat consumption, its growth trends, and the feed required to sustain this growth. In particular, we examine the competition for feed grains between the poultry and pork industries and their respective feed-ingredient requirements. We briefly look at the impact of the "ethanol for fuel movement" on maize production and availability. Finally, we look at ways to alleviate the present and future pressures on poultry feed grains and ingredient availability.

2 MEAT PRODUCTION AND CONSUMPTION

The relationship between affluence and meat consumption is well established, showing a clear increase in meat consumption with increased per capita income. As a consequence, today's feed production has tended to be concentrated in Europe and North America. For example, the Netherlands produces approximately 0.81 million tons of feed per million people, while China and India produce approximately 0.07 and 0.01 million tons of feed per million people, respectively. Asia accounts for a larger portion of the global population than any other region; China and India together account for over 2 billion people. Given this large population, there is a significant imbalance in feed production in Asia. In tomor-

row's world, we will be confronted by significant increases in per capita consumption by an ever increasing global population. This situation is hugely magnified in the Asia–Pacific region, with annual meat consumption in China alone predicted to increase from about 50 kg per capita today to approximately 70 kg per capita by 2030.

It is sobering to look at this increase in meat consumption in light of the animal feed needed to deliver the required increase in production. Currently, approximately 720 million tons of feed produced globally. It is estimated that the feed required to produce 20 kg of extra meat for China's 1.5 billion people in 2030 will represent an extra 320 million tons of feed, and that this will bring global feed production to 1 300 million tons (Lyons, 2007). As a whole, Asia in 2015 will represent more than 60 percent of the global population, more than 70 percent of global pork consumption, and more than 35 percent of global chicken consumption, requiring approximately 391 million tons of pig and poultry feed. Even if the largest producers of grains such as Brazil, Argentina, the United States of America and Ukraine could double grain production, there would still be insufficient feed available to deliver the extra 20 kg of meat to China, let alone to meet the needs of Asia as a whole. The question is then: where will this extra feed come from? And, more importantly: where will the raw materials for these feeds come from?

3 ETHANOL PRODUCTION

The push towards biofuels is partly explained by a desire to be energy independent – to reduce dependency on the 140 billion gallons of gasoline consumed annually in the United States of America alone. It is also driven by the Kyoto Protocol, which mandates greenhouse gas reduction. In the United States of America, a target of 7.5 billion gallons of ethanol by 2012 has already meant that there are 111 dry mill ethanol plants in operation, with a further 80 or more being built, which will consume 60 million tons of grain and produce 20 million tons of distillers dried grains with solubles (DDGS) annually (Lyons, 2007). Increasing this target five-fold means 400 more ethanol plants. The "ethanol for fuel movement" has led to the single largest construction and investment programme ever in United States agriculture, with over US$ 70 billion invested in 2006 alone. Iowa: the heart of the country's "Corn Belt" has dozens of distilleries, with many more under construction. Ultimately, this will mean that globally about 3 million more tons of DDGS will be produced than soy (116 million tons DDGS vs. 113 million tons of soy). Where is all this grain going to come from? There are 2 000 million tons of grain scattered around the world, a quantity which while large, is very finite (Lyons, 2007).

Can we increase maize production? The answer is yes, but at a cost. In fact, in 2007 there will be a shift away from soy acreage planted towards maize (some 3–4 million acres of soy) thus driving up the price of soy. In Asia, not only will we be confronted by ever increasing grain prices, but very soon we will have major problems sourcing the grain needed to sustain increased meat production and meet the growing demands of Asian consumers.

4 GLOBAL CHALLENGES TO POULTRY FEED PRODUCTION TODAY

As previously stated, Asia in 2015 will represent more than 60 percent of the global population, more than 70 percent of global pork consumption, and more than 35 percent of

global chicken consumption, requiring approximately 391 million tons of pig and poultry feed. If current trends continue, pork will be the most consumed animal protein, globally, and most certainly in Asia. What does this mean for poultry production and from where will the poultry industry in Asia get its "share" of feed grains and ingredients?

The Asian poultry industry will have to look to history for the feed solutions of the future. For tomorrow's feed solutions lie in by-product utilization. The use of vegetable by-products (from rice and wheat), oilseed meals (soy, rapeseed, coconut, palm), starch/distilling by-products (DDGS, cassava residue, sweet potato, wheat/sorghum) and other novel plant materials and by-products will become paramount in ensuring that the poultry industry has adequate feed ingredients to meet increased demand.

5 POULTRY SOLUTIONS FOR THE FUTURE

A typical poultry diet, contains approximately 70 percent cereal grains and 25 percent soybean meal, and has a digestibility of only 75 percent. This means that, in effect, 25 percent of the feed is being wasted. Can we use soy as an energy source rather than just as a protein source? Do we think of soy as a protein source, but overlook the fact that it also contains 35 percent carbohydrates – including various fibres and non-starch carbohydrates? We sometimes fail to consider these facts, and in many cases take for granted the amount of fibre we waste in both poultry and pork production. With world cereal production (soy and grain) at some 2.5 billion tons, nearly 800 million tons are wasted. When copra meal, palm kernel meal, and the myriad of fibrous by-products are added to the equation, we realize that with limited grains, animals in the future will have to use fibre in their diet. In a recent review, Lyons (2007) noted that some 4 000 years ago, the Chinese faced similar problems to those we face today – limited protein and poor digestibility of raw materials. They developed what is called the "koji" process – or solid state fermentation (SSF) – in which the organism does the digesting for us.

The role of SSF enzymes as a means to utilize the fibre component in poultry diets has been gathering significant momentum, and much has been done to demonstrate the efficacy of such technologies. Rutz *et al.*, (2007) report that a natural SSF enzyme complex is extremely effective in releasing energy and reducing gut viscosity, both of which are important considerations when utilizing by-products such as wheat bran in animal diets while maintaining performance. The future, however, will see next-generation SSF products that will be tailored to the by-product used. Different micro-organisms and strains will be screened and selected for maximum fibre utilization for particular by-products.

6 CONCLUSION

Feed is the major (65–70 percent) cost in pig and poultry production, so it is essential to minimize feed costs. The search for alternatives to maize and soybean as sources of feed ingredients, and hence of a means to reduce feed costs, is not a new matter for nutritionists. However, the situation has recently been significantly aggravated by the fact that much of the maize formerly used in animal diets will be diverted to ethanol production. In addition, in Asia we see a significant increase in poultry consumption; this will mean that we face a large gap in the availability of feed grains to sustain poultry meat production. The use of by-products, and in particular the use of fibre as an energy source, in poultry

diets will be the key to meeting the increased need for feed ingredients. Technologies such as solid state fermentation complex enzyme systems hold the key to closing the feed-availability gap and providing the much needed "extra" feed ingredients to take the Asian poultry industry to 2015 and beyond.

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Feed availability inducing structural change in the poultry sector

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SUMMARY

Feed is the most important input for poultry production in terms of production costs. Poultry have high requirements for protein and energy density to ensure their performance. Feed costs for intensive boiler or layer production amount to about 70 percent of total production costs. The availability of high-quality, low-cost feed is a crucial prerequisite for poultry production. Therefore, structural changes in feed production and feed market prices have an impact on the poultry sector in structural terms. This paper presents a retrospective description of developments in feed and poultry production. The impact of developments in feed production and availability on the structure of the poultry sector is assessed. The developments considered include technological progress, subsidies and competing demand for feedstock as an input for biofuel[1] production. Current trends in the feed sector are assessed, and a hypothesis about their impact on structural changes in the poultry sector is proposed.

Key words: poultry, feed, structure, change

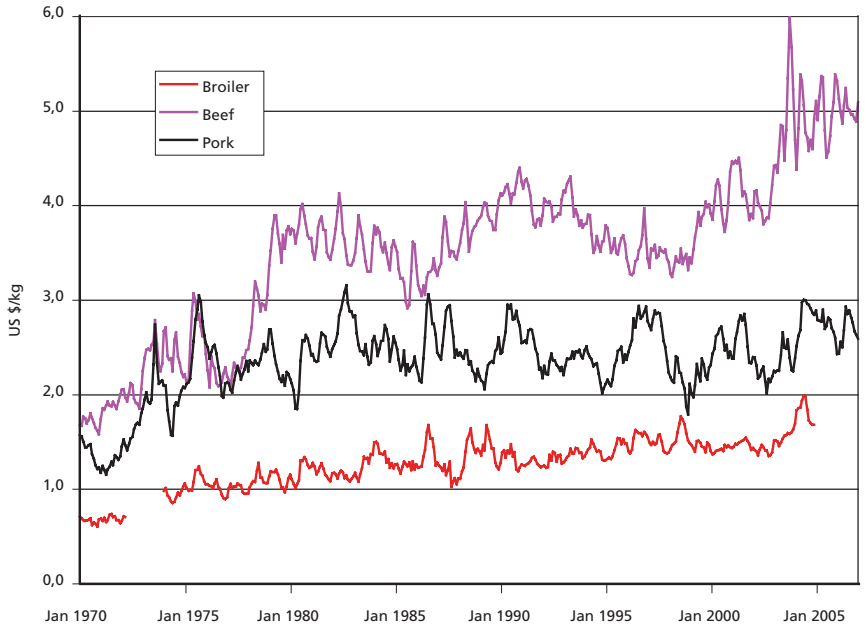
1 INTRODUCTION

The availability of relatively low-priced, high-quality feed is a crucial prerequisite for competitive poultry production. The high productivity potential of poultry, resulting from its efficient feed conversion compared to other livestock, can only be achieved with protein and energy-dense feed (Chadd, in FAO, 2008a). These high feed-quality requirements result from the relatively small monogastric stomachs of poultry. Low-intensity poultry production systems making use of low-quality left-over feed are characterized by relatively marginal meat growth rates and low egg yields.

Subsidized crop production created surpluses in Europe and North America and made feed available at relatively low costs. Before these surpluses became available, low-intensity poultry production systems prevailed not only in developing but also in developed countries. There have been several waves of poultry sector development and intensification of production systems. Together with changes in the demand for livestock products, these

[1] Biofuel is usually defined as any fuel from organic (non-fossil) material. Within the context of this paper biofuel is used for liquid fuels derived from feedstocks.

FIGURE 1
Broiler, pork and beef wholesale prices in the United States of America



Source: USDA.

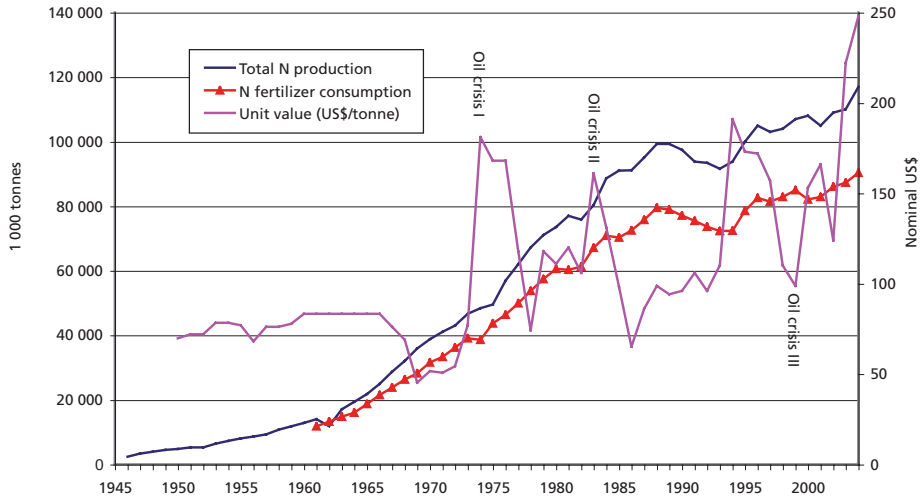
developments can be seen as a result of changes in the feed market.

Poultry meat has a comparative production-cost advantage over pork and beef because of its more efficient use of feed. As can be seen from Figure 1, the wholesale price of broiler meat in the United States of America has been below beef and pork prices.

2 FEED SURPLUSES INDUCING A FIRST WAVE OF POULTRY-SECTOR GROWTH

After the Second World War, nitrogen fertilizer became increasingly available (Figure 2). Existing production capacities were used for the Haber-Bosch ammonia synthesis process (Smil, 2004). The subsequent increased use of nitrogen fertilizer, together with other technical progress in crop production such as breeding and mechanization, resulted in significantly higher crop yields. Crop surpluses made feed for poultry production increasingly available. A first wave of intensified poultry production using high-quality feed inputs occurred in the United States of America in the 1950s and in Europe in the 1960s. Industrialized poultry production supplied the increasing demand for animal-based protein which was arising from growing incomes. Feed surpluses were a prerequisite for poultry-sector intensification and contributed to the industrialization of the sector.

FIGURE 2
World nitrogen production



Sources: U.S. Geological Survey; fertilizer consumption from IFA Databank.

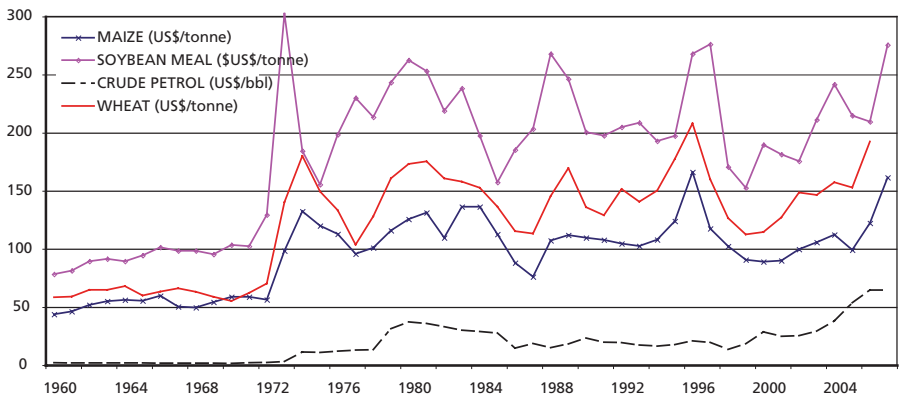
3 SUSTAINED SECTOR GROWTH FUELLED BY CROP PRODUCTION SUBSIDIES

Subsequent to the first wave of poultry-sector intensification, the demand for animal-based protein increased simultaneously with income growth in developed countries. Additional demand for meat resulted from rising incomes in developing countries, especially in emerging economies in Asia. The increased demand for meat was met through sustained growth and intensification of beef, pork and broiler production. Developing countries were applying the same intensified poultry production systems. These trends led to an accelerated demand for high-quality feed. Between 1975 and 1985 the global quantity of manufactured feed increased by 52 percent to 440 million tonnes (Feed International, 2002). During this period, several shocks and an increased nominal price level occurred for major feed commodities (see Figure 3).

A variety of substantial subsidies for crop production were paid, including for the major feed commodities. Subsidies for various agricultural products are paid in developed countries. OECD Producer Subsidy Equivalent (PSE) is an internationally recognized unit of measurement. It represents the monetary equivalent of the gross transfers to agricultural producers, measured at farm-gate prices. The PSE is the only available and internationally comparable indicator of support levels in agriculture in OECD countries. In Figure 4 the commodity PSE is presented as a percentage share of farm-gate prices.

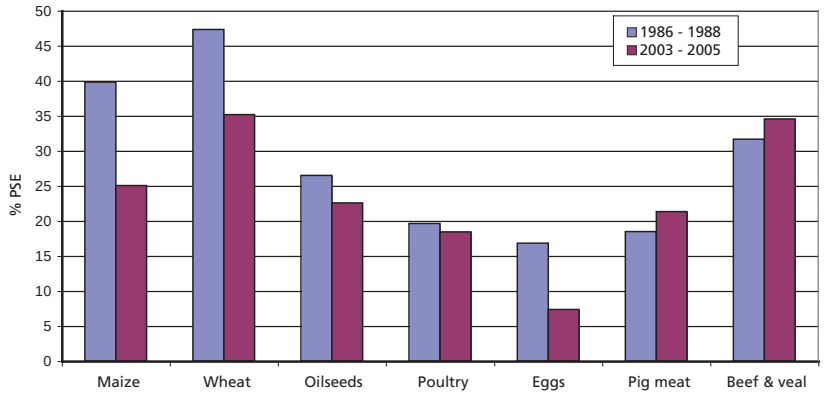
During the time period 1986-1988 the PSE for the production of maize and wheat, respectively, averaged at 40 percent and 47 percent of the farm-gate price. Compared to the level of direct support for poultry meat, eggs or pig meat, the support level for these main feed commodities was substantially higher. It is also worth noting, that all PSE levels

FIGURE 3
World market prices for maize, wheat, soybean meal and crude petrol



Note: bbl = barrel.
Source: World Bank (2007).

FIGURE 4
Subsidy levels for OECD countries for different agricultural commodities

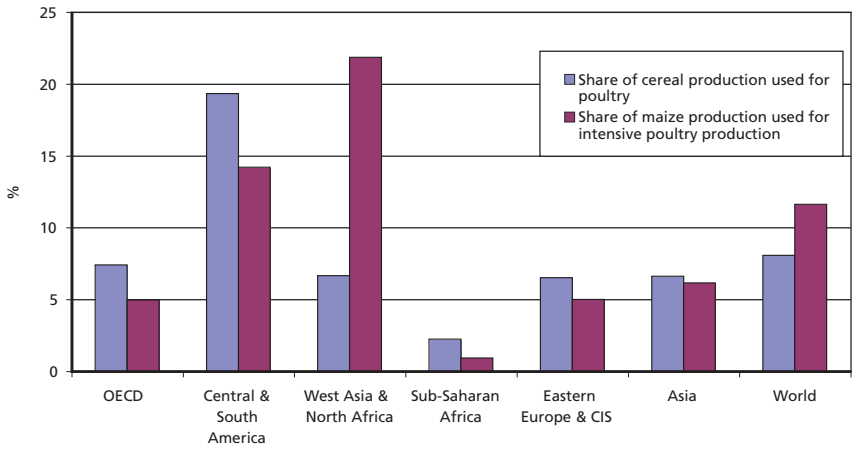


Sources: OECD (2007).

presented in Figure 4 are lower for the time period 2003-2005, with the exception of pig meat and beef and veal, which showed increased PSE levels. The high support levels for feed commodities and their subsequent use in livestock production imply a substantial indirect support.

Subsidies for crop production meant that feed continued to be available at relatively low costs in the world market; this fostered another wave of poultry-sector growth in both developed and developing countries. For example, exports of maize and soybeans from the United States of America, a major contributor to international trade in these products, are

FIGURE 5
Share of cereal production used for poultry



Sources: Gerber *et al.* (in FAO, 2008b) and FAO (2002).

estimated to have been 19 percent and 12 percent, respectively, below production costs during the period from 1997 to 2003 (IATP, 2005). In the United States of America, about 55–65 percent of maize and 45–50 percent of soybeans are used for domestic livestock production, which also results in substantial support for the sector (Wise, 2005).

The availability of low-cost feed commodities also enabled poultry-sector growth in feed-importing countries. Imports of low-cost feed stocks, together with a protection policy for poultry products, facilitated accelerated growth of the domestic poultry sector. Based on poultry production output data for boiler meat and eggs, it can be estimated that a total of 294 million tonnes of feed and 190 million tonnes of cereal were utilized for poultry production in 2004 (Gerber et al., in FAO, 2008b). About 8 percent of world cereal production is used for poultry production, but the proportion varies substantially between regions (see Figure 5). For intensive poultry production systems, the share of maize used is also shown in Figure 5. In Central and South America, the share of cereal production utilized for poultry production is relatively high. In West Asia and North Africa, large amounts of cereals are imported. During the period 2001-2003 about 8.4 million tonnes of maize were imported, while at the same time only 1.7 million tonnes of maize were exported (Steinfeld et al., in FAO, 2006, p. 367). More than 20 percent of the regional production of maize is used for intensive poultry production. Poultry production in this region is benefiting from low-cost maize imports.

4 TRENDS IN FEED PRICES AND THE IMPACT OF BIOFUEL PRODUCTION

Several factors are causing a rise in feed prices. The demand for livestock products, and therefore feed commodities, is likely to increase as a result of rising incomes in emerging countries. At the same time, direct subsidies for crop production continue to decrease, and additional demand for cereals is resulting from the fast growing biofuel production sector.

In 2006, about 45.6 billion litres of bioethanol and 7.6 million litres of biodiesel were produced (FAPRI, 2007). Brazil and the United States of America are the main producing countries for bioethanol, with a share of 80 percent of total production; conversely, the European Union (EU) is producing 81 percent of total biodiesel. The most common inputs for biofuel production are maize, sugarcane, oilseeds and cassava. The 2006 annual production of biofuel in Brazil required 206 million tonnes of sugar cane, while 55 million tonnes of maize were used in the United States of America. In the EU, about 8 million tonnes of oilseeds were used for the production of biodiesel in 2006 (OECD/FAO, 2007).

The use of feed commodities for biofuel production is likely to increase within the next decade due to the expected high oil prices, sustained policy support, and sunk investment costs in biofuel production capacity. A second generation of biofuel production techniques, utilizing non-feed cellulosic inputs is not likely to be competitive during this time horizon (Naylor et al., 2007). FAPRI (2007) projected a 94 percent increase in bioethanol production by 2016. This would require 264 million tonnes of maize, assuming it is the only feed input used and conversion efficiency stays the same. In view of these trends, the question that has to be addressed is whether increasing demand for feed commodities can be met by expanding production, and at what costs? Increased crop production via increased productivity and expansion of arable land might be feasible; the technical potential for improving crop production is under-utilized (FAO, 2002, p. 40). However, yield improvements and expansion in marginal land will only be achievable with increasing marginal costs of production. Therefore, increased prices for feed commodities can be expected in the future.

Several price shocks can be noted in the nominal price series data presented in Figure 3. Since the end of 2006, prices for feed commodities such as maize, wheat and soybean meal have increased by more than 50 percent. This might indicate a new price level for feed commodities resulting from additional demand for biofuel production.

With rising crude oil prices and policy support for biofuels, investments in biofuel production facilities are becoming increasingly profitable. Given a complete market integration of the feed market into the energy market, the break even point for feed-based biofuel production would become a long-term floor price for feed commodities. The energy market is relatively large compared to the feed market, and would therefore, in the long term, drive feed prices up to a ceiling price at which feed stocks would no longer be competitive.

Complete energy and feed market integration has not yet been reached. Sufficient capacity in terms of biofuel production facilities and an effective distribution system for a flex-fuel fleet would be the necessary conditions for full market integration. Nevertheless, impacts of feed-based biofuel production can already be observed. The Brazilian market for sugar cane, for instance, is already completely integrated, and a strong co-movement of sugar cane and oil prices can be demonstrated (Schmidhuber, 2006).

The impact of the use of maize and cassava for bioethanol production in the United States of America and China is not limited to raising the prices of these commodities. Considerable ripple effects are evident in the shape of increased prices and changes in the planted area of other feed crops (Naylor et al. 2007). In addition, the crude-oil market is relatively volatile. Over the last 25 years, the volatility of crude-oil prices has been more than twice as high as that of maize, wheat or soybean meal prices, based on the coefficient of variation. Price-shock transmissions from the energy market into the feed market can therefore be expected in the future.

In the case of protein-rich feed stocks, price increases resulting from rising demand for biofuels are expected to be limited (Schmidhuber, 2006). Additional protein-rich co-products from the use of feed commodities for biofuel production would be available for livestock. The co-products in question are: dried distiller grains with solubles (DDGS); maize gluten feed and germ meal from wheat and maize used for bioethanol; crushed stover from cassava used for bioethanol; and soybean and rapeseed meal from biodiesel production. To a limited extend, these are valuable protein ingredients for poultry diets (Chadd, in FAO, 2008a).

5 CONCLUSIONS AND OUTLOOK

The rapidly increasing demand for livestock-based protein can only be met on the basis of intensified production systems. Cereal prices and oil prices have become linked, and projections that model the impact of biofuels show significant increases in prices for feed commodities (Schmidhuber, 2006). Energy market shocks will transmit into the feed market and increase market risk for poultry production. Risk-mitigation strategies for capital-intensive poultry production will become increasingly important in order to cope with market shocks. In the competition for the scarce resource feed, poultry has competitive advantages over other livestock as it has the best feed conversion rate. Poultry production cost will rise as a result of higher feed costs, but good feed conversion rates give a comparative advantage over other livestock production systems. In particular, the efficient conversion of feed energy into meat by broilers provides a comparative cost advantage over other livestock sectors (Chadd, in FAO, 2008a). The changes in feed production are favouring and accelerating poultry-sector growth and inducing structural changes towards intensified production systems. Animal diets will become more diversified due to the use of biofuel co-products with valuable protein content.

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Social impacts of structural change in the poultry sector

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SUMMARY

This paper attempts to highlight the social impacts that could be important as the poultry sector changes shape, although there is limited published evidence on which to draw. The paper begins by outlining some of the features of structural change, which are described in more detail in other papers presented at this conference. It then takes three areas of social impact and examines them briefly in relation to structural adjustments: culture change, as exemplified by changes in consumption and marketing of poultry products; livelihoods impacts, under each of the five "capitals" of the livelihoods framework; and gender effects. It concludes by drawing some lessons for policy-makers and development agencies.

Key words: adjustments, change, poultry

1 INTRODUCTION

Papers presented earlier in this conference and the working papers prepared as background indicate that the poultry sector is already changing shape and is likely to continue to do so. Changes in structure of the sector can be expected to have impacts on social factors: the food that people consume, their social networks, the way in which they make their living, and gender dynamics within households and in society.

There is limited published evidence on which to draw, and the data available from recent studies are seldom disaggregated by social criteria; nevertheless there are clear indications of the relationship between the organization of the sector and the lives of people that make a living from it or use its products. The paper begins by revisiting the features of structural change in the poultry sector, something that is described in more detail in other papers presented at this conference. It then briefly examines three areas of social impact: culture change, exemplified by changes in consumption and marketing patterns; livelihoods impacts, under each of the five "capitals" of the livelihoods framework; and gender effects. It concludes by drawing some lessons for policy-makers and development agencies.

2 STRUCTURAL CHANGE

Extrapolating from the pattern in China, India, Brazil, the United States of America and Thailand, structural change implies:

- functional concentration – fewer production units but larger ones, fewer live-bird markets and traders on bicycles, small slaughter points replaced by larger slaughterhouses, and more large retail outlets;

- geographic concentration or relocation of feed production, markets, poultry production and processing facilities; and
- integration of market chains, with control in the hands of large companies which may contract farmers to carry out operations on their own farms, or employ managers and workers in company enterprises.

Any combination of these trends will have an effect on the actors who participate in the poultry sector and on the roles that they play. The number of people making a living in the sector may remain the same, although this depends on the employment structure within a market chain – in a vertically integrated and concentrated chain there are likely to be fewer people involved in primary production and transport, but more employed in processing and retailing. However, unless cooperative models of ownership can be made to operate successfully, there will be a shift from single or family ownership of premises and enterprises towards employment in large companies.

Notwithstanding this trend is the fact that large numbers of people keep small flocks, with those scavenging in the backyard representing a safety net that requires very little investment. Table 1 shows figures for Southeast Asian countries. In Africa smallholder production is estimated to range from 16 percent (Nigeria) to over 90 percent (United Republic of Tanzania).

Small-scale commercial poultry development has been promoted by development agencies and practitioners as a route out of poverty. The model for smallholder poultry development pioneered by the NGO BRAC in Bangladesh and adapted for use in Afghanistan, India, Sri Lanka, Sudan, Uganda, and the United Republic of Tanzania, is one example that has provided many people with a route out of poverty (Dolberg in FAO, 2007a). It divides the production cycle into distinct activities with different people involved in (and specialist in) each. Will this model and others like it be competitive if there is an accelerating trend towards concentration and relocation? What are the implications for people who have invested large proportions of their income in poultry enterprises?

TABLE 1
Ownership of backyard and small commercial poultry flocks: Southeast Asia

	Small commercial	Backyard
Cambodia	< 1% of poultry	99.9% of farms, 90% of poultry
Indonesia	11.80% of poultry	63.4% of poultry
Lao People's Democratic Republic	10% of poultry	90% of poultry
Thailand	10% of production, 98% of producers	
Viet Nam	10–15% of production, few producers	65% of production, possibly 70% of poultry

Source: Adapted from Rushton *et al*. (in FAO, 2005).

3 CULTURE CHANGE

If culture is defined as the attitudes and behaviour of people or "the way we do things", then changes to the shape of the poultry sector both affect and are affected by culture. We will use food-consumption patterns to illustrate the point. On a recent visit to Hunan Province China, it was striking to find two very different cultures of marketing and consumption existing, for the time being, side by side (Figure 1).

A "wet" market had many kinds of eggs on display – from fresh to preserved, accessible to people to pick their own. Live poultry were kept in cages where the buyer could select a duck or chicken, which was promptly killed and defeathered. There was also "warm" meat on sale, nothing chilled or preserved. A large global supermarket chain, which had an outlet in the city not many kilometres away also sold many kinds of eggs, but all packed and sealed in plastic. Figure 1 shows preserved egg yolks, hygienically sealed and easy to prepare, and a rotisserie where the consumer can buy a freshly roasted bird and take it home to heat up and eat. There were also many kinds of chilled, frozen and dried poultry meat.

Economic growth and urbanization in eastern China are both affecting culture: the demand for products from supermarkets grows as more people move to cities and become richer, and women in particular have more money and less time to spend on food preparation. Economic policy is accelerating cultural change as it is easier now than formerly

FIGURE 1
Traditional" and "urbanized" marketing of poultry products, Hunan Province 2007

Traditional: a wet market

Urbanized: a supermarket

for global businesses with very large retail outlets to invest in China. These cultural and economic changes are driving a change in the structure of the sector, as large retail outlets demand reliable supplies of safe products, which are easier to obtain from larger producers. At the same time, there remains a large demand for fresh products from local markets, perhaps from less wealthy or more traditional consumers, perhaps from people who prefer to trust their judgment and buy meat from birds that they have seen alive.

If China follows a similar pattern to that of the industrialized countries, consumption patterns will split between a large demand for cheap and convenient food, and a continuing but much smaller demand for specialized (and expensive) foods including those that are very fresh and from known sources. Large retail outlets already sell such a range of products, and the products on sale vary from province to province to suit local tastes. Some people will choose to use the large outlets and diversify their food consumption – others may be forced to change their consumption habits for economic reasons.

4 LIVELIHOODS

The sustainable livelihoods framework identifies five types of "capital" that are necessary to people. Poultry contribute in some degree to all of them (FAO, 2007b).

4.1 Human capital

Human capital directly builds up the health and capability of people, particularly nutrition and education. Poultry in small flocks contribute directly and indirectly to household nutrition. A survey in rural Turkey found that poultry meat and eggs contributed on average 40 percent (minimum 25 percent, maximum 60 percent) to total protein intake (Geerlings, in FAO, 2006). In Egypt, income losses after outbreaks of highly pathogenic avian influenza (HPAI) forced households to cut down on household expenses and change their diet in favour of cheaper food items (Geerlings *et al.,* 2007). Structural change that leaves very small flocks and small rural markets untouched will allow poultry to continue to contribute to household nutrition.

4.2 Social capital

Poultry contribute to social obligations and religious ceremonies, and in some cases they need to be specialized birds of local breeds. In Egypt and Turkey, for example, it is traditional to provide poultry meat and eggs to visitors, and when these are not available social occasions are fewer. Women who own and sell birds have opportunities to network and may have increased social standing. Income from sales of poultry products provides women with money for their daughters' trousseaus or to buy cell phones. In the United States of America and the United Kingdom, the sale of turkeys for roasting soars at Thanksgiving and Christmas.

Fighting cocks form a specialized, although usually illegal, part of the social fabric. They have a very high value to their owners, some of whom are extremely wealthy, and are associated with gambling and other risky activities.

Traders of poultry and eggs have a social as well as an economic place in society. Small traders on bicycles travelling in a radius of 20 or 30 km from their home base carry information between villages, and this adds to their social standing.

FIGURE 2
"Pheriwallahs": small traders of poultry in West Bengal, India, 2007

PHOTO CREDIT: MAMTA DHAWAN.

Structural change could pose a large threat to the social capital of small-scale urban poultry keepers, such as those in Egypt with very small rooftop flocks, who may lose a source of social capital without being able to find an obvious substitute. Small traders in peri-urban and urban areas may find their supply chains disrupted or relocated beyond their reach.

4.3 Natural capital

Herded duck flocks have a special place in the ecology of paddy rice systems, where they scavenge for crop residues, insects and snails, and deposit manure; their presence has been found to increase the root growth of rice. In Turkey, rural women list insect control as one of the reasons that they like to keep chickens (Geerlings, in FAO, 2006). Mixed enterprises where ducks or geese share the same pond as fish and provide manure for nutrition are also a profitable and ecologically sound part of mixed farms in wetter areas of Asia.

Natural capital may be most affected by structural change if this involves banning extensive duck production – a possibility in Southeast Asia where there are concerns about persistence of HPAI virus in extensive ducks systems in wetland areas.

4.4 Financial capital

In many countries, poultry owned by poor families provide income for their owners. In Egypt, poultry can contribute 44 percent of income, or up to 90 percent at certain times for very poor households (Geerlings *et al.*, 2007). This is an unusually high figure; by contrast, in Viet Nam's "delta" areas in the north and south of the country, very small poultry flocks owned by poor families contribute approximately 5 percent of the income of their owners (ACI, 2006b). Small poultry flocks are a convenient part of the livelihoods portfolio because they need little investment and can be managed from home with family labour.

Small commercial flocks have been an accessible first step out of poverty for many

farmers in Asia and Africa, but are particularly vulnerable to structural change. In India, the Kuroiler value chain (described by Ahuja and Sen in FAO, 2008) appears to be flourishing as an intermediate step in structural change. It is longer and more formal than the value chains usually associated with village flocks, but less concentrated than commercial broiler chains. The Kuroiler is a five-way cross that has the hardiness of a traditional bird but grows larger and faster. Eggs are supplied from the parent company to hatcheries, which produce day-old chicks for sale to "mother units" kept by village entrepreneurs. They raise the birds to two or three weeks old in netted houses, vaccinate them and sell them to pheriwallahs (small traders) or directly to owners of scavenging flocks in the same village.

An evaluation of the impact of the value chain is currently under way; initial impressions suggest that it provides a livelihood to large numbers of people, the level of investment and profit increasing with concentration up the chain. Those owning scavenging flocks have made some changes to their previous practice, as they now have to buy young birds instead of rearing them, but otherwise keep the birds and market them in much the same way as the traditional "desi" breed, which still makes up part of the village flock. Pheriwallahs retain their old modes of transport and range of travel, but spend a large proportion of their time trading in Kuroilers. The mother units are an introduction to the system for those who have more to invest and prefer a village-based enterprise to employment or a business in town.

By contrast, Viet Nam had a dynamic small commercial poultry sector with farmers in villages rearing flocks of up to a few hundred "white feather" birds from day-old chicks supplied by large breeding companies, who also provide feed and advice. During the HPAI outbreaks and subsequent adjustments to the sector in Viet Nam in 2005–2006, these farmers were badly hit and slower to recover than larger enterprises. Some have recovered and are flourishing while others have permanently lost a large part of their market share (ACI, 2006a and b).

Structural change has the potential to reduce financial capital for some while increasing opportunities for others. Entrepreneurial small-scale producers, who are able to upgrade to meet the needs of concentrated market chains, may convert to contract production, borrow money to invest in more biosecure premises or form cooperatives. Some people who have never worked in primary poultry production may find employment in processing or retailing. Producers and market operators who are less agile, more vulnerable, or located in places where regulations are more strictly applied (e.g. within or close to cities) will find their livelihoods reduced and will need to seek alternatives. If structural change is guided by risk assessment and adapted to local needs, rural backyard flocks need hardly be affected.

4.5 Physical capital

Small-scale commercial flocks require investment in physical capital: fences, poultry houses, netting to exclude wild birds, feed storage. Many owners of small commercial flocks borrow money, often at high rates, to make their initial investments. To a certain extent this is a sunk cost, as not all of it can easily be converted to other uses if the owner changes from poultry to another enterprise.

FIGURE 3
Physical capital associated with small commercial poultry flocks in Asia

4.6 Gender

Gender includes dimensions of women's welfare, children's welfare and household dynamics, in all of which poultry play a part. Backyard poultry are mostly owned and managed by women. Small-scale commercial poultry are often owned and sometimes traded by women. In many West African rural communities, children have care of poultry. This is a means by which they make a contribution to the family and also gain experience of taking responsibility and sometimes earning income. Poultry houses are constructed with very small entrance-ways, through which only children can pass, and this reduces the chance of theft by adults.

FIGURE 4
A woman owner of a backyard flock in Egypt

Source: Geerlings *et al.* (2007)

Structural change may bring up problems if it requires family members to change from ownership of a flock to employment in a business outside the home, means that people must own land or have access to capital in order to participate in changes, or requires an enterprise to be moved to a different location.

A small flock kept near the house, whether scavenging or enclosed, is a family-friendly and fairly time-flexible enterprise that allows some members of the family to earn an income from the home and to adjust their schedule around other activities. Employment in other parts of the poultry market chain, while it may be equally profitable, requires adjustment of family roles and timetable. Home-based enterprises in non-poultry activities are easy to find in some places and less available or acceptable in others.

In some countries, women do not have title to land, and this means that restructuring that requires relocation of production premises will exclude them. If they do not have title to assets, they may also be unable to borrow money to invest in larger and more biosecure premises or transport facilities, or to become part of a cooperative scheme.

5 CONCLUSIONS FOR POLICY-MAKERS AND DEVELOPMENT AGENCIES

Structural change in the poultry sector faces us with three separate social challenges: those related to very small flocks/backyard systems; those related to herded ducks; and those related to small commercial operations.

Very small flocks in cities are, perhaps inevitably, under pressure from biosecurity regulations and restructuring proposals. However, this question needs to be revisited; while birds scavenging in city streets are a human and animal health risk, those confined on rooftops need not necessarily be, and they play an important part in the lives of their owners. In rural areas, there are no compelling reasons to put backyard flocks under pressure. In places where very small poultry flocks are restricted, poor women and their families will suffer and people will keep poultry illegally – there is already evidence to demonstrate this from studies in progress. In places where backyard poultry are permitted, culturally appropriate and inexpensive biosecurity measures appropriate to the sometimes small risks posed by these systems need to be developed with local people and promoted on farms and in local markets.

Herded duck keeping is a unique system that fits the ecology and social fabric of wetland areas where paddy rice is grown, and satisfies a large demand for duck meat and eggs. However, areas with double-crop paddy rice and herded ducks coincide with areas that have had high levels of HPAI outbreaks. As the systems cannot be made biosecure by any of the methods used for enclosed birds, there is some doubt as to their long-term future. An interim solution is to vaccinate the birds and use very careful surveillance to detect the occurrence of disease. If such systems are banned, their owners have the choice to:

- enclose them, requiring investment and with possible consequences for rice production; or
- stop keeping them, with a consequent loss of livelihood and the need to change rice pest control and nutrition practices.

Where poultry keeping and sale become more tightly regulated **small-scale commercial operators** face a challenge. What choices do they have? They can:

- upgrade and/or upscale their enterprises;

- find niche markets and produce or market specialized products;
- find different ways to do business (e.g. contract farming, partnerships, cooperatives); or
- find a livelihood away from primary poultry production or trading.

All of the above require some assistance in the form of knowledge transfer or investment support if development is to be equitable.

An overall conclusion is that strategies for developing the poultry sector and adjusting its structure for safer production need to be based on a deep understanding of the sector and framing negotiations for change to take account of social as well as economic realities. This could involve activities such as:

- mapping not only product flows but human behaviour in poultry market chains, to learn about the most effective entry points for change, and about the people who will have least voice and be most at risk;
- anticipating cultural and financial barriers to change;
- giving due warning of changes so that the most vulnerable people have time to adapt; and
- knowing the full value of poultry to owners and traders so that alternative employment can provide comparable benefits.

Social change is part of life and all progress brings about social impacts. Changes to the poultry sector in developing countries will change the social fabric and the livelihoods portfolio of many vulnerable people, and so they need to be carefully considered and backed up by supporting measures where existing coping strategies will not be enough. As poultry are to a great extent private sector business, providing appropriate support will be a challenge for governments and development agencies.

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Sector trends and impacts

SUMMARY OF DISCUSSION

The question of the future prospects for Sector 4 (backyard poultry) production was raised by several speakers. It was noted that small-scale poultry keeping remains widespread among the rural poor and is often particularly significant for women. Its contribution to livelihoods and nutrition at the household level attracts some attention to poultry keeping as a development tool; the importance of mircofinance to such projects was noted. In some parts of the world, the social significance of poultry keeping also favours the continued existence of Sector 4. The potential for consumers to turn away from intensively produced poultry because of safety concerns or for cultural reasons was noted. It was argued that it is possible for more than one type production system to co-exist within a single country, i.e. that the spread of industrialized production does not necessarily mean that small-scale production will disappear. There was also a suggestion that the intensification process may take longer than usually predicted and that a longer time horizon (to 2050 rather than 2030) should be taken into consideration.

It was, however, recognized that there are a number of factors likely to promote a decline of Sector 4. These included: urbanization; government policies that promote intensification; a lack of interest in poultry keeping among the younger generation; and the inability of small-scale producers to meet the demands of new markets that emerge with urbanization and higher incomes (the importance of links to the supply chain for the future of small-scale production was noted). For some speakers the decline of Sector 4 was not to be greatly regretted, because of its inefficiency and its associated human health risks. Other speakers rejected both arguments, referring to the high level of adaptation to the production environment, which makes this sector particularly efficient if family labour and environmental externalities are taken into account. Moreover, the short market chains involved minimize the risk with respect to food safety.

The situation in developed countries such as France, where small-scale poultry keeping almost disappeared but is now re-emerging to supply niche markets, was noted. There was some speculation as to whether a similar pattern would be seen in the future in developing countries, and whether this prospect should in any way be taken into account in the current advice being given to these countries. The preservation of poultry genetic resources was noted as another advantage of sustaining small-scale production.

There was some difference of opinion regarding the future of "feel good" production (free range, etc). On the one hand there was a view that such production is inefficient and will decline, while on the other hand there was a view that niche markets for such products would grow and that commercial production would seek to respond to this demand.

With regard to the location of the industry on a global scale, it was suggested that the share of poultry meat being produced in the developing world will further increase. The domination of the industry by a small number of countries was considered by some speak-

ers to be a worrying trend. Concern was expressed regarding the potential of the highly pathogenic avian influenza situation to inhibit the entrance of small countries into the international market. The significance of regional differences within countries was noted. The rural/urban population ratio and level of income has a strong impact on demand for poultry products.

The growth of environmental concerns was also recognized as a challenge for the poultry industry. It was suggested that the industry's "free ride" with regard to environmental impacts would come to an end, and that welfare issues would also become more prominent, at least in some markets. The need to address the industry's contribution to global warming was recognized.

The future of feed inputs to the poultry industry was another issue that gave rise to some discussion. It was noted that the feed industry in the West would continue to supply the East for some time to come. A greater emphasis on "designer diets" for different types of bird under different conditions was noted as future trend. Efficiency of nitrogen and phosphorus use was suggested as an important area for research. There was some difference of opinion regarding the significance of the biofuel industry as a competitor for feed inputs. However, it was argued that the increase in the price of soy and maize would trigger a search for alternative feed crops. The by-products of ethanol production were described as having some potential as feeds, but it was noted there are still questions about the cost of production. It was argued that in future there will be more discussion about income relative to feed cost, rather than feed efficiency, and that restructuring will be driven by profitability.

In the field of genetics, it was suggested that there is a need to develop quality poultry suitable for production in a wider range of conditions. Specific efficiencies (phosphorus and nitrogen use) were also recognized as a challenge for breeders.

PART 2

Risks and Challenges for Poultry Production

Risks associated with poultry production systems

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SUMMARY

Every poultry farm has its own risk profile for the introduction of pathogens, subsequent development of disease, and spread of pathogens to other farms. This risk profile is determined by a complex interaction between the levels of infection in an area, the measures implemented on the farm to prevent disease, and other factors including the density of farms in the area and linkages with other farms and markets. Farm biosecurity measures reduce, but do not eliminate, the risk of introduction or onward transmission of pathogens; they include factors such as the location of farms, the physical facilities, and the operational procedures implemented. Investments in these measures are subject to the law of diminishing returns. The Food and Agriculture Organization of the United Nations (FAO) has defined four production systems based partly on the biosecurity measures implemented. Distinguishing between farms on the basis of the measures practised is important, as not all intensive poultry production units apply biosecurity measures appropriate to the level of risk of virus incursion. Experiences with highly pathogenic avian influenza viruses of the H5N1 subtype have shown that farms in all production systems have experienced outbreaks, of highly pathogenic avian influenza, and that it is not possible to blame one particular system for the genesis or spread of the disease. Nevertheless, farms that rear ducks outdoors or where poultry are sold through poorly regulated live poultry markets appear to be high-risk enterprises, especially in countries where infection is present. Enhancement of biosecurity measures is generally agreed to be the best way to minimize this risk, but not all farms are in a position to implement stringent biosecurity, especially those that rely on rearing poultry outdoors. Formal risk analysis has rarely been applied to individual farms, but would assist in determining the benefits of existing and proposed on-farm biosecurity measures and in highlighting gaps in our knowledge regarding the levels of hazard for farms.

Key words: poultry, production, systems, risks, H5N1

1 INTRODUCTION

Many different methods are used for rearing poultry. Production systems range from small, village-level scavenging poultry flocks (Kitalyi, in FAO, 1998) from which few poultry enter the formal market system, to integrated intensive operations in which large companies control all aspects of the production and marketing chain upstream and downstream from production units (see, for example, Tyson Foods, 2006). Between lies a range of systems

– from individual farms practising industrial-type production (Sims *et al.*, 2003) to flocks of ducks reared on paddy fields (Gilbert *et al.*, 2006) which are often transported long distances to graze on recently harvested fields.

Each of these systems, and each individual farm or flock, has its own risk profile for the introduction of pathogens, subsequent development of disease, and spread of disease to other farms. This is influenced by a number of factors, including: the density of farms (Marangon *et al.,* 2004), especially for agents in which rate of transmission is density dependent (e.g. airborne spread) (Truscott *et al.,* 2007); and the linkages between different farms through production and market chains, which may lead to disease transmission that is density independent (e.g. spread via fomites) (ibid.).

This review examines the various production systems, discussing the risks they face and the risk they pose with regard to animal diseases, focusing on highly pathogenic avian influenza (HPAI) caused by viruses of the H5N1 subtype. It considers the systems' key weaknesses and strengths in relation to disease prevention and spread, with special emphasis on biosecurity measures employed on farms. It reviews the interaction between the threat of infection and the different production systems, how the former varies over time, and the influence of this and other factors, such as farm density, on the overall risk of disease in different production systems. It also considers how these risks can be assessed and managed.

1.1 Production systems and biosecurity – some background and definitions

In 2004, the Food and Agriculture Organization of the United Nations (FAO) defined four production systems (originally referred to as "sectors", but the term "system" is now preferred) based on the characteristics of the production methods, especially the biosecurity measures implemented, and the extent of involvement of the farm in the formal market chain (FAO, 2004b). The features of this classification system have been reviewed elsewhere (Sims and Narrod, in FAO, 2008) and are summarized in Table 1.

The term "biosecurity" has been used widely in the debate on avian influenza (FAO, 2004a; Thieme, in FAO, 2007a; Otte *et al.,* in FAO, 2007b). In essence, it describes the sum of the measures taken to prevent incursion and spread of disease. In this paper, this term is applied specifically to farms, and refers to the hygiene and management measures taken to minimize the risk of incursion of pathogens onto individual farms (sometimes referred to as "bioexclusion") and to minimize the risk of onward transmission to other farms if infection occurs (often referred to as "biocontainment"). Farm biosecurity practices cover a broad range of measures. These have been divided into three categories (Shane, 1997):

i) conceptual, including the choice of location for farms;
ii) structural, covering the physical facilities, such as netting to protect against entry of wild birds; and
iii) operational, covering the work procedures that farm staff and visitors are expected to follow.

Field experience suggests that breakdowns in biosecurity can occur if attention is not paid to any one of these three elements.

Farm biosecurity, in its broad sense, covers all measures used to prevent disease. There-

TABLE 1
Summary of FAO production systems

Production system	Main characteristics
System 1	Integrated, industrialized enterprise with sophisticated, high-level farm biosecurity measures. Full control over all farm inputs and outputs (e.g. breeding stock, feed mill, slaughterhouse, processing, distribution, animal health services).
System 2	Commercial, intensive poultry production involving largely independent enterprises or contractors, practising moderate to high-level biosecurity. Distribution of poultry to slaughterhouses and/or to live poultry markets.
System 3	Commercial farms with relatively poor biosecurity. Sales are more likely to be through live poultry markets or to traders who on-sell through live bird markets. This system covers ducks and other poultry. Production may be intensive or extensive.
System 4	Village-level, scavenging chickens for local consumption. These small flocks are reared in village households. An occasional bird is sold locally, bartered, used as a gift or, occasionally, sold to a poultry trader for cash[1].

fore, other measures applied to individual poultry, such as vaccination, that reduce the risk of infection following virus incursion into a flock of poultry and the likelihood of onward transmission to other farms can also be regarded as biosecurity measures. However, as these are often treated separately, under the category of disease control and preventive measures (see, for example, FAO, 2004b), and are considered in detail in many other papers, they are not covered in depth here. The focus in this paper is worker behaviour and physical facilities (including farm location), which form the basis of most farm biosecurity plans and activities.

As with other measures used to control and prevent disease in poultry, farm biosecurity measures reduce, but do not eliminate, the risk of infection and disease. As a United Kingdom leaflet (DEFRA, 2006) on poultry-farm biosecurity states:

> *"Biosecurity means taking steps to ensure good hygiene practices are in place so that the risk of a disease occurring or spreading is minimized".*

Despite utilizing sophisticated biosecurity measures, the defences of some well-managed farms are sometimes breached by horizontally transmitted pathogens (East *et al.*, 2006; Otte *et al.*, in FAO, 2007b), including avian influenza viruses. This reaffirms that reliance on biosecurity measures alone will not prevent all cases of infection and disease.

In fact, there is no such thing as a totally biosecure farm – the investment required to achieve this would never make economic sense. Total biosecurity is restricted to high-

[1] Village-level flocks from which poultry or products are sold regularly into markets outside the local district should be classified as system 3 farms.

security laboratories (and even these have, at times, failed to contain viruses).

The likelihood of incursion of a particular pathogen depends on the properties of the agent, including its means of spread and survival in the environment. This means that some agents can be kept out of farms more readily than others. For example, biosecurity measures to prevent campylobacter infections have a high failure rate (see Otte *et al*., in FAO, 2007b), which is probably linked to the agent's biology and its high prevalence in nature. Other agents, especially certain parasites and agents that require close contact between infected animals for transmission, can be readily excluded.

1.2 Biosecurity and farm density

Modelling studies of outbreaks of H5N1 HPAI in Great Britain suggest that infection is likely to be extinguished if infected farms are relatively isolated, but can cause large clusters of disease in areas with high density of poultry flocks (Truscott *et al*., 2007). This matches field observations in earlier cases of HPAI in the United Kingdom, in which the disease was restricted to single farms or small clusters of neighbouring farms (Sims and Narrod, in FAO, 2008), and recent experiences in Italy, Canada and the Netherlands, where there was considerable local spread once virus gained access to a farm in areas with dense populations of poultry farms (Capua *et al*., 2003; Stegeman *et al*., 2004; Power, 2005).

Many of the areas with dense poultry production (so-called densely populated poultry areas) have developed without an overall master plan (Capua *et al*., 2003). Expansion of the poultry industry in specific locations usually occurred as a result of some economic or production advantage (such as easy access to markets, or ready availability of a supply of feed, land, etc), which then attracted other farm operators and increased the concentration of farms. A number of countries are contemplating the establishment of new livestock production zones. If designed and planned properly, these could reduce the likelihood of the spread of disease. However, it is also possible that they could increase risk if they lead to excessively high concentrations of farms (which may also emit excessive air, land and water pollutants if too concentrated and improperly regulated).

2 PRODUCTION SYSTEMS AND RISKS OF H5N1 HPAI

The current panzootic of H5N1 HPAI has focused attention on the risks associated with, and posed by, different poultry production systems. It has provided an opportunity to reflect on their role in the genesis, spread and prevention of HPAI, and has drawn a remarkably broad range of responses regarding the apparent contribution of the different production systems.

For example, many veterinarians and other poultry-industry experts regard enhancement of commercial farm biosecurity measures as the most appropriate response to this panzootic and to avian influenza generally (see, for example, TAES, 1995). Some have called for greater intensification of poultry production, or at least moves to enclosed production (Martin *et al*., in FAO/OIE, 2006), with a few countries even calling for the virtual elimination of "backyard" and free grazing poultry production (see, for example, MARD, 2006, cited by ACI, 2006). Others have proffered alternative, almost diametrically opposed, views suggesting that this disease is largely the result of industrialization of poultry production (see, for example, Grain, 2006; Greger, 2006). This view has also been promoted by

those opposed to so-called "factory farming" on welfare and environmental grounds (see, for example, Beyond Factory Farming, 2006).

In fact, blame for the current H5N1 HPAI panzootic cannot be attributed to any one production system, as farms in all systems have been affected and played some role in the persistence and spread of this disease (Sims and Narrod, in FAO, 2008). All production systems have their strengths and weaknesses, which are described below, although some specific production and marketing methods, notably free range rearing of commercial ducks and sale of poultry through poorly regulated live poultry markets, appear to have played a particularly important role in the genesis of this particular panzootic (Sims *et al*., 2005).

Despite calls by some for elimination of certain production methods, all of the current production systems are expected to persist for the foreseeable future. Even if there is an increase in intensification (as planned in some countries and likely to occur by evolution in others), smallholder and village/backyard flocks will still be present; although, based on experiences in developed countries, the proportion of poultry reared in such systems will likely diminish over time.

These flocks are most likely to persist in poorer countries, especially in places where they help to ensure financial stability for vulnerable groups and increase diversity of sources of income. In some countries, measures taken to control HPAI have already resulted in exclusion of some smaller producers from formal market chains (FAO/MARD, 2007). These households will need assistance to develop appropriate methods to prevent avian influenza and other diseases, and in some cases to retain or restore access to markets. The methods used to do this will probably differ from those used in larger-scale commercial farms, given the marked differences in production methods between the two. Small non-commercial flocks will also persist in rich countries, with some people choosing to rear poultry as a hobby, or to meet particular cultural or social needs and preferences such as rearing of game birds or desire to use freshly laid eggs.

Industrial production will also continue, although production methods will likely continue to evolve over time. Current trends suggest that this type of production will probably grow as long as demand for cheap and affordable poultry and traceability of food products increases. Free-range commercial production will also increase in places where consumers are prepared to pay a premium for poultry or eggs produced using these methods.

2.1 Biosecurity and intensive production

The use of intensive production methods does not mean that farms necessarily implement biosecurity measures appropriate to the level of risk. The outbreak of HPAI in western Canada in 2004 revealed many flaws in biosecurity practices in farms that were infected (Power, 2005). Outbreaks of HPAI in the Lao People's Democratic Republic in 2004 were reported in commercial farms around Vientiane, but not in backyard flocks located away from the city. Several papers and articles (e.g. Grain, 2006) have suggested that this showed that intensive poultry rearing represents a higher risk than the rearing of scavenging poultry. However, such statements did not take into consideration the low level biosecurity measures practised on these commercial farms, which were deemed to be system 3 farms by several independent observers (see, for example, Rushton *et al*., in FAO, 2005a) and the possible occurrence of unreported disease in the village flocks.

Classifying all industrialized poultry farms together, without regard to the biosecurity measures implemented, is unhelpful and provides no indication of the likelihood of disease outbreaks on individual farms. This varies depending on the measures used to reduce the risk of infection on the farm, as well as other factors such as the presence of the agent in the area around the farm, the density of farms in the area and the measures taken to prevent infection by other farms.

For example, the risk of HPAI virus incursion into a farm is likely to be lower in infected areas where well-managed vaccine campaigns are implemented than in places where vaccination is not used. This occurs because vaccination, when applied correctly, reduces the levels of excretion in infected birds, therefore reducing the overall levels of virus in an area, and also increases the resistance of poultry to infection (van der Goot *et al*., 2005; Ellis *et al*., 2006).

2.2 Farm biosecurity and H5N1 HPAI

If a farm becomes infected with an H5N1 HPAI virus, it is an indication of a mismatch between the measures implemented and the risk of incursion. This does not necessarily indicate that the farmer has failed to implement appropriate biosecurity measures, as infection can sometimes occur even with well-designed and properly operated systems. However, in some outbreaks of H5N1 HPAI, specific deficiencies in biosecurity measures were identified (see for example DEFRA, 2007) which, had they been implemented properly, may have prevented viral entry. In others, the reason for the incursion of virus remains unknown.

Unfortunately, few field investigations of H5N1 HPAI in Asia provide sufficient detail on the biosecurity measures practised on infected farms to assess whether disease occurred as a result of poor management or whether the level of infection around the farm was such that it overwhelmed otherwise "reasonable" measures. If gains are to be made in understanding the role of different production systems with respect to this disease, future investigations should include better information on biosecurity measures, similar to that provided in investigations of the February 2007 outbreak in turkeys in the United Kingdom (DEFRA, 2007).

Only one small case-control study on H5N1 HPAI has been published (Kung *et al*., 2007), involving an outbreak in Hong Kong SAR. This study concluded that links to retail markets were a key factor in the outbreak, although the sample size was small and many of the cases were probably the result of local secondary spread due to proximity to infected premises. Biosecurity measures implemented at the time of this outbreak were deficient on all but a few farms (Sims, unpublished).

A study of outbreaks of HPAI in Israel in 2006 provided some general information on the biosecurity measures on infected farms. All had open sheds, but two of the affected farms (breeder farms) otherwise implemented higher-level biosecurity measures than the others. The precise means of introduction of infection to these farms was not determined, although close interactions between personnel and shared vehicles for deliveries may have played a role. The possibility of the introduction of virus by wild birds could not be ruled out (Balicer *et al*., 2007).

Results of case-control studies for other avian influenza viruses are also pertinent. A

study to evaluate risk factors for spread of low pathogenicity H7N2 avian influenza among commercial poultry in the United States of America (McQuiston *et al*., 2005) found that disposal of dead birds off-farm for rendering was a significant risk factor. Wild birds are well established as a source of avian influenza viruses, and a number of farms have been exposed due to inadequate bird-proofing, use of untreated drinking water, or contaminated feed and litter.

Studies in which an attempt was made to compare the number of cases of H5N1 HPAI in different farm types have not conclusively demonstrated relationships between the overall risk of infection with H5N1 viruses and specific farm production systems – due largely to problems of ascertainment bias. One study in Thailand (Tiensin *et al*., 2005) which suggested broiler farms may have been more likely to be infected acknowledged this possibility; when the study was conducted there was considerable under-reporting and non-recognition of infection, especially in subclinically infected ducks.

Recently, reported outbreaks in Viet Nam and Thailand have all been in small flocks reared under conditions of minimal biosecurity (therefore, largely production system 3), but, again, it is not known whether other outbreaks have occurred and gone unreported in farms in other systems.

Virtually all veterinarians working in the poultry industry and international agencies agree that farms practising high-level biosecurity are less likely to be infected than those with poor biosecurity, at least at the beginning of an outbreak in a particular area. Despite the larger number of inputs to industrial-style farms, the concurrent implementation of biosecurity measures can reduce the risk associated with these. There are exceptions to this rule. Minimally biosecure farms in remote locations, away from known sources of infection, are at low risk of being infected, whereas farms that purport to practise high-level biosecurity, but still engage in high-risk practices, such as sale of poultry through poorly controlled live poultry markets, are at a higher risk than would appear if only the farm facilities and management practices were examined. The rule is also less relevant in infected areas with a high density of farms – due to the potential for local transmission of virus over short distances. This can lead to the spread of infection to farms that otherwise implement appropriate biosecurity measures.

The following notes provide information on the biosecurity measures implemented in the different production systems, and factors affecting their vulnerability.

System 1

By definition, system 1 farms practise high-level biosecurity (if they don't they should not be classified as system 1 farms).

System 1 operations are often large multifarm, multibarn enterprises, and as a consequence of their size, have more inputs (and outputs) than smaller farms (Otte *et al*., in FAO, 2007b). In addition, ownership of these farms is largely concentrated in the hands of a few large transnational companies. This allows greater control over inputs, and as these enterprises invest considerable sums in facilities and poultry, it is likely that appropriate biosecurity measures will be implemented to protect this investment.

Many of the companies operating system 1 farms work in multiple countries, and this can result in transborder movement of poultry, poultry products or equipment, which may

involve movement from infected countries to uninfected countries. The outbreak of H5N1 HPAI in a turkey flock in Sussex, United Kingdom, in 2007 (although not strictly a system 1 enterprise based on the biosecurity systems in use) demonstrated the extent of transborder trade in poultry meat through this one large company –and the risks that this can create if strict biosecurity measures are not maintained.

Risks to system 1 farms are offset by the biosecurity procedures in place and the controls these enterprises have over the source of inputs, many of which are derived from suppliers that form part of the integrated company.

System 1 farms have on occasions become infected with HPAI, but it has not always been possible to determine the reason for this. In one case, it is presumed that a combination of a high level of virus in the area around the farm and climatic conditions that facilitated dispersal of contaminated material may have played a role (Sims, unpublished).

In some countries, owners of integrated system 1 farms have strong political connections and it has been suggested (although not proven) that this may have led to collusion between government and industry and covering up of disease outbreaks (Davis, 2006). Regardless of the truth of these allegations, there is a segment of the community that remains suspicious of the motives of these companies and has lost faith in them, fearing that outbreaks in company farms may go unreported.

The only way to overcome this is to have independent, well-resourced veterinary services backed by appropriate legal powers to take action in the event of an outbreak of a disease such as HPAI. This must be coupled with strong open links between the private and public sectors.

Integrated farming operations often choose to locate their operations away from other farms, especially from farms at higher risk of infection. However, if another farmer also chooses to establish similar poultry operations in the same area, the benefits to both from isolation will be diminished. Some system 1 farms have also attempted to improve the biosecurity of system 3 and 4 flocks in the vicinity of their enterprises, to minimize the level of hazard in the area around their poultry houses.

System 2

Biosecurity measures for system 2 farms vary considerably, in line with the broad definition of this system (i.e. farms that practice "medium to high-level" biosecurity). Well-managed farms will have a similar risk profile to system 1 farms, whereas those at the lower end of the classification are likely to represent a greater risk. This is compounded if the farm sells poultry to multiple traders, does not practise all-in all-out management, or has direct links with poorly managed live poultry markets. The location of these farms plays an important role in the risk of infection.

Many supposed system 2 farms have been affected in the current panzootic of H5N1 HPAI. In some cases, breaches in biosecurity measures implemented on these farms contributed to the outbreaks, as was seen in outbreaks in Hong Kong SAR in 2002 where some farms had links to live poultry markets.

System 3

System 3 farms are generally considered to be the most vulnerable to virus incursion, especially large system 3 farms. Not only do these farms employ minimal biosecurity measures, they are also most likely to encounter virus through the marketing chain or potentially via contact with wild birds (e.g. grazing ducks in Asia).

Some of these farmers only rear poultry when they deem that it is likely to be profitable to do so or when they have surplus funds to invest. It appears that they are willing to take the risk that their flock may get infected (or do not have sufficient resources), and therefore invest less in facilities and biosecurity measures. In other cases, they do not own the building in which their poultry are housed and are, therefore, unwilling to invest in structural alterations that would enhance biosecurity (Pagani and Kilany, in FAO, 2007c). In so doing they potentially increase the risk for surrounding farms and those linked to the farm via the same marketing and supply chains.

Wild birds are recognized as a potential source of avian influenza viruses including H5N1 HPAI viruses. If poorly biosecure (system 3) farms are located in places that attract wild birds, the level of hazard is greater than for farms located elsewhere. This was the basis for interventions in Russia, in which poorly biosecure flocks near sites of congregation of wild water fowl were vaccinated after analysis of information from outbreaks in such farms in 2005/2006 (Irza, 2006).

System 3 farms are found in many locations – urban, peri-urban and rural. Some of these have developed from small, system 4 backyard flocks, and occupy the same site and use the same inappropriate facilities as the original flock. Often, these are located near to other poultry. In system 3 farms where poultry are allowed to range freely, the concentration of other poultry and wild birds in the area is an important factor that is likely to determine the risk of exposure.

Many outbreaks have occurred in system 3 farms, including grazing duck flocks, but a lack of denominator data prevents assessment of the relative susceptibility of these compared to farms using other production systems (Morris and Jackson, in FAO, 2005b).

System 4

System 4 farms differ little from system 3 farms except for the scale of the enterprises and the limited commercial sale of poultry in the former, most of which is conducted locally.

Although system 4 farms often implement few formal biosecurity measures, isolated system 4 farms can operate almost as a closed system, with few contacts with the commercial industry. Inputs are derived locally with minimal contact with traders. This means they can remain free from infection despite not implementing specific measures to prevent infection.

This was the case with backyard poultry in Hong Kong SAR in 1997 – very few, if any, of these birds were sold through commercial markets. This has also been described in isolated communities in Viet Nam (Edan *et al*., 2006). In HPAI outbreaks in the Netherlands and Canada very few "backyard" flocks were found to be infected (Halvorson and Hueston, 2006), suggesting that links between farms may be more important than proximity (unless airborne spread occurs).

Major risks for system 4 producers include human traffic in villages, wandering poultry and wild birds.

2.3 Combinations of farming systems

The mix of different farm types in a particular area is probably a more important factor than the concentration of farms in determining the overall risk for these farms. If all farms in an area practise high-level biosecurity, the risk of infection is reduced. However, if one or more farms in the area persist with high-risk practices, then the risk to all farms in the area is increased.

3 WHY DO FARMERS IMPLEMENT BIOSECURITY MEASURES?

For most large farms, commercial interest dictates that the farm owners implement biosecurity measures to reduce the risk of disease, especially if they believe that their flock is in danger of being infected and that the cost of outbreaks will outweigh the investment in biosecurity measures. To make informed decisions, farmers must understand the risks posed by their farming practices, the type of measures to implement, and the likely effectiveness of the biosecurity measures they implement. These are difficult to quantify, even for those with considerable animal health expertise.

Ultimately, the amount spent on biosecurity measures by individual farmers is an economic decision similar to other decisions relating to purchase of insurance. As with other similar decisions, it is subject to the law of diminishing returns. In addition, some farmers will choose to accept the risk of a disease outbreak and continue to engage in high-risk practices that provide few impediments to the incursion and subsequent onward spread of H5N1 HPAI viruses. This can occur if the farm owner does not have the resources to invest or cannot obtain credit, if there is no disincentive or regulation forcing biosecurity measures, or if the farmer perceives the overall risk (or cost of infection) as being low. By choosing not to invest in biosecurity measures, farmers make short-term savings, but these can be easily lost through poorer productivity resulting from the introduction and persistence of other pathogens and diseases. It can also lead to loss of entire flocks if an outbreak of H5N1 HPAI occurs.

In Australia, implementation of biosecurity measures is linked to co-funding agreements between government and industry for support in handling emergency animal diseases. This provides a strong incentive for farms to put in place appropriate measures and is supported by the various producer/poultry industry groups. Recent surveys suggest that this may be having a positive effect on farm management practices, with most commercial farms implementing the required biosecurity measures (East, 2007).

In other places, such as Hong Kong SAR, farm owners are not licensed to keep poultry unless they implement certain biosecurity measures such as bird-proofing. This is coupled with enforcement of these licence conditions.

For village-level producers, the incentives to implement biosecurity measures may differ from those of large producers. These may relate more to public health issues than to concerns about production, especially given that poultry die-offs occur regularly and in many communities are accepted as the norm in low-input systems. This is an area that warrants further research.

4 RISK ANALYSIS – RISK ASSESSMENT AND RISK MANAGEMENT RELATING TO FARMS AND FARM SYSTEMS

Most biosecurity programmes are based on some form of risk analysis, which involves identifying hazards, the pathways for their entry into farms, and the effect of existing measures taken at or outside the farm to reduce (or increase) these risks. However, most of these assessments, when they occur, are informal and probably not even identified as risk analyses by farm managers when developing and implementing farm procedures.

Generic biosecurity plans and guidelines are also available for farmers through government animal health services, universities and poultry industry associations, which are then adapted by farmers to local farm conditions (see for example University of Minnesota[2], University of California[3]).

So far, there has been little use of formal risk analysis on farms, but if this technique were to be applied it could provide better information on the likelihood of breakdowns, based on existing or proposed practices. This would give farm operators and animal health authorities clear indications as to whether additional measures need to be taken to prevent disease, especially if the analysis suggests that existing procedures are associated with a high probability of disease breakdowns and spread.

The overall risk of incursion of H5N1 HPAI viruses (or other pathogens) into a specific farm is determined by a complex interaction between the levels of infection in the area (the level of hazard), which varies over time, and the likelihood of carriage of the virus into the farm.

The risk of virus incursion depends on the number of "contacts" with the world outside the farm, and the probability of each of these "contacts" involving infected or contaminated material. For example, larger farms tend to have more inputs (greater amounts of feed and greater movement of people such as catching crews and vaccination teams). However, these risks are modified by the biosecurity measures practised on-farm relating to these inputs.

Risk analysis for incursion of specific pathogens (such as H5N1 viruses) into farms in different production systems, if performed, should employ the same principles and techniques used by individual countries or states when performing import risk analysis – see OIE (2007) for details on import risk analyses. In these assessments, the farm can be considered as the "importing country" with the risk of "importing" virus depending on the level of infection in the area around the farm and the probability of virus entering the farm via each of the potential infection pathways – which in this case include animal feed, traders, wild birds, farm workers, water, day-old chicks, other items that are brought onto a farm, and direct spread of virus via dust and wind.

The risk analysis process includes hazard identification, risk assessment and risk management. The fourth component, risk communication, is used to inform farmers and workers of the need to implement appropriate biosecurity measures.

As a formal risk analysis can be costly, most enterprises would not normally opt to use this technique, even if available. The only exceptions would be large system 1 farms set-

[2] http://www.ansci.umn.edu/poultry/resources/biosecurity.htm

[3] http://www.vetmed.ucdavis.edu/vetext/INF-PO_Forum/checklist-2pp.pdf

ting up compartments for export, in which case importing countries would almost certainly demand a thorough and transparent risk analysis before accepting produce from the compartment. However, governments and industry groups would benefit from obtaining this type of information when devising control and preventive programmes.

Most veterinarians servicing the poultry industry have not been formally trained in risk analysis (Halvorson and Hueston, 2006), although they utilize the same scientific principles when developing biosecurity plans. To overcome this deficiency, and simplify the process of assessing risks, an exposure risk index has been developed that allows some comparison of the level of risk posed by different events and activities. This is based around the quantity of the hazardous material, the amount of pathogen in the hazardous material, the amount of this that is available (e.g. a mound of contaminated faeces versus faeces that is spread out over a field), the survival of the pathogen in the hazardous material, and the proximity of the material to susceptible poultry (ibid.). Use of this system correlates well with perceptions of veterinarians regarding the relative risk posed by various hazards, and could be an alternative to formal risk assessment.

4.1 Issues relating to hazard identification

Hazard identification is the process by which the potential threats to the area of interest (in this case, individual farms) are assessed. This is usually applied to specific pathogens, such as H5N1 HPAI viruses.

The best way to understand and identify hazards is to review the pathways that farms use for the introduction of items or people, and to assess where these come from and the likelihood of their being or becoming contaminated (fomites) or infected (poultry) along the supply chain. This assessment should also examine activities in the vicinity of the farm that might add to the risk, such as the presence of other farms or flocks of poultry, slaughter plants, processing plants or markets; the management procedures in place in these enterprises; and their sources of poultry or poultry meat. Market value chain analyses help to provide this information by identifying high-risk practices; this helps to overcome some of the constraints associated with disease surveillance discussed below.

Hazard identification for H5N1 HPAI in many infected developing countries is hampered by the limited availability of surveillance data. Generally speaking, these data do not provide accurate information on the infection status in any given place or area. Disease reports provide some indication of the levels of infection. However, active surveillance studies, when performed, have shown that "passive" disease reports underestimate the prevalence of infection, as clinically silent infection can occur (e.g. in ducks) and not all cases of disease suggestive of HPAI are reported to authorities. Even when active surveillance is done, it usually only gives an indication of presence of virus (if, in fact, virus is detected) in certain areas at a particular point in time.

Even when surveillance studies are undertaken, negative results do not necessarily prove the absence of infection. For example, serological studies in unvaccinated chickens are of limited value for detecting past exposure to H5N1 HPAI in a flock, due to the high case-fatality rate in infected poultry (Sims *et al*., 2003), and virological surveillance on apparently healthy chickens on farms is insensitive due to the limits on the number of samples that can be processed. Wild-bird surveillance on healthy live birds has failed to detect virus in

most places where this has been done, even in places where wild birds are known to have played a role in virus transmission. As a consequence, low-level infection, such as might occur in the early stages of an outbreak in a farm or in a flock of wild birds, can remain undetected.

Seasonal effects also need to be considered in assessing surveillance data. The levels of circulating virus can vary depending on the weather conditions (e.g. longer survival of virus in cool weather) and other factors such as the number of susceptible poultry being reared in the vicinity. Poultry numbers can increase prior to festivals as producers rear more poultry to take advantage of increased demand and prices. They can also increase dramatically just prior to rice harvests when additional ducks are bred to graze harvested rice paddies. Periods of wild-bird migration can also be associated with increased levels of influenza viruses in a given area.

The location and species affected are also crucial. If infection with influenza viruses is confined to wild birds, then those farms that prevent or limit direct and indirect contact between wild birds and poultry are less likely to become infected than those that do not practise these preventive measures. However, once infection is established in poultry, it is generally accepted that spread of virus is more likely to occur by contacts within the poultry industry.

In conducting a hazard analysis it needs to be recognized that infection with H5N1 HPAI will not normally persist in a flock of chickens for an extended period of time unless there is regular replenishment of susceptible poultry to the flock during the period it is infected. If there are no populations of birds in which the virus can persist, then the disease is relatively easy to contain and may even self-extinguish (at least until the next virus incursion to the area).

By contrast, live-poultry markets, where there is a constant inflow of poultry, and where a transient population of poultry is kept for more than 24 hours, provide ideal sites for perpetuation of avian influenza viruses (Kung *et al*., 2003). Similarly, duck flocks can probably remain infected for an extended period of time. Experimental studies suggest that individual ducks probably only excrete virus for several weeks (Hulse-Post *et al*., 2005), but the virus would likely take longer to transmit through an entire flock. Longevity of infection in a duck flock is also expected to increase if there is regular introduction of new susceptible birds.

As the level of threat varies over time, a two-level biosecurity system has been promoted in some places. This involves the use of a standard set of biosecurity measures under normal conditions, but enhanced biosecurity measures (in which farm inputs and visits are severely curtailed) when the threat increases, such as when new cases of infection have recently been diagnosed in the area around the farm (see, for example, OMAFRA, 2005). This works well when a disease is notified early, but in a number of cases in Asia, disease was already widespread before it was detected or reported, somewhat reducing the value of such a system.

4.2 Risk assessment

Risk assessment applied to farms should comprise a release assessment (i.e. what is the likelihood that virus outside the farm will get in to the farm?) and an exposure assessment

(what is the likelihood that virus once inside the farm will actually infect and cause disease in poultry?). Both are influenced by management systems employed on farms to reduce these risks. These are combined with an assessment of consequences to provide an overall assessment of risk. In the case of H5N1 HPAI in fully susceptible chickens, the consequences of infection are extremely serious due to the high rates of mortality produced and the losses arising from culling affected and in-contact poultry by veterinary authorities when the disease is reported.

The risk assessment should take account of existing risk-reduction measures as well as any proposed measures.

4.3 Release assessment

The main pathways that can lead to incursion of avian viruses into farms are well known (Halvorson and Hueston, 2006), and include: visitors, such as traders and work crews; manure haulage; dead-bird pick-up; off-farm labour; egg collection; allowing free ranging of poultry if this results in sharing areas with other poultry or wild birds; use of untreated water from ponds or rivers for drinking, cleaning or cooling; use of raw (not heat treated) animal feed and poor handling of feed; poor rodent control; introduction of new stock without appropriate quarantine and hygiene measures; and access of wild birds to poultry sheds, feed or water supplies.

Although it may not be possible to quantify all of these risks, several important principles apply. First, the level of risk is determined by the frequency of the event. Therefore, high-risk daily activities are often of greater consequence than similar activities that occur only a few times a year. In addition, the risks posed by these activities are influenced by the measures put in place to address them and the degree of compliance with these measures.

For example, if farm workers live off-site then they should be required to change their clothing and possibly shower when entering the farm. If this is done properly, the risk associated with this activity is lowered.

Another point to note is that the results of one survey, involving self-assessment of biosecurity measures and subsequent cross-checking by field observations, demonstrated marked differences between the perceptions of farmers regarding the biosecurity measures on farms, as recorded in a survey, and the situation on the ground (Nespeca *et al.*, 1997). This suggests that independent audits of biosecurity procedures are valuable in ensuring that measures are being implemented.

A hazard profile can be developed for each individual farm (as shown in the hypothetical example in Table 2) based on the source of the inputs and the likelihood that these are contaminated. This uses a qualitative assessment of risk, but if appropriate data are available, a quantitative assessment should be conducted.

4.4 Exposure assessment

The effect of incursion of H5N1 HPAI virus into a flock of poultry depends on the susceptibility of the species reared (e.g. turkeys have been shown to be more susceptible than chickens), the method of rearing and the mode of introduction. For example, in the case of virus introduced to a poultry house on footwear, birds on litter are generally at higher risk of exposure to the pathogen than those in cages.

TABLE 2
Hypothetical hazard profile for a poultry farm

Pathway	Factors affecting level of hazard	Release assessment
Day-old chicks	No known infection in the province where the farm sources day-old chicks. All chicks are delivered in new cardboard containers. The vehicle used to transport the day-old chicks is fumigated daily and goes through a disinfectant bath before entering the farm.	Negligible
Animal feed	Bulk heat-treated feed from a single company. No feed vehicle enters the premises – transfer of feed over boundary fence.	Negligible
Wild birds	A few starlings and sparrows have been found within sheds two weeks previously. Repairs have been made to bird proofing. No major bodies of water on the farm to attract wild birds. Nearest permanent watercourse 2 km away.	Low
Water	Drinking and cooling water from a bore.	Negligible
Tradespeople	Farm staff conduct all repairs.	Negligible
Catching crews	All birds in one shed are sent to slaughter on a single day using own staff.	Negligible
Vaccinators	No outside workers vaccinate.	Negligible
Traders	All trading done by telephone. No company representatives allowed on premises.	Negligible
Local spread	No farms within 1 km.	Negligible
Dead bird disposal	Composted on site.	
Links to live poultry markets	All sales direct to slaughterhouse in farm vehicles.	Negligible
Farm workers	Farm workers are not allowed to keep poultry or visit places where poultry are kept. All staff must change clothing on entry to the farm.	Low
Veterinarian	One routine visit per month. Must change clothes and shower on entry. No contact with other poultry allowed within the previous 24 hours.	Low
Faeces	Composted on site.	Negligible
Fencing/security	Farm securely fenced and entry gate locked at all times.	Negligible
Rodents	Regular programme of rodent baiting. Grass kept low around barns.	Negligible
Neighbouring farm	Nearest chicken farm is 3 km away. Village 1.5 km away with several non-commercial flocks of chickens.	Negligible
Other (markets roads, slaughterhouses, etc.)	One major road used by poultry vehicles approximately 1 km away. Nearest slaughterhouse 7 km away. No live poultry markets within 50 km.	Negligible

Consequences of exposure are modified by the use of vaccines, which can increase resistance to infection and also reduce Ro (case reproduction number) below 1 (van der Goot *et al*., 2005), preventing onward transmission in a flock. Vaccination has been the main method used in a number of places, including Hong Kong SAR, to increase resistance and reduce the effects if virus enters a farm, (Sims, 2007).

The stocking density of poultry in a farm can also influence the size of the outbreak. Infection can be self-limiting in scavenging poultry flocks kept at low density, and may not affect all poultry in the flock, especially if these are not housed close together at night.

Airborne spread (if it occurs) or introduction of virus via feed or water could result in a more rapid increase in the levels of disease if multiple poultry are exposed simultaneously compared with the slow onset associated with exposure of a single bird or small number of birds.

4.5 Risk management

Once the risk assessment is completed, the risk of infection is established, and the implications of various measures are determined, farmers and veterinarians should then make appropriate changes to existing biosecurity systems.

For some farms, the risk of virus incursion in the current location will be deemed to be so high that the only alternatives are to relocate the farm or to use other measures such as prophylactic vaccination to minimize the risk associated with exposure to virus once it enters the flock.

4.6 Farm biosecurity and Hazard Analysis and Critical Control Points (HACCP)-type procedures

Farm biosecurity measures lend themselves to methods based on HACCP-type management. HACCP is based around identification of key hazards, and determining critical control points along the production pathway, at which these hazards are monitored and corrective action taken if problems are detected (see, for example, Grimes and Jackson, 2001). Use of HACCP-type procedures when developing individual farm-biosecurity plans, also facilitates auditing by independent parties.

All commercial farms should have a biosecurity plan. This can range from a very simple plan for a system 3 farm to a full manual of procedures for a system 1 integrated operation.

5 BIOCONTAINMENT

So far, this paper has concentrated on measures used to limit the entry of pathogens onto farms, which reflects the view of most farmers when it comes to disease prevention. This focus on preventing pathogens from gaining entry to farms is probably based on the belief that there is more benefit to individual farmers in reducing the risk of introduction than in trying to deal with the consequences after it has occurred.

There is a public-good element in biocontainment which owners of individual units may choose to ignore. Once infection occurs on a farm, little direct benefit accrues to individual farm operators if they implement biocontainment measures. This benefit is a collective one distributed to all players in the industry (see the discussion on the Nash equilibrium presented by Otte *et al*., in FAO, 2007b).

Biocontainment is also imposed on farms by animal health authorities once disease is reported. This is usually achieved through combinations of movement restrictions and culling affected poultry.

Larger multi-barn farms are more likely to consider issues relating to biocontainment, as the effects of the transmission of infection from one shed to the other sheds can be significant. However, geographical and financial constraints and land-tenure issues often dictate the location and degree of separation of individual barns on farms, and distance from other farms, leading to compromises in biosecurity.

A study of poultry farms in Australia found that one of the key risk factors for seropositivity for Newcastle disease virus was proximity to other farms. This suggested that airborne spread may have been involved, although other horizontal links between these farms could not be ruled out (East *et al*., 2006).

Many modern enclosed poultry houses require forced ventilation to ensure the welfare of the housed poultry. The large extraction fans used can blow plumes of dust from inside sheds over considerable distances. It is still not clear whether avian influenza viruses survive in dispersed dust from farms, but this potential risk needs to be considered especially when farms are located close together (Power, 2005). Local spread of HPAI has been reported in some outbreaks (Brugh and Johnson 1986) even though avian influenza viruses are not normally considered to be spread over more than a few metres by air. Whether this local spread is due to airborne particles, flies, transfer by small birds (e.g. starlings) or local movement of people involved in control operations is yet to be determined.

When dealing with agents that can be spread by air, careful choice of the site of farms is required. Airborne spread cannot be prevented through adjustments to management on existing farms in areas with high concentrations of poultry farms (Shane, 1997).

Biocontainment depends on early diagnosis and action on infected farms. However, infection with H5N1 HPAI viruses can be present for seven days or more before being recognized in unvaccinated flocks (and possibly longer in vaccinated flocks, assuming only partial flock immunity) due to the lag phase between virus introduction and spread to sufficient numbers of poultry to cause a significant increase in mortality. This can lead to inadvertent transmission of infection if these poultry or products from them are sold. This is compounded by some farmers deliberately selling flocks that are known to be infected during the early stages of outbreaks (the short window between the first few fatal cases of disease and high rates of mortality has been exploited by observant farmers who, on detecting a slight increase in mortality, sell poultry before the disease spreads within their flock).

To overcome these problems, preventive biocontainment measures should be in place before infection occurs. This should cover issues such as farm density, direction of ventilation outputs, manure handling and dead-bird disposal. However, as these preventive measures may not be implemented voluntarily, it may be necessary to drive their implementation through the use of appropriate, enforceable regulations controlling density of farms (perhaps through a moratorium on building new farms within a certain distance of existing farms and closure (with compensation) of existing farms to reduce density) and rules for the disposal of waste material and carcases.

In areas where the risk of incursion and subsequent transmission is high, it is reasonable to use prophylactic vaccination both to reduce the likelihood of infection and to reduce

excretion of virus if infection occurs. This approach has been applied in Italy and Hong Kong SAR.

Not surprisingly, larger farms have more outputs than smaller ones, including quantities of poultry and manure/litter (Otte *et al.*, in FAO, 2007b). Therefore, large farms that do not implement appropriate biocontainment measures, such as on-site composting of manure before removal from the farm, can pose a high risk to other farms in the area, if they become infected.

6 METHODS FOR MINIMIZING RISK OF INFECTION INTO AND OUT OF FARMS

The general consensus, emerging from a UN technical workshop held in Rome in June 2007 (FAO, 2007d) was that many high-risk commercial practices, involving both marketing and production of poultry, exist in countries enzootically infected with H5N1 HPAI, and also in those at risk of becoming so. These practices are not restricted to any one production system.

When developing disease-control programmes, high-risk practices in all production systems should be identified and, where appropriate and feasible, modified over time. However, consideration should be given to the potential adverse effects (environmental, social, gender and economic) of any proposed changes before any significant modifications are made. Support should be provided to vulnerable members of communities disadvantaged by enforced changes. If changes to production and marketing practices are impractical, alternative disease-control measures will need to be implemented.

None of the above implies that all poultry must be housed or reared under intensive, industrial conditions.

The following section provides some suggestions on ways to enhance biosecurity in farms in each production system.

System 1

The best way to minimize risk to and from system 1 farms is to locate these away from other farms and to have clear, audited working procedures for ensuring high-level biosecurity.

Some biosecurity guides provide general guidance on appropriate separation for poultry farms and individual barns on farms (see Millar, 2004). These are of limited value for places with pre-existing farms, where the only way to apply these guidelines is through closing some of these farms. Nevertheless, if certain areas appear to have excessively high concentrations of poultry, bans on new farms in these areas are warranted, and provision of incentives for existing farms to close or relocate may be justified.

By definition, these farms already implement high-level biosecurity measures. However, these can be strengthened through compartmentalization, in which all inputs are tightly controlled and contacts with farms and suppliers outside the compartment are largely severed, so that all farms and related downstream and upstream units, such as feed suppliers and slaughterhouses in the compartment, can be defined as discrete epidemiological units.

To ensure biosecurity systems are operating properly, regular independent audits, daily compliance checks and implementation of HACCP systems will provide greater assurance of the measures implemented.

Most system 1 farms sell poultry through slaughterhouses rather than through live poultry markets; this reduces the risk of infection especially if the slaughterhouse does not receive poultry from other farms.

System 1 farms should implement regular targeted surveillance to demonstrate ongoing freedom from infection.

Often these farms self-regulate, and it is better for some overseeing of biosecurity measures to be provided by official veterinary services.

System 2

System 2 farms vary in the quality of their biosecurity measures. One option to strengthen these is to put in place specific standards that have to be met through farm licenses or permits, as is used in Hong Kong SAR. This must be backed by appropriate enforcement.

This can also be done through restrictions placed on access to markets, so as to only include farms meeting certain conditions, such as biosecurity standards.

Use of schemes such as that operating in Australia, where application of specific biosecurity measures is a requirement for participation in government cost-sharing arrangements in the event of serious disease outbreaks, also warrants consideration.

In places where system 2 farms sell poultry through poorly regulated live-poultry markets, attention should be paid to reducing the risk posed by these markets through improving management and hygiene and enhancing traceability and certification for poultry entering these markets (however, conditions for issuance of certificates must be scientifically sound and properly designed so as to actually reduce risk – this is not the case with much of the current certification in Asia).

As with system 1 farms, relocation may be required if the farm is located in an area where there are many other farms and the risk of infection is high. Independent biosecurity audits should be conducted to assess compliance with biosecurity plans and standards.

System 3

This paper has argued that system 3 farms are considered to be at high risk of virus incursion because of the lack of biosecurity measures and, in many cases, their links to poorly controlled live-bird market systems.

These farms often do not incorporate biosecurity measures appropriate to the level of risk of a breakdown. This raises a number of questions about these practices. First, increasing the size of a poultry flock from (system 4) backyard production to small-scale commercial production has allowed many disadvantaged people (especially women) to move out of poverty by taking advantage of the high returns potentially available from poultry rearing. However, this creates an externality if there is no regulation of biosecurity standards for these farms.

One solution is to modify production and biosecurity systems on these system 3 farms so that they become system 2 farms. However, this requires changes in management systems (full dependence on purchased feed) and, possibly, changes in the breed(s) reared to those amenable to intensive production. It also requires considerable investment in facilities. For many this is not economically or technically feasible.

This process can be driven by urban markets that demand "clean" certified produce.

At present this reduces opportunities for smallholders in system 3 to market their produce through legitimate channels. Small, independent system 3 farms will probably struggle to meet these market demands. Nevertheless, there is potential to develop "clean" villages or communes if all poultry-rearing households in these locations agree to restrictions on the entry of poultry and middlemen, and on methods of marketing; other disease control and preventive measures (such as vaccination); and submit to regular surveillance testing. This would require full cooperation from all poultry rearing households and community animal health workers in the commune as well as traders and others who visit. This is a relatively new concept that warrants further exploration.

Other options available for those farms that cannot upgrade are segregation of species (a major challenge in many rural areas), vaccination, small behavioural changes by poultry rearers (e.g. changing footwear before entering poultry enclosures, and not allowing visitors to enter premises) and indirect measures that reduce levels of infection in markets through better management, which reduces the likelihood of poultry traders inadvertently transporting virus from markets to farms.

Where changes to management cannot be implemented (e.g. grazing ducks in Viet Nam) there will likely be ongoing reliance on vaccination, coupled with movement controls.

System 4

Similar measures to those proposed for system 3 can also be adopted for system 4 flocks, in particular the behavioural changes that do not require investment in facilities. There has been a push towards confinement of scavenging poultry, but this may not be feasible for flocks in which the main advantage is the "free" feed obtained through scavenging.

Again, if husbandry methods can't be changed, then other means to protect these poultry must be found, such as vaccination or better control of disease in production systems 1, 2, and 3, which will reduce the risk to these flocks (except in places where wild birds are playing a significant role in the spread of disease).

7 CONCLUSIONS

This paper has demonstrated that our knowledge of the role of different production systems in the persistence and spread of H5N1 HPAI viruses remains poor, due to a lack of detailed studies and investigations of outbreaks. This could be improved through use of formal risk assessments on a selection of farms in different production systems, and better case investigations.

Farms in all production systems have been affected by H5N1 HPAI, and appropriate measures need to be taken in all four systems to prevent infection and onward transmission of these viruses.

System 1 farms face risks because of their size, and sometimes their international trading practices, but these are mitigated by implementation of high-level biosecurity measures. System 2 farms vary markedly in their susceptibility to infection, depending on their location, the quality of their biosecurity measures and the method they use to sell poultry. Some lower-level system 2 farms represent a significant risk. If system 1 or system 2 farms are infected, there is a high probability of subsequent local spread of infection, depending on the density of farms in the vicinity. System 3 production is deemed to represent the highest

risk for incursion of H5N1 viruses, because in many parts of the world most sales from these farms are through live-poultry markets, and farm biosecurity measures are poor. System 3 production also includes grazing ducks, which are believed to have played a critical role in the genesis of the H5N1 HPAI panzootic. System 4 flocks are small and in some cases may already be largely segregated from the commercial sector – which offers some protection from infection.

If HPAI caused by Asian lineage viruses of the H5N1 subtype is to be contained, and perhaps even eliminated, all farms will be required to implement appropriate measures to minimize the risk of virus incursions and subsequent spread to other farms. This will require concerted efforts by animal health authorities and the private sector.

In many farms there is still a mismatch between the risk of infection and the biosecurity measures in place. This can be overcome by enhancing the biosecurity of farms using measures appropriate to the production system and/or by increasing resistance of poultry through vaccination and other control measures. Ultimately, this is a decision that has to be made by individual farm owners, but it can be guided by government regulations and quality information about the risks associated with different production systems and ways to overcome them.

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Poultry production and the environment – a review

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SUMMARY

Over the past decades, the poultry sector's growth and trends towards intensification and concentration have given rise to a number of environmental concerns. A direct consequence of these structural changes (industrialization, geographical concentration and intensification) in poultry production is that far more waste than can be managed by land disposal is produced, resulting in environmental problems. This paper analyses the environmental impacts arising from intensive poultry production, evaluating such impacts across the food chain and all environmental media. The paper also presents technical options to mitigate environmental impacts, such as improvements to farm management, animal-waste management and nutrition management, along with options to reduce the impacts of intensive feed production.

Key words: poultry, intensification, future, climate

1 INTRODUCTION

Over recent decades the poultry industry has made tremendous adjustments to meet the increasing demand for inexpensive and safe supply of meat and eggs. Over the past three decades, the poultry sector has been growing at more than 5 percent *per annum* (compared to 3 percent for pig meat and 1.5 percent for bovine meat) and its share in world meat production increased from 15 percent three decades ago to 30 percent currently (FAO, 2006a).

This growth has been accompanied by structural changes within the sector, characterized by the emergence and growth of "land-independent" (industrial) farming establishments, and the intensification and concentration of poultry operations. Pressure to lower production costs and increase supply has led to more efficient operations, made possible through the shift to larger, specialized and more integrated facilities, and through improvements in the use of animal genetics, optimized nutrition and new production technologies. The driving forces behind structural change in poultry production are no different than those that affect other livestock commodities: market pull, innovation and economies of scale. Innovation and economies of size that characterize the livestock sector have also served to separate animal production from crop production. Large, specialized facilities today focus on producing animals, and purchase most of their feed. This often means that there is limited access to land on which to spread manure.

The use of large facilities associated with higher concentrations of poultry, has given rise to environmental concerns that are not only limited to the local production settings, but extend to environmental problems at regional and global scales. The obvious, and often limited, impacts observed at production-site level, thus, tend to obscure much larger impacts on the regional and global environment. In this paper we therefore analyse the sector's impacts by zooming out across the three spatial scales. Furthermore, the use of a scale approach is a useful structure for the analysis of environmental impacts because it directly links the outcomes of the review to the policy interventions that are required at the various levels (farm to international).

This paper also adopts the food-chain approach, analysing the environmental impacts arising from poultry production, and evaluating such impacts all the way from feed production to animal production and slaughtering. It considers impacts on all environmental media – air, water and land, at local, regional and global scales. The issue of disease transmission from/to wildlife populations is, however, omitted as other papers in these proceedings discuss this topic.

The next section will give an overview of environmental issues at the level of production and processing (Section 2). We then present an in-depth analysis of the impacts of poultry production as the sector intensifies in certain preferred areas (Section 3). Section 4 deals with global environmental issues associated with the poultry sector. We then briefly present technical options (Section 5), followed by conclusions (Section 6).

2 ISSUES AT THE LEVEL OF PRODUCTION AND PROCESSING UNITS

This section provides an overview of environmental concerns at the local level, arising from two point sources: the animal production site and the abattoir. At this level, impacts are usually directly observed by farmers, neighbours and policy-makers.

2.1 Animal production units

Local disturbances (e.g. odour, flies and rodents) and landscape degradation are typical local negative amenities in the surroundings of poultry farms. Pollution of soil and water with nutrients, pathogens and heavy metals is generally caused by poor manure-management and occurs where manure is stored. Water and soil pollution related to poultry litter is, however, generally not an issue at the production site, as poultry manure is only directly discharged into the environment in exceptional conditions. Indeed, the high nutrient content and low water content of poultry litter make it a valuable input to agriculture. Manure is either recycled on cropland belonging to the animal farm or marketed. In the usual set-up, an intermediary or a processor collects manure from poultry farms. Manure is either resold rough or processed into compost or pellets. Manure products are used as fertilizer, or as animal feed especially for fish and cattle.

In south Viet Nam, the authors observed that end users may be located as far as 300 km from the animal farm where manure is produced. An intermediary will sell manure to the group of users with highest willingness to pay, which can change throughout the year, and from year to year, according to the cropping calendar and the economic conditions. Manure price at the animal-farm gate varies with its pureness (presence of litter) and water content and with the season (demand). On average, 20 kg bags of fresh chicken manure

without litter are sold for VND4 000 to 6 000 while 20 kg bags of manure with litter are sold for VND1 500 to 2 000.[1]

Local disturbances

Poultry facilities are a source of odour and attract flies, rodents and other pests that create local nuisances and carry disease. Odour emissions from poultry farms adversely affect the life of people living in the vicinity. Odour associated with poultry operations comes from fresh and decomposing waste products such as manure, carcasses, feathers and bedding/litter (Kolominskas *et al.*, 2002; Ferket *et al.*, 2002). On-farm odour is mainly emitted from poultry buildings, and manure and storage facilities. Odour from animal feeding operations is not caused by a single compound, but is rather the result of a large number of contributing compounds including ammonia (NH_3), volatile organic compounds (VOCs), and hydrogen sulphide (H_2S) (IEEP, 2005). Of the several manure-based compounds which produce odour, the most commonly reported is ammonia. Ammonia gas has a sharp and pungent odour and can act as an irritant when present in elevated concentrations.

Odour is a local issue, which is hardly quantifiable; the impact greatly depends on the subjective perception of populations neighbouring the farm. It is, therefore, difficult to evaluate the maximum distance over which odorous gas travels; however, odour problems are generally concentrated within 500 metres of the farm. Although generally not causing any public-health concern, odours can represent a strong local problem that is frequently reported by farms' neighbours as the most disturbing environmental impact. The emission of odours mostly depends on the frequency of animal-house cleaning, on the temperature and humidity of the manure, on the type of manure storage, and on air movements. For these reasons it is generally higher in waterfowl farms than in chicken farms.

Flies are an additional concern for residents living near poultry facilities. Research conducted by the Ohio Department of Health indicated that residences that were located in close proximity to poultry facilities (within half a mile[2]) had 83 times the average number of flies. In addition to the nuisance they cause, flies and mosquitoes can transmit diseases, such as cholera, dysentery, typhoid, malaria, filaria and dengue fever. Although less often reported than flies and mosquitoes, rats and similar pests are also a local nuisance associated with poultry production. As with flies and mosquitoes, they can be a vector for disease transmission. Their presence is mainly related to animal-feed management and especially to storage and losses from feeding systems.

Pesticides used to control pests (e.g. parasites and disease vectors) and predators have been reported to cause pollution when they enter groundwater and surface water. Active molecules or their degradation products enter ecosystems in solution, in emulsion or bound to soil particles, and may, in some instances, impair the uses of surface waters and groundwater (World Bank, 2007).

Land use and landscape

The trend to larger production units, and their regional concentration, certainly has the potential to adversely affect surrounding land use and the appearance of the landscape.

[1] VND = Vientamese dong.

[2] Approximately 800m.

Massive industrial poultry installations can create an adverse aesthetic impact. Impact on land use in highly concentrated areas is manifested through conflict with development needs and in some areas with rural tourism.

Poultry carcass disposal

Improper disposal of poultry carcasses can contribute to water-quality problems especially in areas prone to flooding or where there is a shallow water table. Methods for the disposal of poultry carcasses include burial, incineration, composting and rendering. In the case of recent highly pathogenic avian influenza (HPAI) outbreaks, the disposal of large numbers of infected birds has presented new and complex problems associated with environmental contamination. Large volumes of carcasses can generate excessive amounts of leachate and other pollutants, increasing the potential for environmental contamination.

Buried birds undergo a decomposition process. During this process, nutrients, pathogens and other components of the carcass are released into the environment. As these substances enter the surrounding soil, they may be broken down, transformed, lost to the air, or otherwise immobilized so that they pose no environmental threat. However, there is a possibility that some constituents may eventually contaminate soil, groundwater and surface water (Freedman and Fleming, 2003). Another related problem is the removal of manure from houses that contain infected birds.

Ritter *et al.* (1988) examined the impact of dead-bird disposal on groundwater quality. They monitored groundwater quality around six disposal pits in Delaware. Producers in Delaware were using open-bottomed pits for their day-to-day mortality disposal. These pits are not strictly the same as burial pits, though there are some similarities. Most of these

BOX 1:

Pollution issues resulting from culling campaigns

There is no clear overview of environmental issues associated with culling campaigns. Punctual observations, however, hint that they may be substantial. In Egypt, about 13 millions birds were culled and buried as part of the control measures implemented in response to the HPAI outbreak. We assume an average weight of 1 kg per bird, and estimate that this amounts to the burial of 13 million kg of fresh organic matter. Water resources are particularly at risk as the animals were buried in areas of shallow water and high human population (310 inhabitants/km^2 on average).

Following the recent avian influenza outbreak in Viet Nam, birds were culled and buried next to land used for human food production. The culling site itself was over a kilometre from the affected farm.

In Nigeria, a UNDP study (2006) found there was no adherence to any standard with regard to the location or the depth of the pits dug for the burial of carcasses. In some villages, the carcasses were thrown randomly into nearby bushes or open dump sites.

pits were located in sandy soils with high seasonal water tables. The potential for pollution of groundwater is high with this method of disposal. After selecting the sites, two to three monitoring wells were placed around each pit to a depth of 4.5 metres. Ammonia concentrations were high in two of the wells. Three of the disposal pits caused an increase in ammonia concentrations in the groundwater. Total dissolved solids concentrations were high in all monitoring wells for most dates. Bacterial contamination of groundwater by the disposal pits was low.

2.2 Slaughterhouse

The most significant environmental issue resulting from slaughterhouse operations is the discharge of wastewater into the environment. Like many other food-processing activities, the necessity for hygiene and quality control in meat processing results in high water usage and consequently high levels of wastewater generation (IEEP, 2005). Poultry processing activities require large amounts of high-quality water for process cleaning and cooling. Typical water usage in poultry slaughterhouses ranges between 6 and 30 cubic metres per tonne of product. Large quantities of water are consumed in poultry slaughterhouses for evisceration, cleaning and washing operations (EU, 2003).

Process wastewater generated during these activities typically has high biochemical and chemical oxygen demand (BOD and COD[3]) due to the presence of organic materials such as blood, fat, flesh, and excreta. In addition, process wastewater may contain high levels of nitrogen, phosphorus, and residues of chemicals such as chlorine used for washing and disinfection, as well as various pathogens including *Salmonella* and *Campylobacter* (World Bank, 2007). Poultry by-products and waste may contain up to 100 different species of micro-organisms, including pathogens, in contaminated feathers, feet and intestinal contents (Arvanitoyannis and Ladas, 2007). Typical values for wastewater produced from poultry processing are 6.8 kg BOD per ton live weight killed (LWK) and 3.5 kg suspended solids per ton of LWK (de Haan *et al*., 1997).

Poultry slaughterhouses release large amounts of waste into the environment, polluting land and surface waters as well as posing a serious human-health risk. The discharge of biodegradable organic compounds may cause a strong reduction of the amount of dissolved oxygen in surface waters, which in turn may lead to reduced levels of activity or even death of aquatic life. Macronutrients (nitrogen, phosphorus) may cause eutrophication of the affected water bodies. Excessive algal growth and subsequent dying off and mineralization of these algae may lead to the death of aquatic life because of oxygen depletion (Verheijen, *et al*., 1996).

Slaughterhouses are usually located in urban or peri-urban locations, where transport costs to markets are minimized and where there is abundant labour supply. This situation increases the risk of environmental impacts: first, because slaughterhouses often lack the land required to set up waste-management facilities; second, because the pollutants that

[3] The Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are parameters that give an indication of the concentration of organic compounds in wastewater. Their calculation is based on standardized chemical procedures for determining how fast biological organisms use up oxygen in a body of water. The concentration of suspended solids represents the amount of insoluble organic and inorganic particles in the wastewater (Verheijen *et al.*, 1996).

are emitted add to those emitted by other human activities; and third, because neighbouring communities are directly affected by surface-water and groundwater contamination.

3 WATERSHED-LEVEL POLLUTION ASSOCIATED WITH WASTE MANAGEMENT

Intensification of production and the geographical concentration of production units often results in environmental concerns. The decoupling of crop and livestock production through the migration of livestock production away from crop activities into areas with little or no agricultural land leads to high levels of environmental impact – mainly related to manure mismanagement and nutrient overloads (Naylor *et al*., 2005).

3.1 Poultry manure

Poultry manure contains considerable amounts of nutrients such as nitrogen, phosphorus, and other excreted substances such as hormones, antibiotics, pathogens and heavy metals which are introduced through feed (Steinfeld *et al*., in FAO, 2006b). Leaching and runoff of these substances has the potential to result in contamination of surface water and groundwater resources.

Nutrients

Animals reared in intensive production systems consume a considerable amount of protein and other nitrogen-containing substances in their diets. The conversion of dietary nitrogen to animal products is relatively inefficient; 50 to 80 percent of the nitrogen is excreted (Arogo *et al*., 2001). Nitrogen is excreted in both organic and inorganic compounds. Nitrogen emissions from manure take four main forms: ammonia (NH_3), dinitrogen (N_2), nitrous oxide (N_2O) and nitrate (NO_3^-).

Phosphorus is an essential element for animal growth. Unlike nitrogen, phosphorus is relatively stable once attached to soil particles and does not leach through the soil into groundwater. It does not pose any environmental risks except as a nutrient; it limits biological activity in water resources and builds up in soil when applied in excess. Phosphorus emissions from manure occur in one main form: phosphate (P_2O_5).

Heavy metals

Manure contains appreciable quantities of potentially toxic metals such as arsenic, copper and zinc (Bolan *et al*., 2004). In excess, these elements can become toxic to plants, can adversely affect organisms that feed on these plants, and can enter water systems through surface run-off and leaching (Gupta and Charles, 1999). Trace elements are introduced into poultry diets either involuntarily through contaminated feedstuffs or voluntarily, as feed additives used to supply animals' requirements or – in much greater proportions – as veterinary medicines or growth promoters.

Drug residues

Antimicrobial agents are administered to poultry for therapeutic reasons or to prevent illness (prophylaxis). At much lower doses (subtherapeutic doses) antimicrobial agents are used as feed additives to increase the rate of growth and to improve feed efficiency (Cam-

pagnolo *et al*., 2002; Steinfeld *et al*., in FAO, 2006b). Irrespective of dosage, an estimated 75 percent of antimicrobial agents administered to confined poultry may be excreted back into the environment (Addison, 1984). Recent evidence suggests that the interaction between bacterial organisms and antimicrobials in the environment may contribute to the development of antimicrobial-resistant bacterial strains (Chee-Stanford *et al*., 2001). Campagnolo *et al*. (2002), in a study that evaluated the presence of antimicrobial compounds in surface water and groundwater resources proximal to intensive poultry operations in Ohio, found antimicrobial residues to be prevalent – present in 12 water samples (67 percent) collected proximal to poultry farms.

In the United States of America, overall use of antimicrobials for non-therapeutic purposes in animals rose by about 50 percent between 1985 and 2001. This was primarily driven by increased use in the poultry industry, where non-therapeutic antibiotic use increased from 2 million to 10.5 million pounds (907 185 kg to 4 762 720 kg) between the 1980s and 2001 – which amounted to a dramatic 307 percent increase on a per-bird basis (Mellon *et al*., 2001).

Pathogens

Manure also contains pathogens which may potentially affect soil and water resources, particularly if poorly managed. Parasites such as *Cryptosporidium* and *Giardia* spp. can easily spread from manure to water supplies and can remain viable in the environment for long periods of time (Bowman *et al*., 2000).

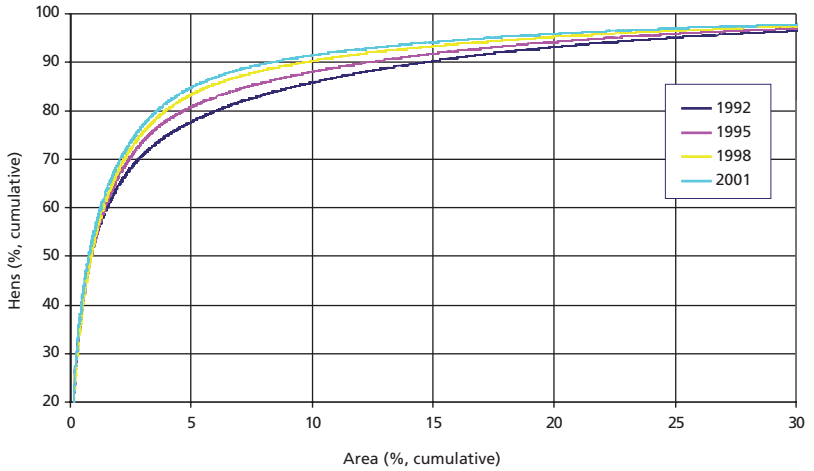
3.2 Regional concentration of production

The trend toward clustering of poultry production in certain preferred locations is ongoing in developed as well as developing economies. An analysis of hen populations at municipio level in Brazil, for example, shows an increasing concentration during the period 1992 to 2001 (see Figure 1). In 1992, 5 percent of the country's total area hosted 78 percent of the chicken population, while in 2001 the same area was home to 85 percent of the population.

Clustering is a process of geographic concentration of production units. This gives rise to groups of interconnected producers, feed mills, slaughterhouses and processing units. Clustering is driven by economies of agglomeration – the benefits that individual units obtain when they locate close to one another. Basically, the more related units clustered together, the lower the unit cost of production and the larger the market that individual units can sell into. In the livestock sector, lower production costs are achieved through competition among suppliers of inputs (e.g. feed mills, veterinary and other services), and specialization and division of labour among producers (e.g. breeding operations, fattening operations and contract farming). If a well-developed transport infrastructure supports this set-up, supply to urban and export markets is often very competitive.

Intensive production, therefore, concentrates in areas favoured by cheap inputs (particularly feed) and services, and by good market outlets for livestock products. Such conditions are found in the vicinity of cities, feed processors and large slaughterhouses, as well as harbours trading feed and animal products. The geographical location of intensive poultry activity is, thus, less and less linked to agricultural and land-use parameters. In other words,

FIGURE 1
Changes in the geographical concentration of chickens in Brazil from 1992 to 2001



poultry production is shifting from agricultural use of the land, based on biophysical criteria (e.g. soil quality, climate, length of growing period) towards industrial use of the land.

3.3 Environmental issues

Gerber *et al*. (2005) summarize some of the major potential impacts of intensive livestock production on land and water resources:

- eutrophication of surface waters, caused by the input of organic substances and nutrients either through wastewater from production, runoff or leakages from storage and handling facilities – affecting aquatic ecosystems and drinking water quality;
- leaching of nitrate, and possible pathogen transfers to groundwater – affecting the quality of drinking water;
- accumulation of nutrients and other elements in soil due to continuous application of excess quantities of manure; and
- impacts of pollution on nutrient-sensitive ecosystems resulting in biodiversity losses.

In most cases, structural changes in the production system have a rather negative impact on manure management practices. In particular, growth in the scale of production and geographical concentration in the vicinity of urban areas, cause dramatic land–livestock imbalances, hampering manure recycling options. Indeed, in such conditions, transport costs associated with carrying manure back to the field are prohibitive.

Contribution to regional-level nutrient overloads

As mentioned above, poultry manure is generally recycled. Despite this apparently safe handling, it often contributes to nutrient-based pollution at regional level. First, areas where poultry production concentrates are also often characterized by high populations of

other livestock species, pigs in particular. Poultry manure, thus, contributes to the structural nutrient overload in these areas. Secondly, the manure may be applied to crops or fish ponds in excess or in addition to chemical fertilizers or fish feed, resulting in an over-supply of nutrients. Such saturated systems will release excessive nutrients into the environment.

Excessive levels of nitrogen in the environment lead to a cascade of effects, including (Erisman *et al*., 2001; De Vries *et al*., 2003):

- decreased species diversity and acidification of non-agricultural soils, due to nitrogen deposition related to ammonia and nitrous oxide emission;
- eutrophication of surface waters, including excess algal growth and a decrease in natural diversity due to runoff of nitrogen from agricultural soils;
- pollution of groundwater due to nitrate leaching from agricultural soils and non-agricultural soils; and
- greenhouse gas emissions in the form of nitrous oxide.

Nitrogen pollution has been identified as posing a risk to the quality of soil and water. These risks relate to high levels of nitrates, which can be leached to the groundwater table or to surface water causing eutrophication. In its nitrate form, nitrogen is very mobile in soil solution and can easily be leached below the rooting zone and into groundwater.

The rapid growth of intensive poultry production in many parts of the world has created regional and local phosphorus imbalances (Gerber *et al*., 2005). The application of manure has resulted in more phosphorus being applied than crops require, and increased potential for phosphorus losses in surface runoff. This situation is exacerbated by manure management being nitrogen based. When manure is applied to meet the nitrogen needs of most crops, a substantial build-up of phosphorus occurs in the soil (Burton and Turner, 2003; Sharpley, 1998). Environmental problems associated with phosphorus losses from soils can have significant off-farm impacts on water quality. In some cases, these impacts are manifested many miles from the site where the phosphorus losses in soil erosion and runoff originally occurred (Sharpley, 1998). Too much phosphorus input into a body of water leads to plant overgrowth, shifts in plant varieties, discolouration, shifts in pH, and depletion of oxygen as a result of plant decomposition. A drop in the level of dissolved oxygen in surface water has deleterious effects on fish populations (Ferket *et al*., 2002). Thus, increased outputs of phosphorus to fresh water can accelerate eutrophication, which impairs water use and can lead to fish kills and toxic algal blooms. In general, 80 percent of the phosphorus contained in animal feed is subsequently excreted (Burton and Turner, 2003).

Food- and water-borne diseases are another major issue associated with manure management. Pathogens are mostly transmitted through untreated animal waste. Recycling manure is a cost-effective way to reduce discharge into the environment and contamination of water systems. However, recycling must be controlled carefully in order to avoid transferring pathogens to the human food chain. Nonetheless, manure is usually not treated, even if limited composting may take place when manure is stored over several weeks (on farm or in a middleman's barn) and crop residues are added.

Soil contamination with heavy metals

With increasing use of metals not only as growth promoters, but also as feed additives to combat diseases in intensive poultry production, manure application has emerged as an important source of environmental contamination with some of these metals. Metals such as arsenic, cobalt, copper, iron, manganese, selenium and zinc are added to feeds as a means to prevent disease, improve weight gain and feed conversion, and increase egg production (Bolan *et al*., 2004; Jackson *et al*., 2003). Typically, animals can absorb only 5–15 percent of the metals they ingest. The majority is therefore excreted in manure. Part is absorbed by the soil, but heavy metals can also end up in water bodies where they become more concentrated.

The environmental risk associated with heavy metals is largely dependent on the soil's ability to adsorb and to desorb these elements, and the potential for leaching or soil-loss to water by erosion. The spreading of animal manure contaminated with heavy metals can lead to an accumulation of these elements in agricultural soils and water bodies. Unlike excess nitrogen and phosphorus applied to land, heavy metals such as zinc and copper remain bound to soil and do not migrate to water supplies except during soil erosion (Ferket *et al*., 2002). The concentrations of copper and zinc needed by animals are moderately low – 8 parts per million (ppm) for copper and 40 ppm for zinc (National Research Council, 1994). Yet, throughout the United States of America, most broiler diets contain levels of 125 to 250 ppm of copper in order to improve feed efficiency. The U.S. Geological Survey has reported that intensive poultry production units in the Delaware–Maryland–Virginia (Delmarva) Peninsula, on the eastern shore of the United States of America are introducing between 20 and 50 tonnes of arsenic into the environment annually (Christen, 2001) (Box 2).

Ecosystem contamination with drug residues and hormones

The excretion of hormones from poultry has been cited as a possible cause of endocrine disruption in wildlife. Endocrine disruptors are a class of compounds (either synthesized or naturally occurring), which are suspected to have adverse effects in animals. They affect organisms primarily by binding to hormone receptors and disrupting the endocrine system. Endocrine disrupting chemicals (EDCs) include pesticides, herbicides and other chemicals that interact with endocrine systems (University of Maryland, 2006).

In poultry production, EDCs can both enter and leave the production cycle. Sources of EDCs during the production phase include contaminants in litter and from grains used as feed. Poultry can also produce EDCs in the form of steroid hormones that are excreted in manure. The steroids of greatest concern are estrone and 17-ß-estradiol. Research has shown that poultry litter contains estrogen (17-ß-estradiol), estrone and testosterone in measurable concentrations, and that these EDCs persist in the litter (Nichols *et al*., 1997; Shore and Shemesh, 2003; Fisher *et al*., 2005). Degradation of steroids in poultry litter during storage is minimal. However, once steroids have reached waterways their degradation is rapid. Research into the endocrine disruption impact of naturally occurring steroids on fish suggests that on runoff from fields where poultry manure has been applied steroid levels are high enough to cause endocrine disruption resulting in reproductive disorders in a variety of wildlife. Endocrine disruption resulting from intensive poultry production has been well documented in the Delmarva Peninsula in the United States of America (Box 3).

BOX 2:

Arsenic use in intensive poultry production in the United States of America

In the United States of America, arsenic is used in poultry production for growth promotion and for controlling intestinal parasites. According to estimates, at least 70 percent of the broiler chickens raised annually in the United States of America (8.7 billion in 2005) are fed arsenic – typically a compound called roxarsone (3-nitro-4-hydroxyphenylarsonic acid). Up to three-quarters of arsenic in feed will pass through chickens into the estimated 26 to 55 billion pounds* of chicken litter or waste created in the United States of America annually. With around 90 percent of chicken waste being currently applied to fields and cropland as "fertilizer", the U.S. Geological Survey has calculated, based on arsenic concentrations in poultry waste, that between 250 000 and 350 000 kg of arsenic is annually applied to land in the United States of America (Rutherford *et al.,* 2003). Because 70–90 percent of arsenic in poultry litter becomes water soluble, it can readily migrate through soils and into underlying groundwater. While soluble or dissolved arsenic poses the greatest risk for environmental contamination, wind or water erosion can transport contaminated soil particles into water bodies (Bellows, 2005). Garbarino *et al.* (2003) estimated that 2 billion pounds of arsenic are annually introduced into the environment from poultry operations in the United States of America. According to the U.S. Environmental Protection Agency (US-EPA, 2007) (http://www.epa.gov/safewater) 13 million Americans drink water contaminated with arsenic beyond the safety standard of 10 parts per billion.

Arsenic as an obstacle to manure management

Apart from its role in the contamination of water and soil resources, arsenic used in poultry production has also become an obstacle to animal waste management. Today, the production of bioenergy and pelletization of animal waste are two important options being explored for poultry waste management. Existing incinerators in the United States of America burn about 680 million kg of poultry litter each year, and the ash from the incineration process is sold as fertilizer. The other new disposal technology is to produce fertilizer pellets directly from poultry waste by drying and pelletizing it. This is currently being implemented in Delaware, where about 55 million kg of pellets are produced annually. Although these two technologies have the potential to reduce or eliminate harmful pathogens in poultry waste, neither can destroy or detoxify arsenic. Preliminary measurements of arsenic concentrations in pelletized waste sold as fertilizer have shown levels between 18 and 22 mg/kg – levels similar to those reported in unprocessed poultry waste. There is, therefore, concern about increased exposure to arsenic through air emissions from energy plants, and contamination of soils and water.

*1 pound = 0.45 kg
Source: Nachman *et al.* (2005)

BOX 3:

Effects of endocrine disruptors from intensive poultry on fish

The Delmarva Peninsula, consisting of eastern Maryland, most of Delaware, and the portion of Virginia east of the Chesapeake Bay, is one of the most densely concentrated poultry producing areas in the United States of America. The region generates 600 million birds and 1.6 billion pounds (726 million kg) of manure (or litter) annually. Excessive land application of poultry wastes has precipitated severe water quality problems in surface waters and groundwaters throughout the region. Impacts include harmful algal blooms, decreases in water clarity, widespread anoxia, and declines in submerged aquatic vegetation. Pollutants and pathogens in poultry litter traditionally linked to environmental degradation include nutrients and protozoan, bacterial and viral agents. In addition, recent attention has turned toward various non-traditional poultry litter-associated contaminants. These include feed additives (e.g. trace metals and antibiotics), poultry house/bedding material impurities (e.g. metals and pesticides) and faecal/urinary steroids (e.g. estrogenic and androgenic hormones). In most vertebrates, sex steroids, specifically 17-ß estradiol (E2) and testosterone, are responsible for gender differentiation, development of reproductive structures and stimulation of breeding behaviours. They are released naturally in poultry urine and faeces and persist at high concentrations and for prolonged durations (more than two years) in litter. Studies conducted on the Delmarva Peninsula and elsewhere have demonstrated the transport of E2 from poultry litter-amended fields to surface waters and groundwaters at levels sufficient to warrant environmental concern. The studies have also confirmed that these contaminants are capable of causing endocrine disruption in aquatic animals.

Source: Fisher *et al*. (2005).

Ecosystem contamination through ammonia deposition

Atmospheric ammonia (NH_3) is increasingly being recognized as a major air pollutant because of its role in regional-scale tropospheric chemistry and its effects when deposited into ecosystems. Ammonia is a soluble and reactive gas. This means that it dissolves, for example in water, and that it will react with other chemicals to form ammonia-containing compounds. The concentrations of ammonia in the air are greatest in areas where there is intensive livestock farming. Agricultural land receiving large inputs of nitrogen from manures normally acts as a source of ammonia, but it may also act as a "sink" and absorb ammonia from the atmosphere. There is little deposition of ammonia gas to intensively managed farmland, which is largely a net source of ammonia (Sutton and Fowler, 1995). Ammonia in the atmosphere can be absorbed by land, water and vegetation (known as dry deposition). It can also be removed from the atmosphere by rain or snow (wet deposition). Impacts of ammonia deposition include; soil and water acidification, eutrophication caused by nitrogen enrichment with consequent species loss, vegetation damage, and increases in emissions of the greenhouse gases such as nitrous oxide.

4 IMPACTS ON THE GLOBAL ENVIRONMENT

Environmental impacts of poultry production are not always confined to specific areas; they also include impacts of a global dimension. Two issues are of relevance: the production of concentrate feed and greenhouse gas production related to energy use in animal production processes and in the transport of processed products. This section analyses these two issues in the context of poultry production and the sector's impacts on the environment.

4.1 Feed production

Overview on feed consumption

The extraordinary performance of the poultry sector over the past three decades has partially been achieved through soaring use of concentrate feed, particularly cereals and soybean meal (FAO, 2006a). We estimate that in 2004 the poultry sector utilized a total of 294 million tonnes of feed, of which approximately 190 million tonnes were cereals, 103 million tonnes soybean meal and 1.6 million tonnes fishmeal.

Estimates put the global use of cereals for feed (all species included) at 666 million tonnes, or about 35 percent of total world cereal use (FAO, 2006a). This implies that in 2004 cereal utilization as feed by the poultry sector represented about 28 percent of the cereal and 75 percent of soybean meal used by the livestock sector.

The estimates for feed utilization by the intensive poultry sector were obtained by applying a two-step approach. The first step estimates total feed use in poultry systems by applying a "utilization approach", i.e. total feed utilization is obtained by multiplying total production (for poultry meat and eggs) by the corresponding feed conversion ratio which reflects both the intensity and efficiency of the livestock system.

The second step involves apportioning the total feed obtained per region based on the concept of "feed baskets". Feed baskets represent the different components that make up a feed ration in any given country. The major elements of feed baskets in intensive poultry systems are usually cereals, oilseeds and fishmeal (Steinfeld *et al.*, in FAO, 2006b), while those in mixed systems are to a greater extent made up of agro-industrial by-products (oilmeals, fishmeal) and crop residues, and contain less cereal. In calculating feed use the following assumptions were made.

1. Cereals make up the bulk of the feed baskets in intensive poultry production – an estimated 60 percent. The rest is shared between oilseeds (mainly soybean) and fishmeal (ibid.). However, cereal use for poultry production differs across countries, with maize dominating in Brazil, China and the United States of America, and wheat in the European Union (EU). In mixed systems, we estimate that cereals make up about 30 percent of the feed basket, with the remainder comprising crop residues and agro-industrial by-products.
2. This estimate also assumes homogeneity of poultry production across countries and regions and, therefore, applies an average feed conversion ratio across all regions. For poultry-meat products, an average was taken based on the feed conversion ratios for broilers, turkeys and ducks. For eggs, the feed conversion ratio average was based on the feed conversion ratio for brown-shelled and white-shelled layers. Poultry reared in landless systems are considered efficient users of feed and therefore have lower feed conversion ratios than those in mixed systems.

Demand for feed by the livestock sector has been a trigger for three major global trends: the intensification of feed production, agricultural expansion and erosion of biodiversity. The production of feed has an impact on the environment at various stages of crop production. In terms of the environment, these three trends have had a number of global impacts, which include land and water pollution, air pollution, greenhouse gas emissions, land-use change through deforestation and habitat change, and overexploitation of non-renewable resources.

Environmental impacts related to feed production

Intensive agriculture. Intensification of feed production affects land and water resources through pollution caused by the intensive use of mineral fertilizer, pesticides and herbicides to maintain high crop yields. It is estimated that only 30–50 percent of applied nitrogen fertilizer (Smil, 1999) and approximately 45 percent of phosphorus fertilizer (Smil, 2000) is taken up by crops. Steinfeld *et al*. (2006) estimated that about 20 million tonnes of nitrogen fertilizer were used in feed production for the livestock sector. Based on the estimation that the poultry sector utilizes 36 percent of feed concentrates (cereals and soybean), we can attribute about 7.2 million tonnes of nitrogen fertilizer use to feed production for the sector.

Intensive feed production also contributes to air pollution. The application of nitrogen fertilizer to cropland is a major source of air pollution through the volatilization of ammonia. Assuming an average mineral fertilizer ammonia volatilization loss rate of 14 percent, it has been estimated that global livestock production can be considered responsible for a global ammonia volatilization from mineral fertilizer of 3.1 million tonnes of NH3-N (nitrogen in ammonia form) per year (Steinfeld *et al*., in FAO, 2006b). Based on these same assumptions, the poultry sector can be considered responsible for about 1.1 million tonnes of ammonia volatilization from mineral fertilizer per year.

Intrusion into natural habitats. Increases in feed production, have to some extent been related to the expansion of cropland dedicated to feed. Feed production to satisfy the feed demand of intensive systems indirectly affects the global land base through changes in land use. Area expansion is in most cases at the expense of forested land (deforestation) cleared for crop production. For example, the land area for soybean production in Brazil increased from 1 million hectares in 1970 to 24 million hectares in 2004 – half of this growth came after 1996, most of it in the Cerrado, with the remainder in the Amazon Basin (Brown, 2005). According to Brazil's National Institute of Space Research (Bickel and Dros, 2003), just over 2.5 million hectares of forest in the Amazon disappeared in 2002, with about 70 percent of the 1.1 million hectare expansion of the agricultural frontier in the Amazon region alone attributed to soybeans. Wassenaar *et al*. (2007) project large hotspots of deforestation in the Brazilian Amazon forest related to the expansion of cropland, mainly for soybean. Changes in land use can have profound impacts on carbon fluxes, leading to increased carbon release and fuelling climate change. In addition to changes in carbon fluxes, deforestation also has an impact on water cycles and increases runoff and consequently soil erosion. WWF (2003) estimates that a soy field in the Cerrado loses approximately 8 tonnes of soil per hectare per year.

Erosion of biodiversity. Feed production is also driving biodiversity erosion through the conversion of natural habitats and the overexploitation of non-renewable resources for feed production. Intensive feed production contributes to biodiversity loss through land use and land-use change, and modification of natural ecosystems and habitats. The demand for feed has triggered increased production and exports from countries such as Brazil. Between 1994 and 2004, land devoted to soybean production in Latin America more than doubled to 39 million hectares (FAOSTAT, 2006).

The clearing of vast areas of the biologically rich Amazon rainforest and the Cerrado to produce maize and soybeans for feed has led to the loss of plant and animal species (Box 4).

Overexploitation of natural resources. The production of fishmeal for the poultry sector is an important factor contributing to the overexploitation of fisheries. The world's fish stocks are facing serious threats to their biodiversity. The principle source of this pressure is overexploitation, which has affected the size and viability of the fish populations (Steinfeld *et al*., in FAO, 2006b). FAO (2005) estimates that 52 percent of the world's fish stocks are fully exploited, and are therefore producing catches that are already at or very close to their maximum sustainable yield. Current estimates are that around 40 percent of global fishmeal production is used for the livestock sector of which 13 percent is used by the poultry sector (Figure 2) (Jackson, 2007).

The expansion of the aquaculture sector and its demand for fishmeal as a feed ingredient has led to a reduction in the use of fishmeal by the poultry sector (as illustrated in

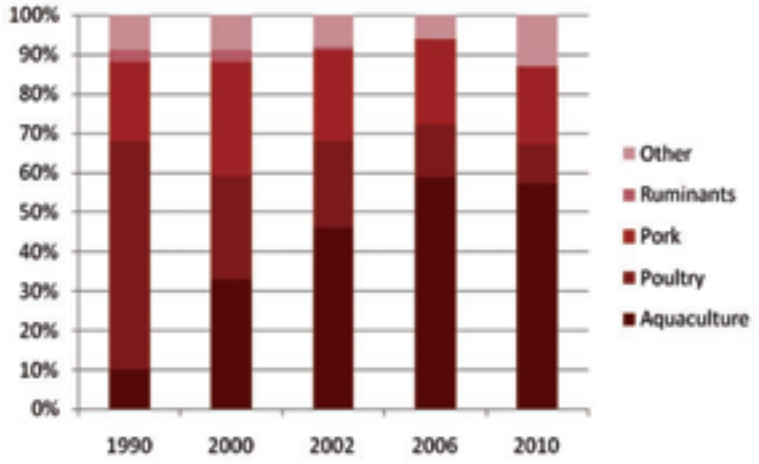
BOX 4:
Soybean production in the Cerrado

The Cerrado is one of the world's biodiversity hotspots. It has an area of 200 million ha and covers a quarter of Brazil, making it the country's second biggest ecosystem after the Amazon. It is regarded as the world's most species-rich savannah. Having approximately 4 400 endemic species in a total of 10 000 species of plants, it is classified as one of the earth's 25 biodiversity "hot spots". However, the areas designated as protected – barely 1.5 percent – are far fewer and smaller than in the Amazon. The Cerrado, Brazil's second major biome, is suffering severe clear-cutting and irreversible losses of its original vegetation and biodiversity. Numerous animal and plant species are threatened with extinction as a result of the expansion of the agricultural frontier, and an estimated 20 percent of threatened and endemic species do not occur in protected areas.

The extent of the destruction of the Cerrado is now evident. Two-thirds of its original vegetation has already been destroyed or severely degraded. Cultivation of soybeans in the Cerrado has since 1970 risen from 20 000 to 29 million tonnes – an increase in Brazilian soybean production from 1.4 percent to 58 percent. As state planning on land use – determining where and how much primary vegetation should be converted to land for agricultural use – exists only in a rudimentary form, soybean expansion is one of the main factors threatening the Cerrado ecosystem.

Sources: Bickel (2005); Klink and Machado, (2005).

FIGURE 2
Past and projected trends in global use of fishmeal by sector



Sources: Marine Aquaculture Task Force (2007); Jackson (2007).

Figure 2). Between 1990 and 2006, the share of fishmeal consumed by the poultry industry decreased drastically from about 58 percent to 13 percent. The poultry sector compensated for this loss by increasing the amount of soybean meal used in feed rations. Despite current and projected decline in the sector's use of fishmeal as a feed input, the role of the industrial poultry sector in the overexploitation and depletion of fisheries can not be ignored.

4.2 Climate change

The relatively high energy input in intensive livestock systems has given rise to concerns regarding greenhouse gas emissions and climate change. The energy consumption of industrially produced poultry is relevant because of the production of carbon dioxide (CO_2) along the production chain. Carbon dioxide emissions are produced by the burning of fossil fuels during animal production and slaughter, and transport of processed and refrigerated products, but importantly also through land use and land-use change, and the use of inputs for the production of feed.

On-farm energy consumption

On-farm energy consumption includes direct and indirect energy input – direct energy refers to fossil energy used for the production process (e.g. energy input for poultry housing systems), and indirect energy to that used as an integral part of the production process (e.g. feed processing). Due to a lack of information on energy use for processing, this estimation of on-farm fossil fuel consumption is limited to quantifying energy use associated with poultry housing.

The energy used for heating, ventilation and air conditioning systems typically accounts for the largest quantity of energy used in intensive poultry operations. Animal housing

TABLE 1
Energy consumption in poultry production

Activity	Estimated energy consumption		
	Broilers[a]	Layers[a]	Turkeys[c]
Local heating	13–20		
Feeding	0.4–0.6	0.5–0.8	
Ventilation	0.10–0.14	0.13–0.45	1.4–1.5
Lighting		0.15–0.40	
Egg preservationb		0.30 –0.35	

Notes: a – Wh (watt hour)/bird/day; b – Wh/egg/day; c – kWh/bird/year.
Sources: World Bank (2007); EU (2003).

facilities are therefore potential sources of carbon dioxide emissions from intensive poultry farms. Other sources of carbon dioxide emissions include energy used for feed preparation, on-farm transport and burning of waste (EU, 2003). Generally, on layer farms, artificial heating of housing is not commonly applied, due to the low temperature needs of birds and the high stocking density. The activities that require energy are ventilation, feed distribution, lighting, and egg collection, sorting and preservation. On broiler farms, the main energy consumption is related to local heating, feed distribution and housing ventilation. Quantification of the energy consumption of intensive poultry farms is a complex undertaking because systems are not homogeneous. The amount of energy consumed varies with the technologies applied, the production characteristics of the farms, and climatic conditions. Table 1 shows energy requirements of some essential activities on broiler, layer and turkey farms in the EU.

A rough indication of the fossil fuel related emissions from intensive poultry systems can be obtained by applying the energy requirements given in Table 1, assuming that the energy consumption for heating during the winter in higher latitude countries is equivalent to the high energy use for ventilation in lower latitudes. By applying these estimates to the global total for intensively produced poultry, it is estimated that about 52 million tonnes of carbon dioxide are emitted per year.

Carbon dioxide emissions from slaughtering

Poultry processing facilities use energy to heat water and produce steam for process applications and cleaning, and for the operation of mechanical and electrical equipment, refrigeration and air compressors. In poultry abattoirs, fossil fuel is mainly used for process heat, while electricity is used for the operation of machinery and for refrigeration, ventilation, lighting and the production of compressed air. Ramírez *et al*. (2004) in an analysis of energy consumption in the EU meat industry found poultry slaughtering to be more energy intensive (3 096 MJ/tonne dress carcass weight) than other meat sectors (1 390 MJ/tonne dress carcass weight for beef and 2 097 MJ/tonne dress carcass weight for pork).

Using the Ramírez *et al*. (2004) estimates of energy consumption values for poultry, we estimate that carbon dioxide emissions from poultry slaughtering facilities amount to 18

million tonnes. This estimate is obtained by applying the energy consumption data to total poultry meat production and multiplying by the respective carbon dioxide emission factors for both electricity and natural gas.

Carbon dioxide emissions from international trade

International trade in poultry meat contributes significant carbon dioxide emissions – induced by fossil fuel use for the shipping of poultry meat. Steinfeld *et al*. (in FAO, 2006b) estimated carbon dioxide emissions by combining traded volumes with respective distances, vessel capacities and speeds, fuel use of main and auxiliary power generators for refrigeration, and their respective emission factors. Based on this analysis, trade in poultry meat was found to contribute an estimated 256 000 tonnes of carbon dioxide (representing about 51 percent of the total carbon dioxide emissions induced by meat-trade ocean transport). The addition of transportation within national boundaries, involving shorter distances, but much larger quantities and less efficient vehicles, would certainly increase significantly the sector's greenhouse gas emissions related to transportation.

Greenhouse gases emissions from feed production

Emissions of greenhouse gases such as carbon dioxide and nitrous oxide are influenced in an indirect way by intensification of feed production, which requires energy input for the production of mineral fertilizer and the subsequent use of this fertilizer in the feed production process.

Carbon dioxide (CO_2). This greenhouse gas is produced by the burning of fossil fuels during the manufacture of fertilizer. By applying energy use per tonne of nitrogen fertilizer (estimated at 40 GJ per tonne) and the IPCC (Intergovernmental Panel on Climate Change) emission factor for natural gas (17 tonnes of carbon per terajoule) to total nitrogen fertilizer use in the production of feed for poultry production (estimated at 7.2 million tonnes) and applying the ratio of the molecular weight of carbon dioxide to the molecular weight of carbon (44/12) results in an estimated annual carbon dioxide emission of 18 million tonnes – about 44 percent of that ascribed to the livestock sector.

Nitrous oxide (N_2O). Poultry production is indirectly associated with the greenhouse gas nitrous oxide because of the sector's high concentrate-feed requirements and the related emissions from arable land due to the use of nitrogen fertilizer. FAO–IFA (2001) reported a 1 percent N_2O-N (nitrogen in nitrous oxide) loss rate from nitrogen mineral fertilizer applied to arable land. By applying this loss rate to the total nitrogen fertilizer attributed to the poultry sector, we estimate that nitrous oxide emissions from poultry feed related fertilizer to be 0.07 million tonnes of N_2O-N per year – about 35 percent of the global nitrous oxide emissions attributed to the livestock sector from mineral fertilizer application.

Overall, intensive poultry production (indirectly and directly) contributes an estimated 3 percent of the total anthropogenic greenhouse gas and is responsible for about 2 percent of the total greenhouse gas emissions from the livestock sector. This estimate however does not include emissions from land use and land-use change associated with feed production or emissions related to transport of feed.

TABLE 1
Summary of greenhouse gas emissions related to poultry production

	Million tonnes carbon dioxide equivalent
Carbon dioxide	
Nitrogen fertilizer production for feed	18
On-farm energy consumption	52
Slaughtering	18
International trade (transport)	0.3
Nitrous oxide	
Indirect fertilizer emissions	0.02
Total	88.3
Share of the livestock sector	2%
Share of anthropogenic emissions	0.3%

Note: These estimates do not include emissions related to land use and land-use change, nor intra-national transportation.

5 TECHNICAL MITIGATION OPTIONS

The magnitude of environmental impacts is highly dependent on production practices and especially on manure management practices. We introduce here a number of techniques and management practices that are available to control the environmental issues described above. Lack of awareness and capital are often cited as the two factors hampering the implementation of such practices.

5.1 Farm management

Taking environmental issues into account in all management strategies at the farm level can reduce the impacts felt at the level of production.

Odour emissions can be controlled by:

- minimizing the surface of manure in contact with air – frequent collection of litter (once a week in dry seasons and twice a week in rainy seasons), closed storage (bags or closed sheds);
- cooling animal manure, achieved as a positive side effect of cooling the animal houses – cooling systems can be equipped with biofilters and air scrubbers that trap odours from the ventilation airflow;
- lowering litter's water content – achieved by the incorporation of hydrophilic products such as hashes, rice husk, peanut husk, dust or sawdust;
- applying deodorant products to feed or directly to animal houses; and
- building wind protection structures.

The proliferation of flies and mosquitoes can be controlled by:

- minimizing the surface of manure in contact with air – frequent collection of litter (once a week in dry seasons and twice in rainy seasons, i.e. at shorter intervals than the length of the larvae development cycle), closed storage (bags or closed sheds);
- lowering litter's water content – achieved by the incorporation of hydrophilic prod-

ucts such as hashes, rice husks, peanut husks, dust, sawdust or available dry crop residues;
- applying insecticides (this practice may however have significant public health-related side effects);
- building wind protection structures;
- positioning nets around the farm.

Rat proliferation can be controlled by:
- minimizing feed losses during storage and feeding;
- raising cats or keeping snakes in cages close to the poultry barn to scare rats; and
- use of poison or traps.

Visual impact and landscaping can be improved by:
- use of screening trees around the farm facility to reduce the visual impact of farm infrastructure and of noise, dust, light and odour;
- use of the natural topography and terrain of the site and the existing vegetative cover to maximize visual screening; and
- use of construction materials that minimize visual impact.

5.2 Animal waste management

Soil and water pollution is controlled through the implementation of good fertilization practices. In brief: environmental risks are reduced when manure is applied in amounts and at times that correspond to crop or fish-pond uptake. Water pollution is often an acute problem in waterfowl production, especially when the flock is concentrated on relatively small ponds. There is currently a lack of information with regard to the effects of waterfowl production on surface water and groundwater resources.

Water- and food-borne disease propagation can be prevented by:
- storing manure in closed buildings or bags – a storage system allows producers to hold manure until a convenient and optimum time for use; storing poultry manure in closed buildings reduces the emissions of gaseous compounds to the air, and the risk of environmental contamination as compared to the risk associated with leaving manure exposed;
- storing the manure for one to two months before its application on land or fish ponds;
- composting manure – potentially reduces or even eliminates certain pathogens and fly larvae, and improves the handling characteristics of manure and other residues by reducing their volume, weight and moisture content (most manure and other organic residues usually contain high nitrogen content and are, therefore, subject to nitrogen loss during composting);
- drying (with machine or by spreading out) – minimizes the moisture content of manure, inhibits chemical reactions, and thus reduces emissions (the best way to prevent ammonia emissions from poultry litter and manure is to reduce microbial decomposition, which can be accomplished by drying the freshly produced manure as soon as possible and keeping it dry);

- timing and rate of manure application – this is a critical management factor; manure must be applied at the correct time of year to prevent losses to surface water, groundwater and the atmosphere, and to optimize the utilization of manure nutrients by growing plants; proper timing is a function of several variables, including weather, soil conditions and stage of crop growth; and
- dead-bird management and disposal, which must comply with legally accepted practices including rendering, composing, incineration and burial; a contingency plan should be in place for disposal of large numbers of dead birds in the event of disease outbreaks; in addition, consideration should be given to impacts on the physical environment – e.g. burial pits should be at least 3 metres above the maximum groundwater table.

5.3 Nutrition management

Nutritional management aims to reduce pollution load by limiting excess nutrient intake and/or improving the nutrient utilization efficacy of the animal. It not only affects the quantity of mineral outputs from animals and the characteristics of manure, but also has cross-media effects – reducing the pollution load of soil, water and air. Nutrition management can also allow improvement to feed conversion ratios through optimal diet balancing and feeding regimes, and improvement to feed digestibility. This reduces the amount of feed used per unit of livestock product. Relevant measures include:

- formulating feeds that closely match the nutritional requirements of birds in their different production and growth stages to reduce the amount of nutrients excreted; options in this category include phase feeding, split-sex feeding or feed formulation on an available-nutrient basis;
- use of low-protein diets supplemented with amino acids, and low-phosphorus diets with highly digestible inorganic phosphates;
- improving feed digestibility and nutrient bioavailability through the use of dietary supplementary enzymes such as phytase, highly digestible genetically modified feedstuffs such as low-phytate maize, and highly digestible synthetic amino acids and trace minerals; and
- using good quality, uncontaminated feed (e.g. in which concentrations of pesticides and dioxins are known and do not exceed acceptable levels) which contains no more copper, zinc, and other additives than is necessary for animal health.

5.4 Feed production

The key to reducing the negative environmental impacts associated with intensive agriculture for feed production lies in increasing efficiency, i.e. increasing production while reducing the use of inputs that adversely affect the environment. The negative effects of feed production can be greatly reduced with appropriate cultivation (e.g. minimum tillage), integrated pest management (IPM) and targeted fertilizer inputs. Technologies are available for many different environments to conserve soil and water resources and to minimize the use and impact of inorganic fertilizers and pesticides.

Good agricultural practices require the application of available knowledge to the utilization of the natural resource base in a sustainable way for the production of safe and

healthy food. Management of resources such as soil and water by minimizing losses of soil, nutrients and agrochemicals through erosion, runoff and leaching into surface water or groundwater is a criterion for good agricultural practice. Good agricultural practice will maintain or improve soil organic matter through the use of appropriate mechanical and conservation tillage practices; will use soil cover to minimize erosion loss by wind or water; and will ensure that agrochemicals and organic and inorganic fertilizers are applied in amounts, at times and using methods, appropriate to agronomic and environmental requirements.

IPM uses an understanding of the life cycle of pests and their interactions with the environment, in combination with available pest control methods, to keep pests at a level that is within an acceptable threshold in terms of economic impact, while giving rise to minimum adverse environmental and human health effects. Recommended IPM approaches include: use of biological controls such as predators, parasites and pathogens to control pests; use of pest-resistant varieties; mechanical and biological controls; and, as a last resort, chemical controls including synthetic and botanical pesticides. Other IPM approaches encompass pesticide application techniques that aim to increase the efficiency of chemical applications.

Minimal tillage practices in agronomic crops such as soybean and maize reduce the loss of nutrients from the field, they also improve the water-stability of soils and reduce soil erosion; this often results in higher levels of soil organic carbon and reduces carbon emissions.

Enhancing the efficiency of water use in feed production by improving irrigation efficiency and water productivity is a further method of reducing adverse environmental impacts. Water productivity can be improved by methods including selection of appropriate crops and cultivars, better planting methods, minimum tillage, timely irrigation that matches water application with the most sensitive growing periods, nutrient management and drip irrigation.

6 CONCLUSIONS

This paper has focused on poultry production in intensive systems and its impacts on the environment. The assessment captures most of the issues associated with poultry production, as environmental impacts related to backyard or mixed extensive systems are marginal because of the limited concentration of wastes and reliance on locally available sources of feed, such as food residues, crop residues or feed collected by free-ranging birds. The review has also demonstrated the need to look beyond the farm level in order to understand the sector's impacts on the environment, as many of the impacts of production are felt beyond the point of production.

Generally, the environmental impacts of the sector are substantial. Poultry production is associated with a variety of pollutants, including oxygen-demanding substances, ammonia, solids, nutrients (specifically nitrogen and phosphorus), pathogens, trace elements, antibiotics, pesticides, hormones, and odour and other airborne emissions. These pollutants have been shown to produce impacts across multiple media. These impacts can be summarized as follows.

Surface water impacts. Impacts are associated with waste spills, as well as surface

runoff and subsurface flow. The oxygen demand and ammonia content of the waste can result in fish kills and reduced biodiversity. Nutrients contribute to eutrophication and associated blooms of toxic algae and other toxic micro-organisms. Human and animal health impacts are associated with drinking contaminated water (pathogens and nitrates) and contact with contaminated water (pathogens and Pfiesteria). Trace elements (e.g. arsenic, copper, selenium and zinc) may also present human health and ecological risks. Antibiotics, pesticides and hormones may have low-level but long-term ecosystem effects.

Groundwater impacts. Impacts associated with pathogens and nitrates in drinking water may cause underlying groundwater to become unsuitable for human consumption.

Air/atmosphere impacts. Impacts include those on human health (caused by ammonia, hydrogen sulfide, other odour-causing compounds, and particulates), and contribution to global warming (due to carbon dioxide and nitrous oxide emissions from the production process and other related activities such as feed production and transport of finished products). Additionally, volatilized ammonia can be re-deposited and contribute to eutrophication, acidification and damage to vegetation and sensitive ecosystems.

Soil impacts. Nutrients and trace elements in animal manure can accumulate in the soil and become toxic to plants.

Other indirect impacts include ecosystem destruction and biodiversity erosion associated with the expansion of feedcrop production into natural habitats and the overexploitation of non-renewable resources for feed production.

Compared to other livestock species, however, poultry performs well from an environmental perspective. A substantial comparative advantage that poultry has over other animal sectors relates to its efficiency in feed conversion. Poultry's feed conversion ratio represents a major contribution to the profitability of the industry in terms of reduced feed inputs as well as in waste output. For cattle in feedlots, it takes roughly 7 kg of grain to produce a 1 kg gain in live weight. For pork, the figure is close to 4 kg per kg of weight gain, for poultry it is just over 2 kg, and for herbivorous species of farmed fish, such as carp, tilapia, and catfish, it is less than 2 kg (Brown, 2005). Another comparative advantage lies in the low water content and high nutrient content of poultry manure. It is, thus, often handled with more care than manure from other species – especially pigs – as recycling is generally economically profitable.

Technologies exist that have the potential to produce substantial reductions in environmental impacts. The problem is one of cost, corresponding incentives/disincentives and awareness. Given the strong reactivity of the sector (large companies, foreign direct investment, demand growth), getting economic incentives and disincentives right within a framework of market forces should be sufficient to minimize environmental impacts.

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Do old and new forms of poultry go together?

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SUMMARY

Given conflicting zoosanitary regimes, the question arises whether or not old and new forms of poultry production may peacefully co-exist in the face of highly pathogenic avian influenza (HPAI) and other biological threats. Here, we argue that commercial poultry plants and associated distribution and marketing channels may have to step-up biosecurity and sanitation efforts in order to halt the evolution of further pathogens that thrive on mass-rearing of birds in quasi-biosecure conditions. Scavenging poultry, on the other hand, may be more capable of resisting parasites and infectious disease agents, but it should be noted that there are a growing number of exceptions, including HPAI and other, mainly RNA, viruses. Mostly, these pathogens first emerge as virulent agents in large poultry plants. Conversely, there is evidence that commercial poultry chains are forced progressively to invest in health protection because the poultry plants are under increasing threat from microbes circulating freely in nearby village or backyard poultry. Given the rapid evolution of medium-size systems and live-bird markets, meeting points between old and new forms of poultry husbandry are on the rise and so are the options for mutually destructive pathogen transmissions. Hence, structural reforms are necessary in order to address the growing health threats present in today's far too complex poultry circuitries.

Key words: old, new, production, systems

1 INTRODUCTION

Large-scale commercial poultry production plays an important role in feeding a rapidly growing urban middle class worldwide. Modern poultry chains provide quality protein which is safe, nutritious and relatively cheap. At the same time, different forms of backyard poultry continue to play an important role in providing food and income to mainly rural societies. The co-existence of large-scale commercial and low-input systems cause conflicts because of contrasting zoosanitary regimes. For example, the switch from low to highly pathogenic avian influenza (HPAI) typically takes place upon the entry of a wild-bird carried virus into a large flock of domestic birds (Duan *et al.*, 2007; Campitelli *et al.*, 2004). Following the propagation of virus in commercial premises, village or backyard poultry also may become infected (Alexander, 2007a). When commercial holdings have restored freedom from HPAI, backyard systems may still be experiencing infection (Sims, 2007).

One of the lessons learned with HPAI H5N1 is that free-ranging ducks in rice–duck agricultural systems may end up as a virus reservoir and a supply source of HPAI virus, which poses a risk to susceptible terrestrial poultry (Gilbert *et al*., 2006). A growing number of live-bird markets (LBM) act as meeting points for poultry of all sorts. LBMs constitute important nodes in the viral contact network structure (Ellis *et al*., 2004). The combination of LBMs, village or backyard poultry, medium-sized holdings, large duck populations in irrigated-rice areas, migratory birds, peri-urban poultry industries and associated input-supply, processing, distribution and marketing networks, including international trade and traffic, has led to entrenchment of the HPAI H5N1 virus in three continents. Hence, disease-prevention efforts should encompass measures that go beyond the veterinary realm, and consider reforming the poultry environments.

2 HPAI H5N1 BIOCOMPARTMENTS

HPAI has over the past five or so decades become increasingly more common in poultry industries across the globe (Alexander, 2007a). Along with the increasing number of outbreaks, the duration of individual HPAI episodes and the number of infections in humans also gradually increased. The surge of HPAI H5N1 in Asia has amplified this trend. Asia today remains the geographical focus of HPAI. The genesis, spread, persistence and continuous evolution of the H5N1 virus in this region brings us to consider the distinct biocompartments sustaining the virus transmission cycles.

First, we consider the wild water-bird reservoir which constitutes the natural ecology for all existing avian influenza viruses (Webster *et al*., 1992). A highly diverse gene pool of continually re-assorting virus genetic segments secures the virus subtype diversity that fits myriad ecological settings across the Palearctic and Nearctic bio-geographical regions. The foremost avian host is the mallard duck, but other dabbing duck species, anseriform birds, shore birds, waders, passerines and other species, including birds of prey, may also be found infected, albeit in decreasing order of virus prevalence and subtype diversity.

Poultry encroachment by avian influenza virus mostly involves opportunistic H7 and H5 subtypes (Alexander, 2007b). Presumably, terrestrial poultry triggered the initial switch from low to highly pathogenic avian influenza H5N1 virus (Duan *et al*., 2007). The strong affinity of this virus to aquatic poultry became clear when, during the 1990s, a diversity of H5N1 genotypes started circulating in healthy, domestic ducks distributed in southern and coastal areas of China (Chen *et al*., 2004). Duck production in China had accelerated since the mid-1980s, and exponential-scale growth continued through the 1990s (FAO, 2007a). While H5N1 prevalence was initially prominent in ducks and geese, infection rates in chickens increased gradually (Chen *et al*., 2006). The spread of the H5N1 virus in poultry assumed subcontinental proportions in 2003–2004 (Li *et al*., 2004). Inter-continental panzootic waves followed during 2005–2007 (Kilpatrick *et al*., 2006). In the process, the H5N1 had spilled back to migratory waterfowl, which occasionally vectored the virus over large distances (Gilbert *et al*., 2006). The virus had also infected commercial poultry chains operating internationally, mainly through trade and traffic of day-old chickens.

The most important biocompartment is the LBM, which acts as an amplifying node for viral traffic, indirectly linking commercial networks and village or backyard poultry (Ellis *et al*., 2004; Sims, 2007). Village poultry may not contribute much to the bulk of live birds

supplied to the markets, but given the readiness with which open systems attract infection, and given also that sales of village poultry go through intermediaries linked to the urban demand centres, village poultry also constitutes a relevant biocompartment.

Free-range duck populations in rice paddies in river deltas, plains and other wetlands of East and Southeast Asia act as another major biocompartment (Gilbert *et al*., 2006). Free-ranging ducks are linked to wild water birds, to village poultry and occasionally also to LBMs, and thus form a supply source for virus dispersal into wider areas (Hulse-Post *et al*., 2005; Gilbert *et al*., 2006). The countries where the H5N1 virus has become entrenched include Bangladesh, China, Indonesia and Viet Nam in Asia, and Egypt and Nigeria in Africa. Today (late 2007) most countries in Asia with important duck populations experience a persisting H5N1 problem. India and the Philippines are among the exceptions. Egypt also reportedly holds 45 million ducks, mainly in the Nile delta. Ducks do not normally show major clinical symptoms (Brown *et al*., 2006; Sturm-Ramirez *et al*., 2005). Kept near or mixed with terrestrial poultry, ducks act as virus supply source while susceptible chickens and other birds support the active spread of disease, particularly when this also involves live-bird markets. Geographic amplification may occur through commercial networks or wild-bird vectoring of virus (Kilpatrick *et al*., 2006).

Transmission cycles are collectively sustained through wild birds, ducks, backyard/village poultry, LBMs, commercial chains and associated distribution networks. These compartments form the component parts of a system of global disease spread and persistence. Mammals, including humans, are also sometimes infected with HPAI H5N1, but these are spill-over infections or short, dead-end infection chains. Humans and other mammals do not form a separate biocompartment sustaining the global transmission cycle.

3 REFORMING BIOCOMPARTMENTS

Arguably, the best prospects for freeing any one biocompartment from HPAI are in the commercial systems. Here, terrestrial poultry is kept in full confinement and input supplies are closely integrated – from grandparent stock to feed mills, hatcheries, production plants, slaughterhouses and processing units, including the product-related distribution and marketing chains. However, in most countries in Asia, and also in Africa, birds produced in biosecure production plants are also supplied to LBMs. Intermediary vendors may also form an important source of infection for commercial plants. Additional risks for H5N1 infection are associated with wild birds and scavenging poultry around premises. Still, these risks may be readily contained; most enterprises producing broiler meat, and those producing hen eggs, succeed in securing HPAI-free production environments even in affected areas. Partially open plants, such as those involving turkeys, quails and domestic waterfowl, pose a higher risk. Theoretically, these risks may be minimized through the creation of clusters of licensed producers, certified HPAI-free, which only supply the LBM allocated to them. No other suppliers would obtain access to these closed LBM systems. Provided such an exercise is supported by proper risk assessment, city councils may assist in creating an expanding HPAI-free poultry production and marketing environment. Once major urban LBMs turn HPAI free, opportunities would arise also for the smaller LBMs and producer associations. Instead of introducing policing and law enforcement, stakeholders may be actively encouraged to take matters in their own hand. If more producers would start supplying exclusively

local markets, a progressive disruption of the transmission cycle could result. It would be necessary to act in cohesion and on the basis of well-defined risk-management schemes.

In situations where LBMs become free from virus and turn HPAI-proof, there would still be virus persistence in more remote rural poultry, particularly in the wetland-associated duck reservoirs. However, given the scattered nature of village flocks and free-ranging ducks populations, this could present a next target for step-wise, progressive HPAI control. In the absence of such progressive, coordinated control, it is unlikely that H5N1 or other HPAI viruses will ever disappear. Periodic epidemic waves would continue, as is observed in the case of the velogene Newcastle Disease viruses which bring severe mortality to village poultry in Asia and Africa, mostly at the onset of the rainy season. HPAI in Southeast Asia could turn increasingly seasonal in areas with a high density of smallholders and/or medium-size, mixed poultry plants. The presence of free-ranging duck virus reservoirs may readily kick-start an epidemic wave, even in the absence of HPAI-infected LBMs or commercial chains. There is also the possibility that wild ducks and other waterfowl will play an increasingly prominent role in vectoring H5N1 viruses across Eurasia (Duan *et al*., 2007).

4 REFORMING OLD AND NEW FORMS OF POULTRY PRODUCTION

The answer to the question of whether old and new forms of poultry go together is mostly negative. The rationale for this goes back to the principles of disease ecology. Progressive intensification of poultry production kicked-off during the 1950s and early 1960s, starting in the United States of America and other developed countries where the market provided the incentive and technologies had become available to apply economies of scale. A global poultry wave followed, with rapid expansion and peak growth in Europe during the 1970s, in Latin America during the 1980s, and in Asia during the 1990s. Industrial production of eggs became an economically viable undertaking almost everywhere on the planet, as long as a sufficiently large demand centre was within reach. Global broiler production became much less evenly distributed in geographical terms because of focal chicken-feed supply sources and energy and transport-related market forces (FAO, 2007). Nonetheless, even in places where poultry-meat production has become concentrated in relatively small areas, there is confidence that specified-pathogen-free environments and a steady supply of high-quality products – nutritious, safe and relatively cheap – can be secured also in the future. However, this may not be achieved in some countries.

Figure 1 displays the trajectories of poultry intensification as experienced in Brazil, China, the European Union (EU15[3]), and the United States of America. Each trajectory is given by the line connecting poultry intensification scores for consecutive years starting from 1960 to 2005. Intensification is measured in terms of the output–input ratio (chicken produce relative to the standing population) held against farmer density. China has only recently started to intensify poultry production on a large, industrial scale and will for a long period of time continue to rely also on smallholders supplying local markets. This could provide a breeding ground for avian pathogens. A growing number of virulent infectious disease agents are finding their way from large to medium to small poultry units and vice versa. Aggressive pathogens thrive well on mass-rearing of birds kept in permanent confinement

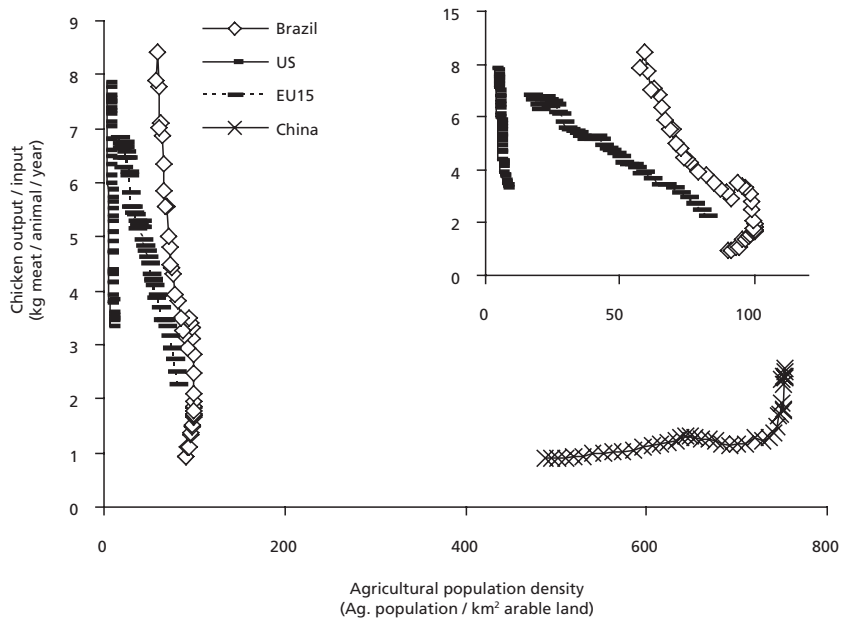
[3] The 15 countries that were members of the European Union prior to expansion in 2004.

and in high concentrations, of the same age and sex, immuno-susceptible, and which are genetically selected for production traits rather than for any resistance against disease agents. While scavenging poultry better resist parasites and infectious disease agents, there are a growing number of exceptions, including HPAI viruses (Alexander, 2007a), velogene Newcastle disease virus (Wan *et al*., 2004), gumboro disease (Gottdenker *et al*., 2005), and infectious bronchitis viruses (Gutierrez-Ruiz *et al*., 2000). Mostly, these pathogens first emerge as virulent agents in large poultry plants. At the same time, there is evidence that commercial poultry production chains are forced to progressively invest in health protection because their poultry plants are under increasing threat from microbes circulating freely in adjacent village or backyard poultry.

Given the rapid evolution of mixed, quasi-biosecure systems and of live-bird markets, the number of meeting points between old and new forms of poultry husbandry is on the rise and, unfortunately, so are the options for mutually destructive pathogen transmissions. Segregation of old and new forms of production, not just in terms of biological compartmentalization, but also in geospatial and land-use terms may be the answer. Due attention should be given to the fact that the rationale for pathogens evolving into virulent forms and engaging in species jumps goes back to disease ecology. Wherever a host ecological vacuum emerges, opportunistic and intrusive disease agents will explore whether this alien

FIGURE 1

Poultry intensification trajectories as observed in Brazil, China, the European Union (EU15) and the United States of America, from 1960 to 2005



Note: The insert in the top-right corner shows further detail of just the United States of America, EU15 and Brazil (from left to right)

host resource may be worthwhile exploiting. RNA viruses are particularly flexible in this regard, capable of blending invasive behaviour and genetic host-range adjustment into a single ecological strategy, securing pathogen fitness in a dynamic host environment. Evidently, poultry production, being highly dynamic, provides the right incentive to drive such developments.

Reforms may even be necessary beyond the poultry subsector. A number of pathogenic agents in food and agriculture have recently been shifting from an animal to a human host preference. An increase in demand for bush meat is believed to have contributed to the evolution of the HIV-AIDS virus (May *et al*., 2001). The recycling of ruminant carcasses brought the bovine spongiform encephalopathy (BSE) – new variant Creutzfeldt-Jakob disease (CJD) prion (Pattison, 1998). Pig production below trees with fruit bats introduced the Nipah virus (Field *et al*., 2001). Civet cats in wet markets brought out the severe acute respiratory syndrome (SARS) corona virus normally carried by horseshoe bats (Lau *et al*., 2005). Given the diversity of pathogens circulating in the natural ecologies, and food-animal chains, plus global factors such as human demography, urbanization, trade liberalization, and, last but not least, climate change, yet more problems will undoubtedly emerge (Slingenbergh *et al*., 2004). Hence, there is some urgency to identify and rectify the food and agricultural practices that amplify these risks.

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OIE standards and guidelines related to trade and poultry diseases

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SUMMARY

Recognizing the difficulty faced by some countries in fully eradicating animal diseases from their territories as a whole, or to maintain animal disease-free status in parts of their national territories, the World Organisation for Animal Health (OIE) has introduced the concepts of zoning and compartmentalization for purposes of disease control and international trade, in the Terrestrial Animal Health Code. Compartmentalization is based mainly on functional separation by biosecurity measures, whereas zoning is based mainly on geographical separation. Relevant animal subpopulations should be clearly defined, recognizable and traceable, and should be epidemiologically separated from other subpopulations. Veterinary authorities as well as the private sector have important responsibilities in the establishment and maintenance of compartments.

Key words: OIE, standards, guidelines, compartmentalization, zoning

1 INTRODUCTION

The World Organisation for Animal Health (OIE)[1] is an independent intergovernmental organization founded in 1924, and having 172 member countries in January 2008. OIE's mandate is to improve animal health worldwide. The organization achieves this mandate through its six primary objectives, which include ensuring transparency in the global animal disease situation, permanent update of disease prevention and control methods, provision of international solidarity in the control of animal diseases, publication of international animal health standards, and improvement of the legal framework and resources of veterinary services. For several years, the OIE has also had a strong focus on improving animal production food safety and animal welfare. OIE's headquarters are in Paris (France), and there are nine regional offices in the five regions. The OIE now has two regional animal health centres operating in collaboration with FAO, based in Bamako and Beirut, and is planning to establish other centres that will serve as regional centres of expertise.

In order to fulfil the mandate to ensure transparency in the global animal disease situation, the OIE manages the World Animal Health Information System (WAHIS)[2], based on

[1] The World Organisation for Animal Health: http://www.oie.int/eng/en_index.htm.

the commitment of member countries to notify the main animal diseases, including zoonoses, to the OIE. In 2004, OIE member countries approved the creation of a single list of diseases notifiable to the OIE to replace the former lists A and B. The content of the list is based on a decision tree which is part of the *Terrestrial Animal Health Code*. Currently, about one-hundred diseases are listed; thirteen of these are poultry diseases, among which are highly pathogenic avian influenza (HPAI), Newcastle disease, Marek's disease, infectious bursal disease and avian infectious laryngotracheitis.[3]

First outbreaks of all listed diseases should be officially notified to the OIE central bureau within 24 hours, and regular update reports should be provided on the outbreak situation. The information is immediately disseminated to the delegates of all member countries, who can use it to analyse the risk of introduction of diseases into their own countries. Member countries must also provide six-monthly reports on their animal disease situation. The World Animal Health Information Database (WAHID) interface provides access to all data held within WAHIS[4]. The OIE animal health information department actively approaches delegates to verify unofficial information on outbreaks of animal diseases in member countries. In the Global Early Warning and Response System (GLEWS), a cooperative mechanism between OIE, FAO and WHO, the official and unofficial outbreak information of the three organizations is shared to allow better intervention, better analysis of data and more targeted capacity-building in relevant member countries.

As the international standard-setting body for animal health, the OIE has defined standards on notification, trade aspects and surveillance of the listed diseases, including the poultry diseases. The aim of the *Terrestrial Animal Health Code*[5] is to ensure the sanitary safety of international trade in terrestrial animals and their products, by detailing the health measures to be used by the veterinary services of importing and exporting countries. The measures are also meant to avoid the transfer of pathogenic or zoonotic agents without imposing unjustified trade restrictions.

The OIE is in a continuous process of updating its disease standards, while taking into account the latest scientific information on the diseases. For example, the chapter on avian influenza in the *Terrestrial Animal Health Code* was updated in 2004. The new chapter has several significant changes compared to the previous one, such as differentiating between low and highly pathogenic avian influenza and defining HPAI as an infection of poultry. The chapter gives trade recommendations for poultry and poultry products like fresh meat, meat products, eggs, feathers and down. *The Terrestrial Animal Health Code* also provides general guidelines for surveillance and specific guidelines by disease.

The specific disease standards are further defined in related chapters, appendices and definitions, which include: standards for surveillance that have to be met if countries are to declare freedom from disease; standards for conducting risk assessments; humane methods for killing animals if stamping-out of infected populations is necessary; methods for disposal of dead animals; biosecurity standards for poultry establishments; standards for

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2 The World Animal Health Information System, WAHIS: http://www.oie.int/eng/info/en_info.htm?e1d5

3 http://www.oie.int/eng/maladies/en_classification2007.htm?e1d7

4 http://www.oie.int/wahid-prod/public.php?page=home

5 Sixteenth edition, 2007, available at http://www.oie.int/eng/normes/mcode/en_sommaire.htm

the inactivation of viruses; and definitions of "infected" and "uninfected" as applied to a country, zone or compartment. The OIE also publishes guidelines on the use of vaccination, when relevant (e.g. for avian influenza prevention and control).

The Code is accompanied by the *OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* (referred to hereafter as the Manual)[6], which outlines a harmonized approach to disease diagnosis by describing internationally agreed laboratory diagnostic techniques. The instructions in the Manual should be followed in order to allow comparison between results from different laboratories in different countries; for this purpose, quality systems should be implemented in laboratories. The Manual also gives general guidelines on principles for the quality of veterinary vaccine production and guidelines for the development, production and use of disease-specific vaccines.

2 AVIAN INFLUENZA AND NEWCASTLE DISEASE

The spread of the current HPAI strain H5N1 has given rise to an unprecedented situation over the past few years.[7] The disease has important economic and social consequences in affected countries, and humans may be infected due to its zoonotic nature. An important risk is the possible development of a human pandemic virus by mutation or recombination with a human influenza virus.

The OIE strategy focuses on eradication at the animal source through the following key actions: early detection; early warning; rapid confirmation of suspects; rapid response; and rapid and transparent notification. The main goal is to reduce the virus load and circulation in poultry and spread to unaffected areas or countries, and therewith also decrease the risk of human infections or the development of a human pandemic virus (FAO and OIE in collaboration with WHO, 2007). High-quality veterinary services complying with OIE standards, legislation and a clear national chain of command are the basis of animal disease control and eradication.[8,9] Important constraints to the effective control of animal diseases exist in developing and transition countries, as many of these countries have weak or non-existent veterinary services. Newcastle disease is a disease of poultry that is endemic in many parts of the world, and is an important differential diagnosis for HPAI, as the diseases can not be differentiated clinically. Most areas affected by HPAI are also affected by endemic Newcastle disease infections with high mortality in poultry. Many countries have expressed an interest in introducing the concepts of zoning and compartmentalization for these two diseases.

3 ZONING AND COMPARTMENTALIZATION

Recognizing the difficulty that some countries have in eradicating animal diseases from their territory as a whole and in maintaining an animal disease-free status, the OIE has introduced the concepts of zoning (Figure 1 below) and compartmentalization (Figure 2 below) for purposes of disease control and international trade, in the *Terrestrial Animal*

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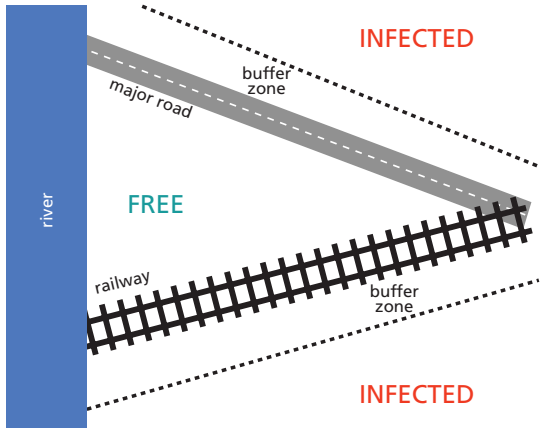
6 Fifth edition 2004: http://www.oie.int/eng/normes/mmanual/A_summry.htm

7 The OIE Avian Influenza Website: http://www.oie.int/eng/info_ev/en_AI_avianinfluenza.htm

8 Capacity-building of veterinary services: http://www.oie.int/eng/OIE/organisation/en_vet_serv.htm?e1d2

9 The new tool for evaluation of veterinary services (PVS Tool) using OIE international standards of quality and evaluation: http://www.oie.int/eng/oie/organisation/en_vet_eval_tool.htm?e1d2

FIGURE 1
The concept of zoning



Health Code. Utilizing these concepts, countries may eradicate a disease from only a part of their territory while the country as a whole is not yet free of the disease. Countries can do this by defining an animal subpopulation with a distinct health status ("free from a certain disease") within its boundaries. They may then resume trade from this part of the territory. Compartmentalization is defined as "one of more establishments under a common biosecurity management system containing animals with a distinct health status", and is therefore based on a functional separation. Zoning applies to animals with a distinct health status on the basis of geographical separation. Zoning has been used regularly by countries in their disease eradication programmes, whereas compartmentalization is a relatively new concept. Both concepts allow concentration of personnel and financial resources where there is greatest chance of success in controlling or eradicating the disease and in gaining or maintaining market access for certain commodities.

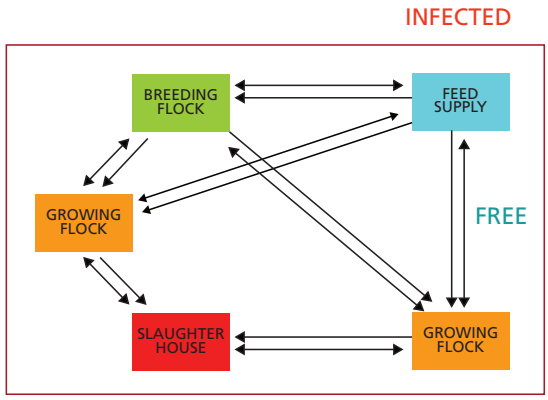
The international standards on zoning and compartmentalization can be found in *Terrestrial Animal Health Code* Chapter 1.3.5 on "Zoning and Compartmentalization". The "General Guidelines on the Application of Compartmentalization" are currently under development and should be added as an appendix to the *Terrestrial Animal Health Code* in 2008 after endorsement by the OIE international committee.[10]

For countries that wish to quickly implement compartmentalization for avian influenza and Newcastle disease as part of their disease control programmes, the OIE has developed a checklist on the practical application of the concept. This checklist is not yet part of the *Terrestrial Animal Health Code*, but can be found on the OIE website.[11] To implement zoning or compartmentalization, other factors like strong veterinary services, a good identification and traceability system, and good surveillance programmes are crucial. Relevant information on these issues can also be found in the *Terrestrial Animal Health Code*: Chapters

[10] See Footnote 5.

[11] http://www.oie.int/eng/info_ev/Other%20Files/En_final_Compartmentalisation_AI_ND_10_05_2007.pdf

FIGURE 2
The concept of compartmentalization



1.3.3 and 1.3.4: Evaluation of Veterinary Services; Appendix 3.5.1: General Principles for the Identification and Traceability of Live Animals; Appendix 3.8.1: General Guidelines on Animal Health Surveillance; and Appendices on disease specific surveillance.[12]

The OIE feels that the time is right to emphasize the possibility of introducing the concepts of zoning and compartmentalization in disease eradication programmes. However, it should also be recognized that the concepts are not automatically applicable to all situations. The basis for applying the concepts is the possibility of clear epidemiological differentiation between the animals that belong to the zone or compartment and those that do not. The effective implementation of the concepts will be influenced by several technical issues, such as the epidemiology of the disease(s) in question, the structure and distribution of the animal population, country and infrastructure factors, the biosecurity measures which may be applicable, the health status of animals in adjacent areas, and the necessary surveillance inside and outside the compartments or zones, which is linked to the efficiency of the veterinary services. For a disease that is transmitted only through direct contact between infected and non-infected animals, the biosecurity measures are different from those needed for diseases that can also be transmitted by air over long distances or that are transmitted only by feed. In the case of the poultry sector, it will in general be easier to implement biosecurity measures in areas where there is a high percentage of highly industrialized commercial poultry compared to areas with a high percentage of smallholders or backyard poultry.

4 PRINCIPLES IN DEFINING A ZONE OR COMPARTMENT

The first basic principle in defining a zone or compartment is clear definition of the animal subpopulation belonging to the zone or compartment. For a zone, this means that the extent of the zone, including its geographical limits including buffer zone, should be clear. For a compartment, it is necessary to define which establishments and related functional

[12] See Footnote 5

units (feed production units, slaughterhouses, etc.) are included. The functional relationships between the units belonging to the compartment, showing their contribution to the compartment, should be described. The animals belonging to the subpopulation in a zone or compartment should always be recognizable and traceable.

The second important principle is to ensure the epidemiological separation of the subpopulation in the zone or compartment from other populations and potential sources of infection. Physical and spatial factors, such as the location of the nearest flocks outside the zone or compartment, the structure of those populations and their health status, and the presence of wild-bird populations, may affect the status of the zone or compartment. Environmental factors, such as existence of nearby wetlands, or seasonal factors may also be important for epidemiological separation. A good biosecurity plan should always be provided for a zone or compartment.

In the case of zoning, the veterinary authority will be primarily responsible for providing the biosecurity plan, whereas in case of compartmentalization, the management of the compartment has the primary responsibility for providing such a plan. The biosecurity plan must describe all factors relevant to the integrity of the zone or compartment, and must show that the zone or compartment is epidemiologically closed. It must provide clear evidence that critical control points for introduction of the pathogen are well managed. Well-described standard operating procedures to implement, maintain and monitor the measures used to manage the critical points should be provided.

Important elements of a biosecurity plan include quality-assurance schemes, procedures for animal and human movement controls, poultry health measures including vaccinations, medications and other veterinary care, control over vehicles, security of feed and water sources, and control of pests and wild-bird populations.

To ensure that the subpopulation in the compartment complies with the defined health status, a surveillance programme should be implemented. Many different combinations of testing and surveillance may be applied to gain the necessary confidence with regard to freedom from the disease in question. However, they should be in compliance with the OIE general and disease-specific surveillance guidelines.[13] Information on the baseline health status of the subpopulation before the zone or compartment was established, and on the surveillance system implemented, should be available, as well as standard operating procedures to be followed in case of suspicion or confirmation of the presence of the disease. A prerequisite for a surveillance programme is the availability of high-quality diagnostic services.

5 RESPONSIBILITIES OF THE VETERINARY AUTHORITY AND THE SECTOR

Veterinary authorities as well as the sector/industry have responsibilities for the establishment of zones and compartments. The veterinary authority is responsible for the essential national infrastructure needed to maintain a zone or compartment (appropriate legislation, national reference laboratories, identification and registration systems, etc) and for the quality of the veterinary services.

Compartmentalization should ideally be the initiative of the private sector; it is par-

[13] See Footnote 5.

ticularly applicable in intensive industries that are vertically integrated. The compartments' responsibilities will lie primarily in the application and monitoring of biosecurity measures, including the use of corrective actions and the implementation of quality-assurance schemes. The management of the compartment should also provide information on the baseline health status of the subpopulation and the surveillance implemented to ensure early detection of disease introduction. The compartment should have standard operating procedures for all actions related to the maintenance of the compartment, and these actions should all be documented. The records should be readily accessible for supervision by the veterinary services. The management of the compartment also has the responsibility to clarify the relationships between the different units comprising the compartment.

The veterinary services are responsible for the supervision, auditing and certification of the compartments. Veterinary services should implement the surveillance programmes in cooperation with the private sector. The veterinary services may also provide model biosecurity plans and generic compartmentalization criteria to facilitate the establishment of the compartments. The costs of maintaining the integrity of compartments should be borne by the private sector.

The initiative for zoning will normally be taken by the government, and the veterinary services will be responsible for the implementation of the zone. Nevertheless, establishments in the zone will be responsible for the implementation of all measures required by the veterinary services, including the biosecurity measures.

Zones and compartments can be established for national disease-control purposes or for international trade purposes. The steps to be taken by veterinary services to resume or maintain trade between exporting and importing countries depend on the circumstances within the countries and on their previous trading history. The importing country must have confidence in the integrity of the zone or compartment as defined by the exporting country. The dossier provided to the importing country must, therefore, contain all information needed for the evaluation and for the country to determine whether it can accept imports from the designated zone or compartment. In the case of compartmentalization, a big part of the dossier will have to be provided by the management of the compartment itself. The importing country must be authorized to conduct an audit *in situ* at any moment.

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Animal welfare in poultry production systems: impact of European Union standards on world trade

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SUMMARY

Animal welfare receives more legislative attention in the European Union (EU) than in many other regions of the world. Animal welfare standards for poultry are generally taken to be higher in the EU than in producing countries exporting to the EU, particularly developing countries. The recent action plan for animal welfare introduced by the European Commission aims to further expand the body of regulatory standards.

In broiler production worldwide, birds are kept on deep litter. Recently, the EU agreed on a new directive to set maximum standards for bird density. However, this is not considered likely to have a great impact on global trade. At present, the difference between Brazil and Thailand and the EU in terms of animal conditions, including bird density, is limited.

In egg production, the majority of commercial layers are kept in battery cages. There is wide variation in space allowance per bird from 300 to 400 cm^2 in Brazil, Ukraine or India to the current 550 cm^2 per hen in the EU. After 2012, hens in the EU will be kept in enriched cages with a minimum space allowance of 750 cm^2 per hen. It can be expected that this will have an impact on world trade in egg products and especially egg powder. Trade in table eggs will continue to be limited to within regions.

The EU is considering the use of labelling to provide consumers with more information concerning the standard of production. Another option could be to use financial mechanisms such as taxes or tariffs. The likelihood that a measure is challenged depends on how difficult it is for exporters outside the EU to meet the requirements.

Keywords: poultry production, animal welfare, economics, international trade

1 INTRODUCTION

Animal welfare in commercial poultry production is an important topic in Europe. In other parts of the world too, there is an increasing focus on farm-animal welfare. In some countries this interest is only driven by export opportunities for poultry meat, especially to Europe. At the same time, increasing requirements pose a possible threat to the market position of meat not produced under upgraded animal-welfare standards or without the

guarantee that it was produced under such standards. This could lead to protection by means of import tariffs to be payed at the EU border for products not produced according to the EU standards. In this article we discuss the worldwide status of poultry welfare at farm level and the impact of changes in welfare regulations and requirements in the EU on world trade. This is discussed for both broilers and layers.

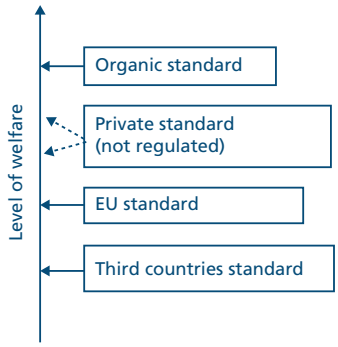
2 THE GLOBAL DIFFUSION OF ANIMAL WELFARE STANDARDS

Animal welfare in poultry production systems is given more legislative attention in the EU than in many other regions. The EU position is partly induced by specific features of the production environment. In addition, policy-makers claim that EU consumers have increasing preferences for the welfare of production animals (European Commission, 2006a). The current situation is presented in Figure 1, in which the vertical line represents a range of lower to higher standards of animal welfare. The legislated standards are placed along the line with no attention given to relative distance at this point. The organic standard for animal welfare is the highest level in the market, far above the regulatory minimum. Producer labels are distributed along the line. This means that some producers, in Europe and elsewhere, maintain animal-welfare standards above the regulatory minimum, usually under a premium-quality label.

Consumer researchers have revealed a wide divergence in the ambitions and motivations of private labels in the EU (Ingenbleek *et al.*, 2007). Producers in developing countries also achieve levels of animal welfare that exceed regulatory minimum levels to a different degree. Selected production chains in developing countries already comply, or potentially will comply with EU standards for farm animal welfare and should be allowed to export their products to the EU.

The difference in standards concerning animal-welfare around the world is related to income, culture and religion. The extent of animal welfare-legislation generally reflects income levels, for a number of reasons. First, the consumption of livestock products grows

FIGURE 1
Current situation of regulatory and private standards for farm animal welfare in the EU and trading partners



Source: adapted from Eaton *et al.* (2005).

with rising income levels – this is initially manifested by increased demand for quantity, then by rising quality requirements and increased demand for superior types of meat and other animal products. Second, as incomes increase, demand for public goods rises as well as demand for private goods. Aspects of animal welfare can be considered public goods; welfare regulations typically serve to ensure that these are provided (McInerny, 2004). Countries in more advanced stages of development have governments that are more effective in supplying such advanced public goods.

Table 1 presents an overview of the relationship between welfare and income levels in a number of countries around the world. The level of legislation in place to regulate the welfare of poultry in these countries was investigated through a survey. For broilers, the level was determined by the maximum bird density per m^2 and for layers by the space allowance per hen and the situation with respect to mutilations (e.g. beak trimming). Each country was given a score on a scale of 1 to 5 for the level of legislation on poultry welfare. A country's income was scored on a similar scale. The following classes were used for gross national income (GNI) per person: 5 for GNI above US$30 000, 4 for GNI between US$20 000 and US$29 999, 3 for GNI between US$10 000 and US$19 999, 2 for GNI between US$5 000 and US$9 999, and 1 for GNI below US$4 999 (data from FAO, 2006).

Table 1 shows that Switzerland has an exceptional position, with a high standard for poultry welfare. Despite minor differences, all countries in northern and western Europe have higher standards for the welfare of both layers and broilers than the EU standard. In general, southern and eastern members of the EU have no poultry welfare legislation except for the EU Directives. The new EU member states, like Poland and Hungary, have a medium level of GNI, but are obliged to work with the EU standards. Outside Europe, only Australia, Canada, New Zealand and the United States of America show any interest in animal welfare.

TABLE 1
Welfare level and income level of selected countries

Welfare level	Income level	Main poultry-producing countries
5	5	Switzerland
4	5	Northern Europe: Denmark, Finland, Norway, Sweden
4	5	Western EU: Austria, Germany Netherlands, United Kingdom
3	4/5	Southern EU: France, Italy, Spain
3	3	Eastern EU: Hungary, Poland
2	5	Australia, Canada, United States of America
1	5	Japan
1	4/3	Near East: Saudi Arabia, United Arab Emirates
1	2/3	South America: Argentina, Brazil, Chile
1	2/3	Eastern Europe: Ukraine, Russian Federation
1	1/2	Asia: China, India, Thailand

3 BROILERS

3.1 Housing systems for broilers

Broilers are generally held in large groups either in environmentally controlled housing or in open, naturally ventilated poultry houses. Broilers are usually kept free on deep litter with automated provision of feed and water. In most countries, commercial breeds selected for rapid growth, are used. Farmers around the world understand that in order to raise the birds with maximum efficiency, many conditions must be fulfilled – stress prevention, supply of good feed and water, and good sanitation. In providing these conditions, farmers ensure a basic level of animal welfare. However, there is a growing consensus that good productivity and health are not necessarily indicators of good welfare (Jones, 1996).

3.2 Welfare regulations for broilers

Following a long period of discussion among the member states, in May 2007 the European Commission agreed on a new directive covering the welfare of broilers (European Commission, 2007). All European producers will have to meet minimum standards by June 2010. According to the EU Commissioner, the directive was needed because "EU consumers repeatedly expressed concern at the welfare problems arising in intensive chicken farming" (ibid.). The main provision of Directive EC/2007/43 is to reduce the stocking density by setting a maximum density of 33 kg per m^2. Under certain conditions, with good ventilation and temperature control systems, the maximum can be 39 kg. Under exceptionally high welfare conditions, the density can be increased by a further 3 kg. This can be achieved by low mortality rates. The directive also sets conditions covering lighting, litter, feeding and ventilation requirements.

Although scientists include more points when assessing the welfare of broilers, such as high growth rate, leg disorders, ascites and respiratory problems (SCAHAW, 2000), in this paper it is assumed that the welfare of broilers, according to the EU directive, can be measured by bird density and mortality. At EU level, there was previously no regulation on broiler welfare. However, Denmark and Sweden already had maximum densities of 40 kg and 36 kg per m^2 of poultry house, respectively (Berg *et al.*, 2004). In Germany and the United Kingdom, the density was controlled by voluntary guidelines. Switzerland, not a member of the EU, maintains a stringent limit for broiler production of 30 kg per m^2 of poultry house. As far as the authors are aware, there is no country outside Europe with any regulation or legislation on maximum broiler density. In the United States of America, the National Chicken Council has developed animal welfare guidelines to ensure the proper care, management and handling of broilers; bird density (with a live weight between 2 and 2.5 kg) is restricted to 38 kg per m^2 (Hess *et al.*, 2007). However, this is a voluntary guideline. In Brazil there are no regulations on the density of broilers; however, due to the climate, farmers keep broilers at a relatively low density of approximately 35 kg per m^2.

3.3 Trade in poultry meat

The international trade in broiler meat grew very rapidly in recent years. In many regions, poultry is increasingly preferred as an affordable source of animal protein, which unlike pork or beef is accepted for consumption by most of the major religions in the world. Figure 2 provides an overview of the global poultry-meat trade in 2004. In 2004, 12 percent of the

FIGURE 2
Main trade flows in poultry meat in 2004 (in 1000 tonnes)

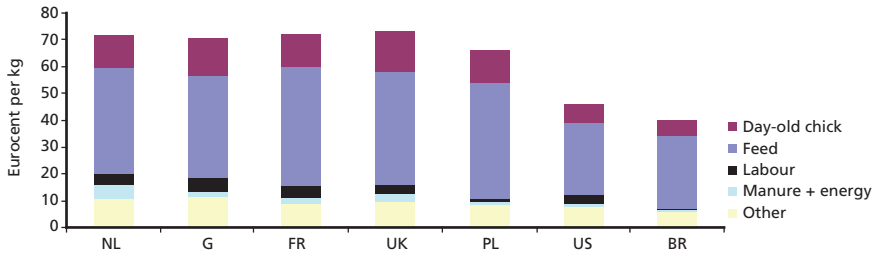
Source: PVE (2007).

poultry meat produced reached the world market (Windhorst, 2006). The main exporters of poultry meat are the United States of America, Brazil and the EU. The main importing regions are the Russian Federation, North Africa and the Near East, China and the EU.

Market developments and outbreaks of diseases (such as avian influenza) affect the make-up and flows of trade in poultry products. While the effects of most outbreak-related disruptions fade after one to two years, endemic diseases may have a lasting impact on trade. Other factors that exert a longer influence are related to the cost of production and consumer preferences (Dyck and Nelson, 2003). In addition, trade policies are particularly determinant for the poultry trade. Each element is discussed separately below.

Production costs. Natural resources and the costs of feed and labour are the main determinants of the competitiveness of livestock and meat-processing sectors. Van Horne and Bondt (2006) analysed the differences in production costs for broiler production across countries. Based on the findings of that study, Figure 3 compares production costs in several EU countries with those in the United States of America and Brazil. In 2004, the production costs of broiler meat in the United States of America were 36 percent lower than in the Netherlands; in Brazil, the production costs were more than 40 percent lower. The lower production costs in the United States of America and Brazil compared to the EU countries were largely due to the lower price of feed (local supplies of feed raw materials) and other favourable conditions. Production is carried out by means of efficiently organized integration. The broilers are kept in relatively simple and cheap poultry houses. In addition, production costs are lower in both countries because of lower levels of legislation and

FIGURE 3
Production costs for broiler meat (eurocent per kg live weight) at farm level in the Netherlands (NL), Germany (G), France (F), United Kingdom (UK), Poland (PL), United States of America (US) and Brazil (BR) in 2004



Source: data from van Horne and Bondt (2006).

regulation. One example is the use of meat-and-bone meal, which is permitted in both countries.

Consumer preferences. Much of the global trade in poultry meat is explained by variations in consumer preferences across the globe. While consumers in the United States of America and the EU largely favour breast cuts, consumers in Asia prefer the meat on legs and wings. Producers export the cuts to the markets where they get the best price (Dyck and Nelson, 2003). The EU provides an example of the way this trade works. All breast cuts from EU slaughters are sold in EU markets, while the meat of legs and wings is exported to the Russian Federation. Imports from Brazil and Thailand satisfy the excess demand for breast cuts in the EU. Similarly, the United States of America's poultry industry supplies boneless chicken breasts to the home market, where consumers pay a relatively high price. The other parts of the carcass are exported to foreign markets where a higher price can be fetched. This explains why meat-producing countries both import and export, and why most of the trade in poultry products takes place in cuts and not whole carcasses.

Trade policy. Trade policy on broiler meat has a large impact on trade flows, in particular the policies of the EU. In order to accommodate a higher domestic price level for poultry by limiting imports, the EU allocates quota for imports from a selected number of exporters, most importantly Brazil and Thailand. Poultry meat from the United States of America is banned from EU markets for sanitary and phytosanitary (SPS) reasons. Following the avian influenza outbreak of 2003/2004, the EU accepts only cooked poultry meat from Thailand (Eaton *et al*., 2005).

3.4 Relation between broiler welfare and world trade

It is considered unlikely that the upgrade of legal EU animal welfare standards will have a large impact on the composition of global trade in poultry meat. The EU has reached agreement with Brazil and Thailand on maximum quota to be imported. Breast meat from Brazil can compete in the European market due to very low production costs. Breast meat from Thailand can compete in the European market as a result of a preference for dark

leg meat in the regional market. Production costs in the EU are expected to increase following the implementation of the EU directive on broiler welfare. The implementation of the broiler directive may, therefore, lead to stronger calls from EU producers for continued border protection to check the competitive pressure from foreign producers. This raises the question of whether EU demand for animal welfare provides a justifiable basis for continued protection.

There are at least two economic arguments as to why it should be considered inappropriate to allow border protection for broiler meat on the grounds of animal-welfare requirements. First, differences in animal-welfare conditions between the EU and exporting countries are currently limited, although there are limitations to a reliance on bird density as a measure of welfare. The density at which broilers are kept in the exporting countries is already at the EU target level. Second, the incremental costs of a further reduction in Brazil and Thailand are lower than in the EU, due to lower costs for housing and labour. Producers in exporting countries would be likely to adapt in response to regulatory demands in the EU for increased animal welfare if they were to be implemented. Meat exporting firms have demonstrated a willingness and capacity to adapt. Bowles *et al*. (2005) provide preliminary evidence of restructuring and certification within Argentinean and Thai broiler meat supply chains in response to changing buyer demands in the EU. Both observations raise questions as to whether continued border protection for EU poultry producers serves as an economically rational instrument to achieve higher levels of animal welfare in the production of the broiler meat consumed in the EU. Furthermore, these points demonstrate that, in principle, an upgrade of EU regulation requirements for animal welfare in imported broiler meat would not operate as a non-tariff barrier to exporters, but rather as an opportunity to create additional added value.

4 LAYERS

4.1 Housing systems for layers

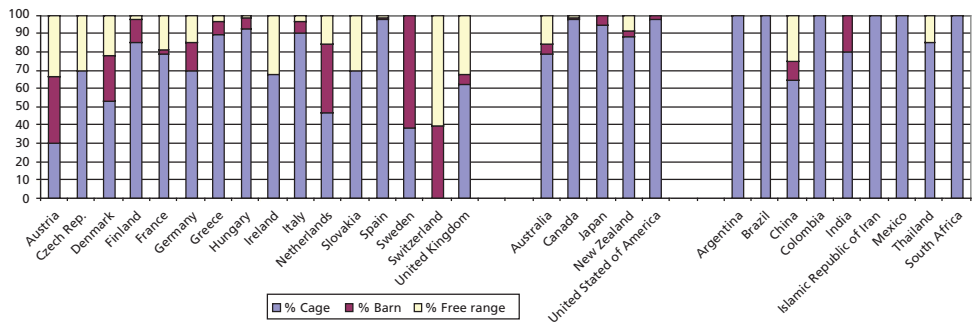
The majority of commercial layers in the world are kept in confined housing systems with light control, power ventilation and mechanical feeding. The space per hen in cages is very limited, with no space to express natural behaviours like sand bathing and wing flapping. In Europe, to accommodate social concerns about animal welfare, alternative housing systems have been developed to improve the welfare of layers. In general, today's egg producer has the choice of three main housing systems:

- battery cages – small enclosures with welded wire mesh sloping floors;
- barn systems – in which the layers are kept on litter and the birds have freedom to move around within the poultry house; and
- free range systems – in which the layers also have access to an outdoor run.

The battery cage is still the most economic way to produce eggs (van Horne, 2006). Such housing has also proved to be the best option for disease prevention (Hulzebosch, 2006). Figure 4 gives an overview of the share of hens kept in cage, barn or free range systems in 30 countries around the world. The data are provided by the IEC (International Egg Commission) reporters in the member countries (IEC, 2007).

Figure 4 shows a wide variation in housing systems. Outside the EU, only Australia and New Zealand have some commercial non-cage systems. In all other countries, farmers

FIGURE 4
Share of hens kept in cages, barn or free range systems in 30 countries around the world



Source: IEC (2007).

mainly work with cage systems. In China, India and South Africa, the numbers with non-cage housing probably refer to non-commercial backyard farming (IEC, 2007). Also within the EU there is a wide variation in the percentage of hens in non-cage systems. Due to growing concern about animal welfare in cages, especially in northwest Europe, farmers are investing in alternative housing systems. The countries with less than half the hens in cage systems are Austria (30 percent), Sweden (39 percent) and the Netherlands (47 percent). Hens are mainly kept in cages in Spain, Hungary, Italy and Greece. Switzerland, not a member of the EU, already has a ban on traditional cages, and as a result all hens are kept in alternative systems.

4.2 Welfare regulations for layers

In the EU, a directive (1999/74/EC) established European standards for improving the welfare of commercial hens. By 2012, all traditional cages in the EU should be replaced by enriched cages or alternative housing systems. In an enriched cage, a hen has 750 cm^2 of cage area, a perch, a nest and a litter box. In the current situation, layers kept in cages within the EU have access to 550 cm^2 per hen. Although there is an EU regulation, individual countries are allowed to have stricter laws. This is the situation in Austria, Germany and Sweden (Berg, 2006). In the Netherlands, a possible ban on all cage systems is being discussed (summer 2007). In this article we take the EU directive as a guideline for defining the main components of welfare. The space allowance per hen, enrichment of the cage and proper beak trimming are the main components regulated by the EU. However, scientists also include expression of natural behaviour, induced moulting, cannibalism, injuries, osteoporosis and depopulation processes in their discussions of poultry welfare (da Cunha, 2007).

In the United States of America, some fast-food chains are demanding minimum standards for housing densities from their suppliers. In 2008, United Egg Producers (UEP) will start a voluntary certification programme to implement a housing density of 430 cm^2 per hen. In Canada, a code of practice recommends a similar density. In Brazil, there is no nationwide legislation governing the welfare of poultry (ibid.).

In general, it can be stated that in countries in Asia and South America, there is no legislation at all to regulate the welfare of layers. An inventory (van Horne, 2006) showed that hens in India, Ukraine and Brazil are kept in cages with a space allowance of 300 to 400 cm^2 per hen. Farmers choose this density as the economic optimum giving the highest income per cage. American calculations (Bell, 2000) show that in purely economic terms, 350 to 400 cm^2 per hen gives the highest income for a farmer in the United States of America.

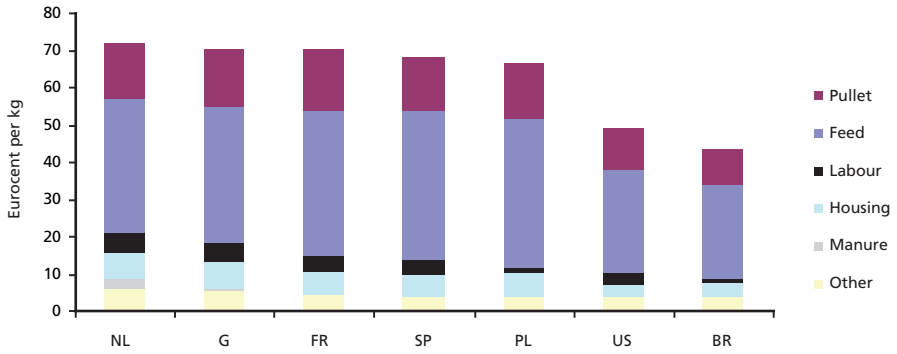
Mutilations, like beak trimming, have also been subject of discussion for many years. Beak treatment of laying hens is regulated at EU level. In order to prevent feather pecking and cannibalism, member states may authorize beak trimming, provided it is carried out by qualified staff on chickens that are less than ten days old. However, within Europe there is great variation between countries with regard to legislation and practice in the field (Fiks-van Niekerk and de Jong, 2007). Beak trimming is not allowed at all in Sweden, Norway and Finland. Beak trimming is strictly regulated in Austria, Belgium, Denmark, Germany, the Netherlands, Switzerland and the United Kingdom. Most southern and eastern European countries (e.g. France, Hungary, Italy, Poland and Spain) have no legislation other than the EU Council Directive 1999/74.

4.3 Trade in eggs and egg products

Worldwide, trade in eggs is very limited. In 2004, only 2 percent of the eggs produced reached the world market (Windhorst, 2006). The main exporters of eggs are the Netherlands (26 percent of total world trade), Spain (10 percent), China (8 percent), Belgium (8 percent) and the United States of America (7 percent). Eggs are mainly traded regionally within Europe as well as among Asian countries. Besides trade in shell eggs, there is some trade in egg products. Trade in egg powder is particularly increasing. Egg powder can be stored for a long period and involves low transportation costs. It is expected that in the near future egg powder will be produced in low-cost countries and exported to the food industry (bakeries, pasta and sauce factories) in developed countries (Tacken *et al*., 2003).

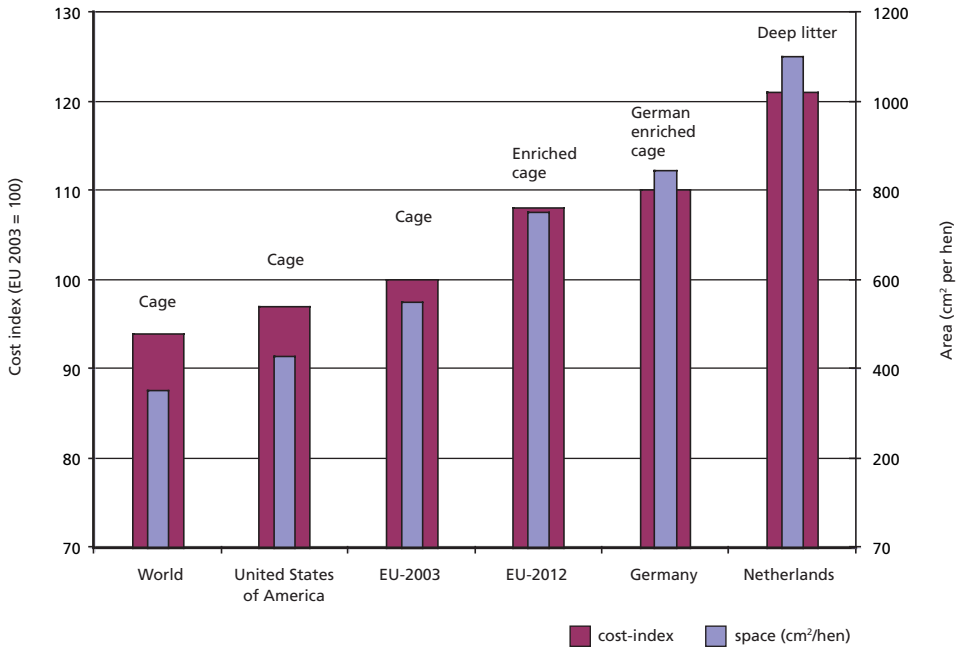
Cost of production. Trade in eggs and egg products is mainly influenced by differences in production costs. Van Horne and Bondt (2006) analysed the differences in production costs for egg production across countries. In this study, the United States of America and Brazil were selected as examples of the situation outside the EU. In 2004, the production costs of eggs in the United States of America were 30 percent lower than in the Netherlands, while in Brazil the production costs were more than 40 percent lower. Figure 5 gives a breakdown of the cost components. The lower production costs in the United States of America and Brazil were largely due to the lower feed price (local supplies of feed raw materials) and the favourable climatic conditions. In addition, production costs in both countries are lower due to lower levels of legislation and regulation, more specifically relating to: a) the absence of legislation on housing requirements (the floor area per hen is between 350 and 400 cm^2); b) the absence of a ban on the use of meat-and-bone meal; and c) the absence of legislation on beak trimming.

FIGURE 5
Production costs for eggs (eurocent per kg) at farm level in the Netherlands (NL), Germany (G), France (F), Spain (SP), Poland (PL), the United States of America (US) and Brazil (B) in 2004



Source: data from Van Horne and Bondt (2006).

FIGURE 6
Relationship between costs for animal welfare and the area per laying hen



4.4 Comparing production cost in housing systems for layers

In general, there is a relationship between production costs and the space standard for laying hens. Figure 6 gives an overview of this relationship in different parts of the world. The calculations were made as part of a study in which a possible ban on enriched cages in the Netherlands was discussed (van Horne *et al*., 2007). If the enriched cage is prohibited unilaterally in the Netherlands in 2012, laying hens will have to be kept in barn housing systems with a minimum area of 1 100 cm^2 per bird. Since 2003, layers in the EU get 550 cm^2, and after 2012 layers will be kept in enriched cages with 750 cm^2 per hen. In the United States of America, voluntary rules apply, which are based on 430 cm^2 per hen with effect from 2008. In the other countries of the world, hens are kept in cages with 300 to 400 cm^2 per hen. Figure 6 shows that the production costs of eggs increase when the area per bird in cage housing is increased from the world level (350 cm^2) to the standard in the United States of America (430) and to the current EU level (550 cm^2). The production costs further increase when there is a switch to enriched cages (750 cm^2), German enriched cages (800 cm^2) and barn systems (1 100 cm^2).

4.5 World trade in relation to welfare of layers

The international trade in table eggs continues to be limited primarily to within regions. This also applies to liquid egg products. Some of the eggs are processed into egg powder. Because of its long-keeping qualities and the relatively low transport costs, there is an international trade in this product. In some countries, such as Brazil and India, the production cost of eggs is much lower than in the EU. This is due to cheaper feed (supply of feed ingredients) and the absence of animal-welfare legislation. The European market is currently protected by import duties which, together with the transport costs, compensate for the difference in production costs. The European purchase price of eggs is increased by animal-welfare measures, while at the same time, the EU intends to reduce the import duties in the context of the World Trade Organization (WTO) negotiations. In this situation, it is economically more attractive for the food industry to replace European liquid-egg products with powdered egg from countries outside the EU. Consequently, egg products will be purchased from third countries where animal welfare standards are significantly lower than in the EU.

5 GENERAL DISCUSSION

Animal welfare is given more legislative attention in the EU than in many other regions. This is especially the case for layers. Some producer labels operate animal welfare standards above the regulatory minimum. Also, producers in developing countries achieve levels of animal welfare that exceed EU regulatory minimum levels to a different degree. Animal welfare concerns should not motivate categorical trade restrictions on imports of poultry products from developing countries into the EU. The European Commission, backed by a group of core member states in northwestern Europe, has indicated strong ambitions to improve animal welfare in the EU and its trading partners (European Commission, 2006b).

The EU focuses on animal welfare via various paths. EU countries are among the driving partners in discussions on animal protection within the World Organisation for Animal

Health (OIE) which has a working group on animal welfare. The OIE is accepted under the WTO agreement as the body that sets the standards on veterinary issues in global trade. Currently, the WTO has not explicitly recognized animal welfare as a legitimate concern, i.e. a cause for impeding trade. The EU has placed the issue of animal welfare on the agenda for negotiations under the Doha Round, but there has been very little discussion recently. Since the 2005 Annual Meeting, the member countries of OIE agree on general guidelines for animal welfare in relation to slaughter, protection for animals during transport and the killing of animals for disease-control purposes (OIE, 2004). In the short term it cannot be expected that the OIE will provide comprehensive global standards on animal welfare at farm level.

Meanwhile, one option is to promote either voluntary or mandatory use of labelling to provide consumers with more information concerning the standard of production. Consumers could then make better-informed choices with respect to their concerns over animal welfare. The aim of such labelling is also to provide an incentive for domestic and foreign producers to increase animal-welfare standards above the EU's minimum requirement. In addition to providing more information to consumers by means of labelling, there is also the possibility of using financial mechanisms such as taxes or tariffs to reduce the price difference for consumers. This could be a European label, tax or tariff based on animal welfare performance. Such a scheme is open to challenge under WTO rules if considered discriminatory against producers of livestock products that want to export to the EU. The likelihood that a measure is challenged depends on how difficult it is for exporters to meet the requirements and the expected effectiveness of the label or (border) tax in segmenting the meat market.

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Zoonotic disease risks and socio-economic impacts of industrial poultry production: review of the experience with contract growing in the United States of America

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SUMMARY

The model of food animal production in the United States of America, which is characterized by an industrial scale and organization, is currently expanding globally, particularly in Asia. The practice of contract poultry growing, in which firms contract out the raising of live chickens to independent farmers, is often a key component of this system. The poultry industry in the United States of America is highly vertically coordinated, and contract growing within this coordinated system reduces economic risk and costs to the firm (known as the integrator), and to some extent to the growers as well by providing the growers with market access for their products. However, contract growers assume the burdens of many of the costs as well as the negative health and social externalities of poultry production, including waste management, occupational and community health risks, implementation of farm-level biosecurity and socio-economic decline. The disparity in economic power between integrator and grower allows the integrator to outsource these externalities onto the grower, and exclude these negative by-products from their costs of production. In light of concerns regarding emerging zoonoses, particularly pandemic influenza, the potential consequences of this system for global public health are significant. A full understanding of experience in the United States of America with respect to the implications of the zoonotic disease risks and economic impacts associated with contract growing can inform policies aimed at reducing these risk factors in nations where the private sector is increasingly adopting a contracting model.

Key words: poultry, United States of America, model, contract

1 INTRODUCTION

Methods of food animal production affect consumer food safety, agricultural and national economies, and the environment. Despite growing awareness of the global implications of food animal production in terms of food safety, its effect on the health, economic and social wellbeing of rural communities is less frequently studied. Over the past 70 years, the production of animals for human consumption has undergone dramatic transformations in intensity, scale and geographic concentration. The poultry industry in the United States of America was the first sector in which rapid consolidation and vertical coordination occurred, starting in the 1930s, and this process has altered broiler poultry production from household-level enterprises to a high-throughput agribusiness on an industrial model. Today, this highly integrated and intensive nature characterizes the poultry industry in developed countries. Middle-income countries, particularly Thailand, Brazil and China, have witnessed a rapid industrialization of the production of food animals for domestic consumption and export in recent years, and these trends are expected to continue as demand for poultry increases around the world (OECD-FAO, 2006). These changes have clear public benefits, in that they facilitate the reliable production and delivery of low-cost animal protein to both domestic and global markets, providing improved quality control and the structure for rapid uptake of new technology. Along with these benefits, however, high-throughput animal husbandry has led to increased concerns about food quality, animal welfare, environmental contamination, cohesion of farming communities and the development of antibiotic resistance (Cole *et al*., 2000; Silbergeld *et al*., 2008).

Human contact with poultry, both at the household and the industrial level, is a clear risk factor for exposure to avian commensals that can infect humans, including bacteria such as *Campylobacter* spp., *Salmonella* spp. and *Listeria monocytogenes*, as well as viruses such as those causing avian influenza. Epidemiological analyses of human infections with the H5N1 strain demonstrate that close interaction with domesticated live poultry is a risk factor for human infection with the virus (van Boven *et al*., 2007; Babakir-Mina *et al*., 2007). Given challenges in animal-disease monitoring in areas with widespread household-level poultry production, coupled with difficulties in active human-health surveillance in most regions of the world, the industrialization of poultry production is viewed by some policy-makers as a way to reduce risk at this critical human–animal interface. Yet, recent H5N1 outbreaks in poultry in the United Kingdom and China, as well as a little-publicized outbreak of low pathogenic avian influenza in the United States of America in 2007, demonstrate how industrialized production poses distinct risks for cross-infectivity between wild birds and poultry, and reinforce how these risks are not prevented by standard biosecurity practices. This is because these large operations, while confined, are not inherently biosecure or biocontained; the lack of adequate management of animal wastes and the transport of these and other by-product materials over long distances may, in particular, provide a major route of pathogen release and transfer.

The industrial poultry model often includes the practice of contract growing, in which firms contract the raising of chickens to independent farmers, who are responsible for the delivery of chickens of market weight back to the firm. The farmer is paid according to the acceptability and total weight of the finished product; he or she bears the costs of feed, energy, labour, and any loss of chickens over the growing period. Contract growing

is a central component of the industrial poultry model in the United States of America. The practice is being expanded by firms from the United States of America in other countries (e.g. Tyson in Mexico) as well as being adopted by local businesses in middle-income countries (e.g. Sadia in Brazil). Vertical coordination and contract growing in this industry are not driven by evidence that these methods decrease zoonotic disease risk, but by the economics of poultry production on a commercial scale.

The implications of contract growing for zoonotic disease emergence and the socio-economic sustainability of rural communities are not well understood. As industrial-scale contract growing is exported to the middle- and low-income nations, it is critically important to examine the consequences of this model for factors relevant to health, including the autonomy and economic solvency of contract growers, poultry workers and their communities. In this paper, we examine the potential consequences of the transition for zoonotic disease exposure and social decline, focusing on experience in the United States of America in order to highlight potential risks facing the developing world.

2 STRUCTURE OF THE POULTRY INDUSTRY IN THE UNITED STATES OF AMERICA

Industrial food animal production is defined by its high-throughput production methods, in which thousands of animals of a single breed are grown at one site under highly controlled conditions. The animals are typically raised in confined housing, provided with defined feeds rather than access to forage, and managed in order to facilitate the uniform and reliable production of meat, milk or eggs.

The transformation of poultry production in the United States of America over the past half century is characterized by vertical integration, vertical coordination and specialization. Vertical integration occurs when a single firm, known as an integrator, controls all or most aspects of production from "farm to fork". Vertical coordination is an organizational structure in which the firm ensures that each production process is managed and coordinated, without the firm necessarily controlling all aspects of production. From a precise definitional perspective, the poultry industry in the United States of America is vertically coordinated, rather than integrated, as key functions (notably raising the animals) are contracted out; however, the firm in this structure is commonly referred to as an integrator, and we will use this term in this paper.

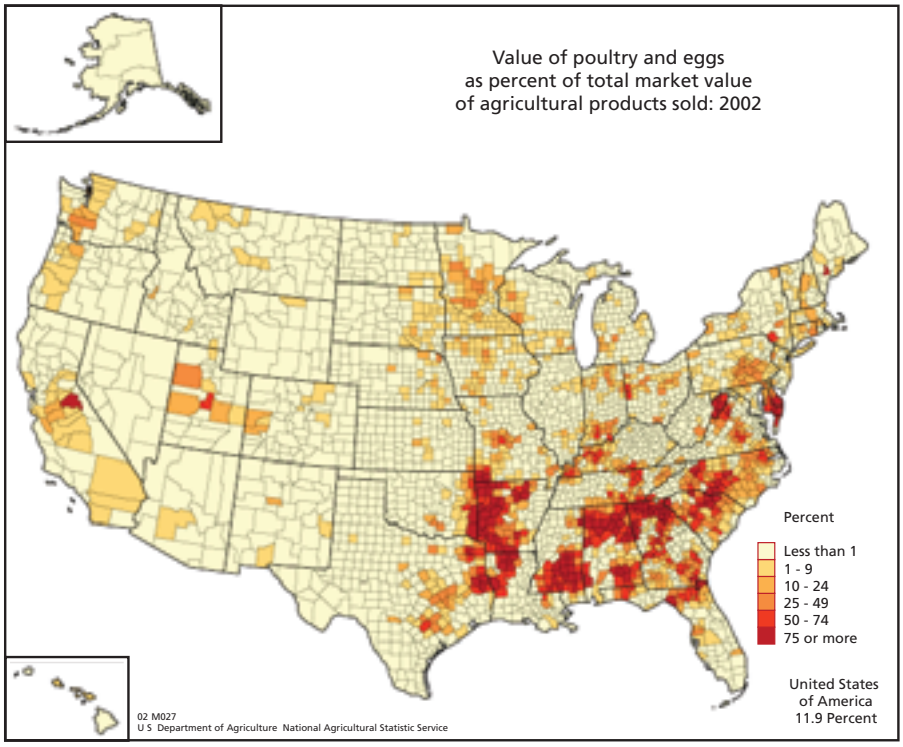
In the United States of America, a relatively small number of corporations function as integrators. Tyson Foods, Pilgrim's Pride, Gold Kist and Perdue, together, produce 75 percent of the broilers sold annually by weight (USPEA, 2005). The poultry industry is highly specialized, with different firms dominating egg, broiler and turkey production. Specialization allows firms to enhance economies of scale by narrowing the range of products produced and streamlining operations. Moreover, a key characteristic in the organization of the integrated industry is that the integrator controls the slaughter and processing of animals into consumer products, thus maintaining economic control at the switch point from agriculture to the food industry. Because of this control, it is difficult for other entities, such as independent farmers, to enter the market.

The poultry industry in the United States of America currently produces nearly 9 billion broiler chickens per year (USDA, 2005). The industry observed staggering increases in pro-

duction and density over the last half century. In 1954, there were no broiler poultry farms in the United States of America with more than 100 000 birds. By 1974, 30 percent of farms had 100 000 birds or more, and by the middle of the 1990s, nearly 100 percent of broiler facilities housed more than 100 000 live birds at a time (Hinrichs and Welsh, 2002). Broilers are the single largest commodity among poultry products, accounting for US$20.9 billion of the US$28.8 billion revenue from poultry in 2005 (USDA, 2005). Poultry production in the United States of America is highly concentrated along the eastern seaboard and in the southeastern states, with nearly 70 percent of total value from poultry generated in the Northeast, Appalachia, Mississippi Delta and the Southeast. Figure 1 depicts dominant regions for poultry and egg production in the United States of America.

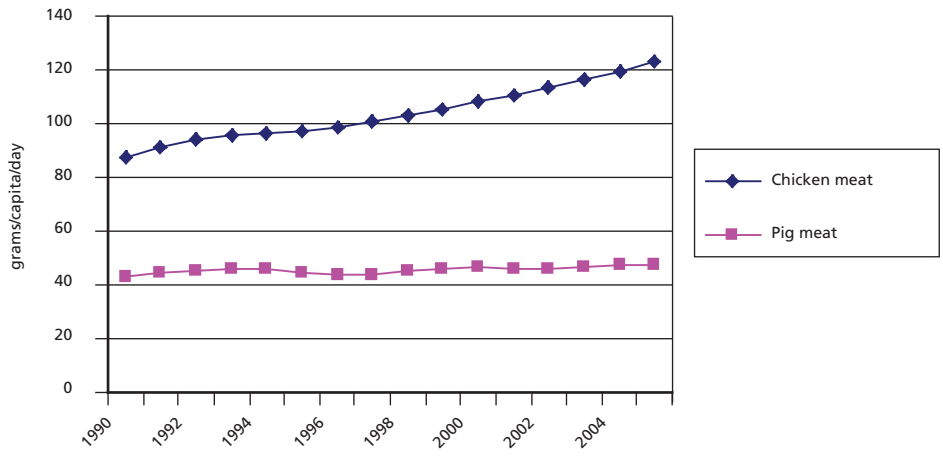
The localization of poultry production in the United States of America is independent of major markets or population centres. The ability to absorb costs, including energy, associated with transporting poultry products from these concentrated areas to major market centres speaks to the vast economies of scale derived from consolidation. Consumption of broilers has increased dramatically in the United States of America, coinciding with the coordination of the industry, even as demand for other meat products has remained stable (Figure 2).

FIGURE 1
Value of poultry and eggs as a percentage of total market value of agricultural products sold in the United States of America in 2002



Source: United States Department of Agriculture. (http://www.nass.usda.gov/research/atlas02/).

FIGURE 2
Per capita consumption of chicken and pig meat in the United States of America, 1990–2005



Source: FAOSTAT (2005).

This transformation in organization and density of production affected the workforce involved in food-animal production and the nature of this work in the United States of America. Grey *et al*. (2007) estimate that at present there are 54 000 poultry and pig workers in the United States of America, of which 10 500 work in broiler confinement facilities (Gray *et al*., 2007). This represents a substantial decrease in the numbers of farmers and farm workers, while the numbers of processing plant workers has increased. On the farm, the growers manage and tend to flocks, usually with the help of hired labour and family members. Chicken catchers, who are contracted or employed by the integrator, harvest live chickens from the growers' facilities at the end of the six-week growing cycle. The remaining workers in the industry work in processing facilities.

3 CONTRACT GROWING: A MODERN "SHARECROPPING" MODEL

Growers play a unique role in the system in that they are responsible for mitigating important health and environmental risks, but are outside the direct employ of the integrator. Contract growing became commonplace in the United States of America soon after mid-century. By 1960, 90 percent of broiler production occurred through contract growing (Welsh, 1997). Integrators breed the parent stock, produce and hatch eggs, provide chicks, feed and veterinary care (including antibiotics and other additives). Growers provide chicken houses, labour, utilities and operating and maintenance costs. Growers are responsible for the disposal of animal wastes and dead birds, as well as cleaning and sanitizing their facilities. Notably, growers are also responsible for many of the costs associated with the implementation of biosecurity measures at the farm level. Growers often, but not always, own the land on which animals are raised, but they do not own the animals. Integrators retain ownership of the animals throughout the growing process and have full access to the

contract growers' facilities. In essence, the grower's product is his or her labour and capital investment, not the animals he or she raises. The system is reminiscent of sharecropping, an agricultural system common in the southern United States of America in the second half of the nineteenth century, in which the farmer sells his or her labour, and works land owned by others, in exchange for a share in the profits determined by the firm to which he or she is contracted. Sharecroppers of this period, like poultry growers, did not sell directly to the consumer market and, therefore, could not adjust directly to market demands.

Integrators set the criteria for raising chickens in the contract, which requires chicken houses to be built to precise specifications, including stipulations for design, construction, ventilation, heating, cooling and lighting systems. Broiler growers typically build at least four houses on their property, each holding between 25 000 and 70 000 birds, and some build as many as 16 (Stull and Broadway, 2003). In fact, one of the incentives to grow poultry rather than other animals or crops is that return per acre of land is relatively high and labour inputs are relatively low for an agricultural investment. However, the costs are considerable, and growers may borrow as much as 110 percent of the cost of construction over 10–15 year loans. A contract with an integrator makes it easier for growers to secure loans (Stull and Broadway, 2003). Start-up costs per growing house average US$170 000, and new growers entering the industry often face costs up to US$600 000 for multiple houses (Cunningham, 2005).

The production contracts also specify payment in terms of weight of acceptable live broiler produced at the end of the growing period. However, this payment is reduced by the cost of feeds required to bring the flock to market weight, and the grower bears the costs of the time taken to reach market weight in terms of energy and labour costs (hiring workers). Specifics of grower contracts differ by integrator, but most are structured using a "tournament scheme" in which a component of payment is based on the relative performance of a given grower. For the tournament component of payment, growers are rewarded or penalized based on their feed conversion rate (the amount of feed required to produce the weight of acceptable broiler at the end of the growing period) in comparison to that of a comparable group of growers contracted with the same integrator during that same harvest period. Contracts also generally include a minimum guaranteed payment per pound[1] of saleable meat (currently about 5 cents/pound). Contract duration varies in length, but most are very short term and only cover a single flock at a time (about six weeks) (Vukina and Leegomonchai, 2006). Contracts generally do not guarantee the number of flocks the grower will receive per year (Vukina and Leegomonchai, 2006). These conditions give considerable power to the integrator.

Growing contracts provide clear benefits to integrators. They allow integrators to maintain control of the stages of production most critical in maintaining the link between demand and supply and safeguard them from a central form of uncertainty in the poultry production process: the actual rearing and survival of marketable chickens. Tournament payments reduce the cost of contracting to the integrator and allow the integrator to pass on some of the market-based uncertainty to the grower. This structure also rewards technical efficiency among growers, to the extent possible given integrator specifications, promoting

[1] 1 pound = approximately 0.45 kg.

efficient use of feed, antibiotics, energy and labour inputs (Knoeber, 1989). Contracting also allows integrators to accommodate new technology into production practices without incurring significant costs (Vukina, 2001). Costs associated with waste management are also shifted to the grower, allowing the integrator freedom to increase production density with reduced concern for constraints posed by disposal of animal wastes.

Importantly, contracting allows integrators to avoid the costly capital investment of building and maintaining chicken houses. Modern high-density poultry houses are highly specific assets, meaning that the design and financial investment associated with facilities renders use for a different purpose difficult, if not impossible. Growers absorb the risk associated with this specific asset, effectively binding them to poultry production under contract to the integrator that stipulated the specifics of house design and management. The location of the growing facilities in close proximity to a particular processing plant and feed mill may also bind a grower to a specific integrator, as can construction and maintenance specifications that vary among firms, making it difficult for a grower to switch integrators (Vukina and Leegomonchai, 2006). Additionally, the integrator may request frequent upgrades and technological improvements to poultry houses as a condition for contract renewal (Vukina and Leegomonchai, 2006). Due to their substantial personal investment in highly specialized chicken houses and a scarcity of other economic opportunities in the region, contract growing creates an uneven economic dynamic that disadvantages growers (Knoeber, 1989; Vukina and Leegomonchai, 2006).

Contracting also has benefits for growers, and these relationships are entered into voluntarily. Contracting has the central benefit of ensuring the growers a market for their products during contracted periods and alleviating cash-flow problems (Vukina, 2001). As noted above, the intensive methods of broiler production reduce the labour costs for farmers. Additionally, contract growing provides an opportunity for farmers to maintain a rural, agricultural lifestyle despite national declines in the numbers of small farms, especially in the traditionally agricultural regions of the southern United States of America. Despite these benefits, however, many contract growers express significant discontent about relationships with integrators. A 1999 survey of 1 424 contract growers in ten states found the tournament scheme, in particular, to be a source of considerable grievances (Farmers' Legal Action Group, 2001). Nearly half the growers believed that the tournament scheme provided poor incentives for hard work. Seventy-eight percent of growers responded that their pay depended more on the quality of the inputs provided by the integrator (chicks, feed) than on the quality of their own work. Grower distrust of the integrator's measurements was also a significant issue in the survey. One-third of respondents expressed confusion regarding their post-harvest settlement sheets, and growers also expressed mistrust about the accuracy of feed weighing, the prompt weighing of birds at the processing facility, and higher than expected condemnation rates at processing. One-third of respondents reported that they are sometimes or often left without birds long enough to cause financial hardship. While 75 percent of growers in the survey believed that broiler growing had been a good decision for them, only 35 percent would encourage others to enter the business.

4 CONTRACTING: SHIFTING THE BURDENS OF POULTRY PRODUCTION

From a financial perspective, as discussed above, contracting allows integrators to maintain equity in the product and control over its production and quantity, while shifting some of the risk involved in the variability of producing live animals to the contractor. From a public-health vantage point, contracting results in a transfer of the health risk associated with intense exposure to live animals and their wastes from integrator to grower, and, in the absence of regulatory controls, ultimately to the public. This phenomenon is the central focus of this paper.

We highlight five negative externalities of contract growing that are relevant to public health: 1) waste management; 2) occupational exposures to, and human infections with, zoonotic pathogens; 3) peri-occupational and community exposures to these pathogens; 4) decline of rural communities; and 5) farm-level biosecurity. High-density animal production is associated with a host of other risks to occupational health (Gray *et al*., 2007; Donham *et al*., 2007) and community well-being – from respiratory disease to odour pollution (Cole *et al*., 2000; Warner *et al*., 1990; Wing and Wolf, 2000). In this paper, we focus on specific risks for zoonotic disease emergence that arise from the outsourcing of negative by-products of production from integrator to grower.

4.1 Waste management

The United States Department of Agriculture (USDA) estimates that confined food animals produce approximately 303 million tonnes of waste per year, which is more than 40 times the mass of human biosolids generated annually (Agricultural Research Service, 2007). It is estimated that the 9 billion broiler chickens grown annually in the United States of America produce between 12 and 23 billion kg of waste annually (Nachman *et al*., 2005). The management of animal wastes and the disposal of dead birds is the sole responsibility of the grower.

Unlike human wastes, animal manure is subjected to few regulations regarding treatment and none for disposal. Ninety percent of poultry litter (which includes excreta, spilled food, dead animals, and the layer of sawdust or other material spread on the floor of the poultry house) is applied to land, or stored in heaps until it is applied to land or transported off the farm (Graham, 2007). The lack of regulation regarding the treatment of animal biosolids is surprising, given that animal waste often contains levels of pathogens higher than those found in human faeces. Many enteric organisms can survive for long periods of time, from days to months, in manure and wastewater (Nicholson *et al*., 2005; Guan and Holley, 2003). Bacterial pathogens such as *Campylobacter* spp, *Salmonella* spp, *Brucella* spp, *Clostridium perfringens* and *Listeria monocytogenes* can be present in fresh poultry manure at high levels, and infectious doses are observed even following holding on site (Cole *et al*., 2000). Additionally, viral persistence in poultry manure poses risks of exposure to zoonotic viruses. Infectious titres of avian influenza virus have been recovered from the manure of infected chickens for up to three weeks (Lu *et al*., 2003), and methods of storage and transport of manure are hypothesized to be potential sources of spread of zoonotic agents (Gilchrist *et al*., 2006).

4.2 Consequences for occupational health and illness

Growers, catchers and their families experience exposure to zoonotic pathogens from direct and indirect occupational contact with live birds and poultry manure. Among these populations, exposure to viral and bacterial pathogens may result from working in the confinement house itself, handling live chickens, cleaning the confinement house or transporting animal waste. Potential exposure pathways include inhalation and ingestion of dusts (inside and near to the poultry house), exposure from lacerations, eye exposure and cross-contamination of drinking water on the farm. In the United States of America, the agricultural workforce in food animal production is not unionized (except for processing-plant workers in some cases) and is not provided with clothing or other personal protective equipment when entering the poultry house. There are typically no cleaning and hygiene facilities provided to these workers.

Occupational exposure to broilers has been shown to increase risk of infection with enteric bacteria, including enterococci (van den Bogaard *et al*., 2002) and *E. coli* (Price *et al*., 2007) and *Campylobacter jejuni* (Wilson, 2007). Poultry workers on the Delmarva Peninsula were shown to have 32 times the odds of carrying gentamicin-resistant E. coli and five times the odds of being infected with a multidrug resistant strain of *E. coli* compared to community referents (Price *et al*., 2007). In an experimental study, Ojeniyi (1989) inoculated chickens with an introduced strain of *E. coli*; poultry workers in contact with these birds were quickly infected by this strain. The implications of zoonotic bacterial infection are clearly intensified by the presence of antibiotic-resistant strains, which complicate treatment and may prolong illness.

Confinement workers and growers also have elevated exposure to zoonotic viruses, and this is of clear concern in relation to viral re-assortment and the development of human–human transmissible strains of influenza viruses. An analysis of human infection with H5N1 in Hong Kong SAR during the 1997/1998 outbreak found that occupational tasks involving direct contact with live poultry were a statistically significant risk factor for seropositivity (Bridges *et al*., 2002); in fact, only those occupational tasks which involved handling live poultry were associated with increased risk of infection. A study of the H7N1 outbreak in the Netherlands in 2003 indicated that the highest rates of human seroprevalence were among individuals with occupational contact with poultry, including cullers, veterinarians and farmers (Koopmans *et al*., 2004). Puzelli *et al*. (2005) reported serological evidence of avian-to-human transmission of both high- and low-pathogenic strains of H7 in Italy. Together, these observations indicate that occupational exposure to industrial poultry production, through growing and working with live poultry, poses a distinct and significant risk of infection with avian influenza viruses.

4.3 Peri-occupational and community exposure

While growers and poultry workers themselves experience the most direct contact with live poultry and are at highest risk of exposure to zoonotic disease, their families and communities are also at elevated risk of exposure and subsequent infection. More research is needed to fully depict the peri-occupational and community infectious-disease risks from confinement facilities, but recent analyses indicate ample reason for concern, particularly for influenza transmission (Graham *et al*., 2007; Gray *et al*., 2007). In an analysis of the H7N1

outbreak in the Netherlands, Fouchier *et al*. (2004) identified H7 seroprevalence in members of farm workers' families, indicating that peri-occupational pathways of exposure are viable for influenza viruses (Fouchier *et al*., 2004). Fey *et al*. (2002) documented the case of a farm child infected by ceftriaxone-resistant salmonella and Gupta *et al*. (2003) identified indistinguishable isolates of ceftriaxone-resistant salmonella in cattle and farm communities. Transmission of methicillin-resistant *Staphylococcus aureus* to families of pig farmers has been reported in the Netherlands, with molecular methods confirming the clonality of human and pig isolates (Huijsdens *et al*., 2003). These studies imply that farm families and communities are a population at elevated risk of infection with farm-based zoonotic pathogens.

Furthermore, exposure among farm communities to drug-resistant bacteria from confinement houses is of significant concern for public health. The presence of pathogens and drug-resistant pathogens has been documented in air and water near to these facilities. Poor waste-management practices contribute to the spread of antibiotic-resistant bacteria in the environment near food animal production facilities (Chapin *et al*., 2005; Sapkota *et al*., 2007; Anderson and Sobsey, 2006), putting community members at increased risk of exposure to drug-resistant strains through air and water pollution. The geographic concentration of industrial food animal production intensifies the impacts of these exposures for farm communities (Silbergeld *et al*., 2008).

The economic burdens associated with treating zoonotic illnesses, particularly drug-resistant infections, among farmers and their families are also significant. In the absence of national health-care resources in the United States of America, the costs associated with these illnesses (including lost work time and any treatment) are largely borne by the grower or the workers. As contract employees, growers generally receive few, if any, health benefits from integrators, which may result in reduced access to primary care and delayed identification and treatment of disease. Farm-based practices to reduce grower exposure to zoonotic agents, such as the purchase and use of personal protective equipment, are also the sole financial responsibility of the grower. In these ways, the health conditions and health-care costs that result from continuous exposure to a high density of live chickens in a confined environment – an exposure required by the very nature of contract growing for a broiler integrator in the United States of America – remain an externality of production, borne not by the integrator but by the grower and the community.

4.4 Investments for biosecurity

Farm-level biosecurity is critical in reducing opportunities for the transfer of pathogens among birds and between poultry and humans. In a vertically coordinated system, integrators can set company-wide biosecurity standards and guidelines for growers to follow. However, these standards often entail additional costs for the grower – including the purchase of new equipment, disinfectant, or structural adjustments – for which the integrator does not provide financial compensation; this reduces incentives for compliance or maintenance of equipment. In the event of an outbreak, growers may experience significant financial losses from culling or flock loss. Compensation schemes typically exclude direct payment to contract growers (World Bank, 2006), despite the fact that both integrators and growers have invested resources into the flock. In the United States of America, the United States Department of Agriculture (USDA) and states pay integrators up to 75 per-

cent of the appraised value of the flock lost to HPAI. Integrators are encouraged, but not required, to compensate the growers for their losses on the basis of what they would have earned had the flock not been culled (Ott and Bergmeier, 2005). Yet, given the low profit margins in the industry, the established level of compensation is generally not high enough for integrators to cover their own losses as well as those of growers. Costs associated with depopulating and disinfecting growing houses, as well as with waste management, in an outbreak are not included in the compensation scheme, and are borne entirely by the grower. Compensation schemes are intended to provide incentives for the early reporting and culling of infected animals to prevent disease spread. Strategies that fail to acknowledge the full financial investment of growers may have the effect of discouraging the early and complete reporting they were designed to facilitate.

4.5 Economic impacts of contracting: social justice concerns

There are also significant economic impacts of industrial poultry production at the community, and even regional, level. These operations often bring increased investment in the local communities in which the industry is based, including jobs, tax revenue, and road and utility infrastructure. These local benefits can be significant, especially in low-income rural areas, and for this reason are often welcomed by some individuals in local communities. Across the agricultural sector, however, concentration and industrialization is associated with economic and community decline (MacCannell, 1988) as well as decreased tax receipts and local purchases (Foltz *et al*., 2002; Durrenberger and Thu, 1996). Property values have also been observed to drop after a confinement house locates in a community (Abeles-Allison and Conner, 1990).

Most importantly, individual benefits in terms of profits are relatively low. Poultry growers do not earn significant profits through contract relationships. Growers invest approximately 50 percent of the capital necessary to produce broiler chickens, but earn less than 3 percent of returns on the investment (Morison, 2007). In the 1999 grower survey, 75 percent of growers in the study made less than US$30 000/year from broiler production, and 45 percent made less than US$15 000/year (the federal poverty standard for a two-person household in 1999 was US$17 029/year) (Saenz *et al*., 2006). According to the survey, the majority of growers earn 50 percent or more of their income from broiler production. Additionally, more than half of survey respondents took on US$100 000 or more to finance the operation, and 52 percent still owed 75 percent or more of the total farm debt (Farmers' Legal Action Group, 2001).

Growers blame lower than expected income on poor chick quality and higher than expected operating costs. From 1980 to 2002, poultry growers experienced an increase in building and equipment costs of more than 200 percent (Cunningham, 2005). Variable costs associated with fuel, electricity and labour – all the sole responsibility of the grower – have also increased in recent years. Yet, integrator payments to growers have not kept pace with these increasing fixed and operating costs; over a 22 year period, base payments per pound increased by only 54 percent, from 3.3 cents in 1980 to 5.0 cents in 2002 (ibid.). Simply adjusting for inflation, 3.3 cents in 1980 would be worth 7.0 cents in 2002; this calculation highlights that grower payments have actually decreased in value as they have not kept pace with baseline inflation (US Department of Labor, 2007).

Financial challenges are only one of the issues facing poultry-growing communities. In the United States of America, one reason for the geographic location of poultry production is related to community empowerment: the siting of confined animal facilities is disproportionately in non-white, low-income communities, who may not have the political or economic resources to resist the industry or mitigate its health and environmental consequences (Wing *et al*., 2000). Confinement houses are more likely to be located in communities with high percentiles of African Americans or persons living in poverty (Wilson *et al*., 2002; Ladd and Edward, 2002), and near low-income and non-white schools (Mirabelli *et al*., 2006). As a consequence, the presence of confinement houses negatively impacts already tenuous social capital, causing rifts and social gaps between independent and contract farmers, and antagonism and hostility directed towards supporters and opponents of industrial food animal production (Wright *et al*., 2001). These studies strongly suggest that the practice of contract growing has important negative implications for both equity and community cohesion, which are independent factors in community health.

5 POLICY IMPLICATIONS

Industrial poultry production brings clear benefits to consumers through reduced prices, and greater security and availability of food products. Yet, the negative public-health implications of poultry production are largely externalized from the production costs faced by integrators. The practice of contract growing facilitates the outsourcing of negative externalities onto growers, poultry workers, local communities and the general public. As contract growing becomes more commonplace in the middle- and low-income nations, attention must be paid to these negative externalities. These practices have local impacts on the health and economic survival of farm communities as well as critical implications for global disease emergence. Contract systems require specific policies in order to mitigate these local, national and global risks.

Policies regarding the treatment and use of animal waste, based not just on nutrient balance, but also on pathogen levels, are imperative in reducing the environmental and health risk caused by exposure to animal waste. The geographic concentration of industrial animal production in rural and peri-urban areas in the developing world, which have high population density and limited public-health surveillance and environmental monitoring, intensifies the need for regulations for the treatment of animal waste in these areas. Waste-management strategies must also consider the liability of the integrator for the by-products of production. Liability strategies that fall solely on the resource-constrained grower may contribute to mismanagement of animal waste and limit incentives for innovations in waste-treatment technologies. Strategies that provide financial incentives for the development of inexpensive, on-farm waste-treatment technologies that reduce pathogens below infectious levels should be a central priority of municipal and federal governments.

Improving occupational health among growers and their communities is another area in which policy action is required. At the farm level, growers, farm workers and their families internalize risks to personal health from exposure to zoonotic pathogens, which may be amplified due to the density of animals within a confined facility. In the absence of employer- or state-sponsored health care, this is both a health and a financial risk. Regulatory standards should mandate the use of personal protective equipment (including goggles,

gloves, aprons and boots) to shield growers and poultry workers from zoonotic-disease exposure. Policies that include growers in health-care programmes, through employer- or state-sponsored systems, can mitigate the financial burden on growers and local communities and reduce disease transmission within farm communities.

Health-care services for contract growers and farm communities are also necessary to provide front-line surveillance for emerging zoonotic diseases. However, in the United States of America, these communities are among the least likely to be served by accessible health-care resources. Active surveillance of poultry-worker and community health is a vital component of public-health policy in nations with industrial animal production; the lack of health surveillance among growers, poultry workers and their families represents a critical missing link in plans for preventing pandemic influenza (Gray *et al*., 2007). Public-health resources should also be devoted to monitoring the health of these workers, even those who are undocumented, so that emerging diseases are identified quickly. Given that both integrators and the public benefit from intensive animal production, community health monitoring provides a potential opportunity for public/private partnerships that can involve private corporations, governments, universities and non-governmental organizations.

Farm-based biosecurity standards, as well as compensation schemes, must be designed to include consideration of the burden on contract growers, to ensure both fairness and effectiveness. One of the most obvious gaps in this respect is the current practice of compensation for flock-loss associated with outbreaks, which does not include direct payment to growers, but, like a bankruptcy claim, considers the grower as a party of last resort. Since growers are the most closely involved with chickens on a daily basis, fair compensation schemes reimbursing growers are vital in setting incentives to report infected birds quickly. When compensation schemes exclude direct payment to contract growers, this provides perverse incentives with respect to halting emerging diseases. Similarly, costs associated with implementing biosecurity plans should be shared between integrators and growers – acknowledging the shared investment in the flock.

Addressing the socioeconomic impacts of contract growing is a challenging issue that requires regulatory, legal and non-governmental approaches. Zoning that limits geographic concentration of industrial food animal facilities, based on human population density, regional infrastructure or environmental carrying capacity could reduce community decline and also impart environmental benefits. Such measures could also reduce the ready movement of pathogens, including viruses, among animal houses. This movement can occur by airborne movement of dusts and aerosols, as well as by vector-transport via insects, small rodents, and wild birds that enter and leave poultry houses that are not completely biosecure. There are also specific suggestions regarding limiting the proximity of poultry and pig houses in order to reduce the possibility of viral mixing of influenza strains (Saenz *et al*., 2006). Laws to strengthen contractor rights within negotiations and ensure fair payment schemes can protect workers, and non-governmental organizations play an important role in improving contract conditions for growers.

The experience with contract growing in the United States of America provides important insights to developing nations who adopt this practice as a component of industrialized poultry production. Contract growing imposes significant health and economic risks on growers and farm communities, as well as the general public. Public health and agricultural

policies must consider factors specific to the contracting relationship and the externalities of industrial poultry production in order to successfully mitigate these risks.

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Response of the Thai poultry industry to highly pathogenic avian influenza

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SUMMARY

Significant markets remain much the same as they were before highly pathogenic avian influenza (HPAI). Thai producers are continually adjusting their marketing strategies. Following the severe HPAI outbreaks of 2003, government stepped in to regulate processing plants through certification programmes. Despite these measures, only half of the existing plants managed to meet the required standards and producers had to adjust their strategies. Adjustment in the private sector is far from easy and requires significant investment in equipment. Skilled labour, however, is one of Thailand's strong points. A cooked-meat customer base is essential for industry survival, and the Thai industry has been successful in meeting customer needs. Thailand will continue to increase exports of cooked chicken meat.

Key words: Thailand, poultry, export, HPAI

1 INTRODUCTION: LOCATION OF BROILER PRODUCTION

Before the outbreak of highly pathogenic avian influenza (HPAI) in 2003, the United States of America, China, Brazil and the countries of the European Union (EU) were the world's four dominant locations of broiler production, followed by Mexico and India. Thailand was placed seventh. Japan, Canada and Argentina, in that order, filled the remaining three places in the top ten broiler-producing countries. In 2007, after the HPAI outbreaks, there were no changes among the top six in the table, but Thailand dropped from position seven to position ten, surpassed by the Russian Federation, Argentina and Japan.

2 BROILER EXPORT

The outbreak of HPAI caused a significant drop in the export of broiler meat from Thailand. HPAI broke out in 2003 when Thailand was the world's fourth largest exporter of broiler meat, behind the United States of America, Brazil and the countries of the EU. While the HPAI crisis led to a virtual cessation of exports from Thailand, by 2007, the country was back to number five among exporting countries, with the same countries as in 2003, plus China, exporting more than Thailand. Before the 2003 HPAI outbreak, broiler exports from Thailand constituted 40 percent of the total broiler production in the country, in comparison to 14 percent in the United States of America and 25 percent in Brazil, while exports constituted only 4 percent of total production in China. In 2007, this proportion

had hardly changed for these three countries, but in the case of Thailand, it had fallen to 29 percent.

Among countries that introduced a total ban on imports of all poultry products were Malaysia and Turkey, while the countries or regions that banned only the import of fresh meat included : Japan, the EU, the Republic of Korea, Singapore, Hong Kong SAR, Canada, South Africa, Switzerland and the Middle East.

3 EXPORT OF COOKED PRODUCTS AND MAJOR MARKETS

Thailand began working with cooked broiler products for export in the early 1970s, and after the HPAI shock all exports consist of cooked products.

The heating temperature required varies from one importing countries to another. In all cases, it is above the requirements set by the World Organisation for Animal Health (OIE), as shown in Table 1.

In 2003, the year that HPAI broke out, the total export of broiler meat from Thailand was 546 000 tonnes, of which approximately 35 percent, or about 190 000 tonnes, were cooked meat. In 2007 it is estimated that the export will be 320 000 tonnes, all of which is cooked meat.

Thailand's major export markets in 2003 were Japan and the EU, which accounted for 50 percent and 38 percent, respectively, of the export, while minor shares went to the Repubic of Korea, China, the Middle East and some other countries. In 2006 after the HPAI outbreak, the share going to Japan and the EU went up to 51 percent and 43 percent, respectively. Nothing was reported to be going to the Repubic of Korea, China or the Middle East, while 6 percent went to other countries.

4 CONCLUSION

Broiler export from Thailand is now based on cooked meat, and this is expected to be the basis for future exports.

TABLE 1
Core temperature and time required for cooked products by different countries

Core temp.	OIE	EU	Japan	Singapore	Hong Kong SAR	New Zealand	Canada	Australia
70°C	3.5 seconds		1 or 30 minutes	3.5 seconds	2 minutes	30 minutes		
74°C					75°C 15 seconds			165 minutes
80°C						5 minutes	15 minutes	125 minutes
100°C						1 minute		
100°C						1 minute		

Food-safety concerns in the poultry sector of developing countries

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SUMMARY

Poultry production is one of the fastest growing livestock industries as a result of its advantages in terms of land use and improvements in the food conversion rate of genetically superior poultry breeds. Among the major concerns related to this development are health issues threatening not only animal production, but also the people using the products derived from these animals. Microbiological risks, such as salmonella-related food poisoning, pesticide residues from feed production, and resistance problems following the use of antibiotics in animal production have become the focus of attention.

In the industrial world, legislation and regulations have been implemented, involving both the public and the private sectors. However, in many developing countries such measures do not exist. Food-borne illnesses are, therefore, still major problems in developing countries. This paper discusses the measures that can and should be taken by developing countries to ensure safe products from the poultry sector. Examples are given from Bangladesh. As production conditions vary greatly as a result of socio-economic, political and environmental factors, regulations applied in one part of the world may not be suitable elsewhere. It is also questionable whether a developing country that does not aim to enter the export market for poultry, or livestock products in general, should apply the same standards as an exporting country. Many countries only produce for their national markets and therefore lack the incentive to follow international regulations; approximately 90 percent of global livestock products are sold in domestic markets. Nevertheless, the prevalence of food-borne diseases in developing countries is alarmingly high, and action is needed especially with regard to consumer awareness. To achieve this, there is a need for more information to be gathered about the conditions in individual countries, and for country-specific political action.

1 INTRODUCTION

The world is experiencing a growing population and rising incomes. This has led to increasing demand for food products, especially meat, milk and eggs. Together with innovations on the supply side, this has caused rapid growth of the livestock sector as a whole. The process has been referred to as a "livestock revolution" comparable to the "green revolution" of the 1960s.

The search for the most viable protein sources has resulted in particularly rapid growth of industrial poultry production. Poultry does not need pastureland, and the food conversion rate of genetically superior poultry breeds is very good compared to other livestock such as cattle. Technical advances in the feed industry have added to the progress. Pork production has followed a similar pattern to poultry. Intensification has brought food-safety concerns into sharper focus (Blancou *et al*., 2005), and these concerns have been increasingly acknowledged, at least in developed countries, as information technology and medical science have advanced (Nelson, in FAO, 2005).

Per capita demand for meat and fish products in developing countries has grown a rate of 3.7 percent over the last 20 years (FAO, 2003). At the same time, the new intensive production systems of the developing world are facing more and more pressure to comply with the regulations that prevail in the global market.

The various factors that influence production conditions (e.g. environment, infrastructure and culture) give rise to differing demands for food-safety standards in different parts of the world. Food-borne diseases can also be related to demographic movements from rural areas to the cities, which cause overcrowding and, therefore, problems with hygiene, sanitation, housing conditions, etc., particularly in developing countries (Heath, 2006). Public health service systems are often unable to adapt to the rapid pace of urbanization. The urban lifestyle has also led to changes in consumption patterns, with more food products consumed outside the home, and to growing consumption of prepared foods (Stamoulis *et al*., 2004). Increased trade in food and feed across country borders, together with increased

TABLE 1
Some factors influencing the incidence of food-borne disease

Food supply system	Health and demographics	Social situation/ lifestyle	Health system and infrastructure	Environmental conditions
Mass production and distribution – larger outbreaks, etc.	Population growth	Increased consumption outside	Decrease of resources and increase of food businesses	Pollution
Intensive agriculture – increased use of drugs and pesticides, etc.	Increase in vulnerable groups, e.g. the elderly, immunosuppression, malnourishment	Increased travel	Lack of water supply, sanitation and fuel for cooking	Changes in ecosystems – lack of water and resources
International trade	Increase in the number of displaced people	Changes in food preparation habits	Inadequate training of health workers	Climate change
More food service establishments – lack of training	Rapid urbanisation – lack of sanitation and water	Poverty and lack of education	Weak surveillance and monitoring systems	
Longer food chain		Lack of time	Lack of access to technologies	
		Changed social and cultural behaviour	Lack of consumer awareness	

Source: adapted from Motarjemi and Käferstein (1999).

leisure and business travel, is contributing to the global character of the food-safety problematic (see Table 1).

Food safety can be defined as the system that keeps food and food products free from substances hazardous to human health. Food safety should be a part of governments' strategies to ensure secure food for the consumers. In this context, a "hazard" refers to any biological, chemical or physical property that may cause unacceptable risk (FAO, 1998). The emergence and discovery of new food-borne pathogens and other food-related hazards has increased the need for food-safety measures. The intensification of food production has also changed food processing and handling systems and raised new challenges for food-safety institutions. Intensification has led to large amounts of potentially infectious material being concentrated at single sites, such as large industrial production establishments or processing plants, and has therefore contributed to the potential for large-scale outbreaks of infection. Changing consumption patterns – street vendors and home cooking of primary products are giving way to the purchase of processed food from supermarkets – make food-safety an issue of public concern rather that just a matter for individual consumers.

Developing countries face difficulties in achieving food-safety goals in animal production systems. These difficulties result from *inter alia* unstable administrative and political structures, lack of infrastructure, and lack of investment in food-safety measures and research, as well as from inadequate consumer information.

Responsibility for ensuring safe food for the consumer has traditionally been seen as the responsibility of public institutions. However, with the intensification and industrialization, responsibility has been shifted to a wider set of stakeholders including the private producer and the consumer.

2 BACKGROUND

2.1 Objectives

The objective of this paper is to describe the food-safety problems facing industrial poultry production systems in general, and then to examine the situation in developing countries – illustrated by a country example. The main risk factors affecting the whole vertical chain of industrial poultry production are described. The control measures, regulations and tools that are commonly applied in developed countries are also briefly described. Some common food-safety issues affecting developing countries are discussed. Utilizing the country example, the question of whether it is appropriate in developing countries to enforce control and regulation systems of the type commonly applied in the developed countries is addressed. Some of the constraints faced by developing countries, such as difficulties in risk management, and lack of administrative capacity, technical qualifications, information technology and so forth, are examined. The importance of cultural, environmental and political factors is highlighted.

The above-mentioned factors certainly differ across the developing world. Nonetheless, the objective is to use the country example to shed some light on the general situation in the developing world. Bangladesh, one of the poorest countries in the world but which has a relatively rapidly growing poultry sector, is used as the example.

The information presented here is drawn from the literature and from personal communication with experts working in the field or in research.

2.2 Defining the production systems

Seré and Steinfeld developed a framework for classifying livestock production systems (FAO, 1996). This classification first distinguishes "solely livestock" from "mixed farming" systems. The first category is then divided into "landless" and "grassland-based" systems. The landless system can also be referred as "industrial". This group has two subgroups: monogastric and ruminant production. Finally, the monogastric system is divided into pork and poultry (meat and eggs) production. This paper will first focus on the "industrial" poultry production system, and will then consider whether the other production systems could be included under food-safety regulations of the type implemented in the industrial system.

FAO has formulated an additional classification of poultry production – Sectors 1 to 4 – based on the level of biosecurity. Sector 1 is defined as "an industrial integrated system with high level biosecurity and bird/products marketed commercially". Sector 2 is described as a commercial system with moderate or high biosecurity and birds/products usually marketed commercially. Sector 3 is also described as a commercial system, but with low or minimal biosecurity and birds/products entering live-bird markets. Sector 4 produces chickens for local consumption only, and is described as having minimal levels of biosecurity. This sector is sometimes called the village or backyard sector. The definitions are constantly under discussion, and some doubts are expressed about categorizing sectors on the basis of biosecurity levels, due, for instance, to disputes about the definition of the term "biosecurity" itself. This paper focuses on the differences that these sectors face with regard to the global regulatory food-safety environment.

Parallel markets for poultry products can be identified in developing countries. On the one hand is industrial production or the formal sector, and on the other the informal market where official hygiene regulations and control measures are not followed (Enste and Schneider, 2000). It is also possible to categorize the poultry market into the export and domestic production sectors. Some vertical integration exists in developing countries – mostly involving Sector 1 and 2 farms. Such farms follow the regulations set by the industry. These are often private rules that have been set according to the needs of the target market and the local circumstances. There is quite an important difference between the two markets. However, there are many examples of interaction between the two, so the division is far from clear cut.

This paper concentrates mostly on broiler meat production, but some parallels to the production of chicken eggs are drawn.

3 THE POTENTIAL RISK FACTORS

Three types of food-borne risk factors for human health can be recognized (FAO, 1998). The first group of risk factors comprises microbiological factors such as *Campylobacter* spp. and *Salmonella* spp. The second group of risk factors comprises chemical factors such as residues from veterinary medications, pesticides, natural toxins or environmental pollution. Excessive use of medication during poultry production, or disinfectants used in the food-processing industry, can give rise to the problem of resistance. This adds to the problem of food hygiene. The third group of risk factors comprises physical hazards such as bone-pieces in meat; this group is not further considered here.

3.1 Microbiological risk factors

Microbiological risk factors include bacteria, viruses, protozoa, helminths, prions and mycotoxins. The most important group with respect to poultry are bacteria such as *Salmonella* spp., *Campylobacter* spp., *Listeria*, clostridia, enterococci and *E. coli.* As far as viruses are concerned, the significance of avian influenza should not be overlooked. Helminths, prions and protozoa are not considered to be major threats to food hygiene in industrial poultry production. Microbiological risk factors can be found in all poultry production systems. The most common microbiological pathogens connected with shell eggs are *Salmonella, Campylobacter, Listeria* and other enterobacteriaceae (Jones *et al*., 2006). The eggs can be infected vertically before laying or as a result of contamination from the environment. Cracks and other damage to the egg shell are obvious locations for pathogen multiplication.

Bacteria

One of the most studied food-borne pathogens is *Salmonella* spp. It is easily spread during the trade and processing of poultry products, specifically non-processed and non-heat handled products. This spread has been facilitated by industrialization and the growing international trade in animal feed, live animals and food. Food-borne *Salmonella* infection in humans is a very widespread problem in the industrialized world. In the European Union (EU), almost 200 000 people were infected during 2004 (EFSA, 2006); Mead *et al*. (1999) report an estimated annual figure of 1.4 million infections in the United States of America. The risk of infection with *Salmonella* has been worsened by the spread of pathogen strains with resistance to antimicrobials, a possible consequence of excessive use of antimicrobials in animal feed and as veterinary treatments (Antunes *et al*., 2006). The virulence of *Salmonella* is related to its ability to avoid host defence mechanisms and to invade non-phagocytic cells, its resistance to environmental factors and its production of enterotoxins (Plym Forshell and Wierup, 2006).

The increasing problem of *Salmonella* infection is not necessarily attributable entirely to the growth and intensification of poultry production; changing consumption patterns may also be a factor. Forsythe and Waldroup (1992) suggest that changes to consumer behaviour, such as eating out more, increased use of microwaves for heating and re-heating food, and increased use of salad bars outside the home, have contributed to the increase in human *Salmonella* infections in the United States of America. More or less similar patterns of consumer behaviour can be found in the other parts of the industrialized world. The above-mentioned study showed, however, that the incidence of human infections increased during the summer months, which implies that processing procedures may not be adequately adjusted to account for high temperatures.

Salmonella is also vertically transmittable, and some human infections can be traced to eggs. Infection with *Salmonella* can occur before laying (Humphrey, 1994), but the surface of the eggs gets contaminated quickly if there is infection in the environment. Chicks hatched uninfected can also be colonized very quickly. In the latter case, the infection can be detected two weeks after hatching, i.e. after the so-called lag phase.

Animal feed is a potential source of *Salmonella* infection. Crump *et al*. (2002) report several cases in which the *Salmonella* strains found in human food have been traced back to animal feed. In countries in the EU, there are specific requirements for the application of

feed-processing techniques to control the most common pathogens, including *Salmonella*. For example, in Denmark there are requirements for heat treatment of feed, and for feed producers to follow HACCP (hazard analysis and critical control points) regulations (Danish Veterinary and Food Administration, 2006).

Sander *et al*. (2002) investigated the additional problem of resistance arising as result of the use of disinfectants in the hatcheries; they identified the same strains of resistant *Salmonella* in the processing plants as in the related hatcheries.

Campylobacter is one of the pathogens most commonly causing food-related illnesses in humans. The bacteria can cause diarrhoea, gastro-intestinal pain and nausea in infected people. In rare cases it also causes Guillain-Barré syndrome, an immunological failure that causes damage to parts of the peripheral nervous system.[1] The most common species of *Campylobacter* diagnosed in humans are *C. jejuni* and more rarely *C. coli* (Jacobs-Reitsma *et al*., 1995); however, there are some small differences between geographical areas. Infections with multiple strains have been identified in most of the flocks of broiler chickens (Jacobs-Reitsma *et al*., 1995). *Campylobacter* does not cause clinical signs in poultry (Wagenaar *et al*., 2006). It remains unclear how flocks get infected with *Campylobacter* before harvesting, but there are several theories. Feed and water, vectors such as rodents and flies, horizontal transmission between birds, and contamination in the hatcheries are possible routes of entry (Hald *et al*., 2004). The view has been that *Campylobacter* is not transmitted vertically, and that chicks are born infection free. The young birds are rapidly colonized only after hatching – infection can be detected after the so-called lag phase of one or two weeks. Vertical transmission has, however, been provoked in experimental conditions, and *Campylobacter* has been found in the oviduct of the chicken and in the semen of the rooster (Byrd *et al*., 2007). This could imply that the bacterial contamination is traceable to the hatcheries and that layers might be infecting the eggs.

Campylobacter is particularly found on raw poultry meat. It is very vulnerable to drying out, but can survive for months in small pools of dirty water. Warm-blooded animals serve as reservoirs (Adams and Moss, 2004). Because of the vulnerability of the bacteria there have been many successful programmes of eradication in primary production. However, the end-result of these measures is questionable; the most probable site for recontamination is the carcass processing plant. Shell eggs are not a major source of *Campylobacter* infection in humans.

Other bacteria, such as *Clostridium perfringes*, *C. botulinum, Listeria monocytogenes* (Rørvik *et al*., 2006) and *E. coli* O157:H7 can also be found in poultry products (WHO, 2007), but these organisms cause food-borne illnesses less frequently than do the two pathogens described above. Besides pathogens associated with the animals themselves, organisms associated with humans, such as members of the enterobacteriaceae and Staphylococcus, are major hygiene concerns in the handling of food products.

Mycotoxins

Mycotoxins secreted from certain strains of fungus can be found in various feed ingredients, including those used in poultry feed. Mycotoxins can infect the plants during their

[1] National Institute of Neural Disorders and Stroke: http://www.ninds.nih.gov/disorders/gbs/gbs.htm

growth or during processing and storage; they can be distinguished into plant pathogens and storage mycotoxins (D'Mello, in FAO, 2004a). Types of feed differ from region to region, and therefore the range of mycotoxins also varies. In tropical areas, *Aspergillus* spp. are the most common organisms involved, while in more temperate areas, *Penicillium* spp. are more common. The third group of toxin-producing fungi is *Fusarium*, which produces fumosin toxin (ibid.). The main toxins of food-safety concern are the carcinogenic mycotoxins aflatoxin B1, aflatoxin M1 and ochratoxin A (FAO, 2000). Oyaejide *et al*. (1987) report that over half the poultry feedstuff examined in Nigeria was contaminated with aflatoxin B1. The Nigerian findings also indicated a higher prevalence of mycotoxins in feeds stored on the farm than in those stored by the feed producer (ibid.). This implies a lack of good management practices on the part of the poultry producer. These substances should be carefully monitored in poultry meat and eggs because of their carcinogenicity to humans. Industrial feed processing mills use various methods to control the risks associated with mycotoxin, including pelleting, heat treatment and irradiation.

Other microbiological risk factors

Parasites of poultry that can cause human infection are very rare. Moreover, virus infections caused by orthomyxoviridae (avian influenza viruses) can be described as a risk factor for the actors involved in food production, but not directly as a hazard for the consumer of the processed poultry product. Prions are mostly considered to be a hazard associated with cattle and sheep meat products rather than poultry products (van de Venter, 2000).

Another important issue, related to both microbiological and chemical risk factors, is the problem of resistant strains of pathogenic bacteria that can affect humans. The spread of resistant strains may be related to the widespread use of antibiotics to treat animals and as growth promoters especially in broiler feed.

3.2 Chemical risk factors

Some chemical substances can be traced all the way into poultry end-products. There are, nowadays, strict restrictions in many countries, but elsewhere residues of antimicrobial medicines can still be found in the end-products.

During the production of feed, there is a need to control the residues of organic and inorganic environmental pollutants such as dioxins, chlorinated biphenyls, furans and heavy metals (Saegerman *et al*., 2006). The control of feed quality and safety is increasing in importance as a result of the expanding international trade in animal feed products. Other risk factors that should be considered are pesticide residues from feed production, and genetically modified organisms (GMOs). A discussion of the latter issue is, however, beyond the scope of this paper.

Antibiotic residues

Antibiotic residues in food products can be the result of excessive use of antimicrobials in veterinary practice or as a supplement in ready-produced animal feed. Policies regulating the use of antibiotics vary greatly between countries; in the developing world, the control is probably generally insufficient.

There are two ways in which the antibiotics in feed can affect human health: the direct

effect of the residues in poultry meat and eggs, and the indirect effect resulting from the selection of antibiotic resistant strains of pathogenic bacteria. The issue of the use of antibiotics as feed additives and the restriction of this use is somewhat controversial. Some suggestive studies imply that the benefits of reducing the amount of resistant bacteria by controlling the use of antibiotics as feed additives might be overshadowed by an increase in the number of cases of human food-borne illnesses (Singer *et al*., 2007) The latter authors describe a model that illustrates the relationship between food-borne illness and the health status of the flocks that supply the food products. The model, which used *Campylobacter* infection as an example, suggests that a small decrease in the levels of illness in the animal flocks will significantly decrease the rate of human infections (ibid.). Moreover, the correlation between the use of antibiotics as growth promoters and the prevalence of pathogen strains has not been definitely proven. The ban in the EU (European Council Directive (EC) 2821/98) was partly a result of pressure from certain member countries; it was accepted as a preventive action in accordance with the precautionary principle (Williams, 2001). Developing countries might not have the motivation or the capacity to enforce such regulations. However, the desire to continue or commence exports to European markets might be a driving force favouring a ban.

The continuous development of techniques for detection also contributes to the problems that developing countries face in terms of conforming to international standards. Technological differences can lead to confusion and unpredicted economic losses associated with the disqualification of export products (Phongvivat, in FAO/WHO, 2004). The acceptable levels for most antibiotics are described under the minimum residue level system (MRL) (ibid.).

Antibiotics are still used as growth promoters in many developed countries, including the United States of America. However, the four main additives, virginiamycin, bacitracin, spiramycin and tylosin, were banned in the EU in 1998 (European Council Directive (EC) 2821/98). Four others, bambermycin, avilamycin, salinomycin and monensin, were banned in 2006 (Hong *et al*., 2005). The antibiotics are used in order to enhance the production qualities of poultry and other livestock. Some studies have shown that production systems using antibiotics as feed additives achieve growth rates up to 10 percent higher than those not doing so (Hughes and Heritage, in FAO, 2004b). There have been other beneficial effects on the product quality, such as decreased fat and increased protein in the meat, as well as indirect benefits such as a reduction in the amount of feed needed, and therefore a reduction in the amount of waste. The practice evidently also decreases the occurrence of gastro-intestinal infections – adding an animal-welfare component to the considerations.

Pesticides

Intensive use of pesticides in many developing countries also affects the safety of food via animal feed with a high level of residues. In order to control plant pests and vectors of disease, the use of versatile pesticides has been widespread in many parts of the developing world. This practice has not been without consequences for the environment, production animals, feed, food crops and public health. There have been studies of immune system-related illnesses, such as immunosuppression and hypersensitivity (Street, 1981), as well as many other illnesses that could be related to the excessive use of pesticides and the result-

ing residues in food products. These illnesses, but also both acute and chronic toxicities, have been reported both in human and animals (Lu and Kacew, 2002).

Pesticide use is highly regulated in the EU and in the United States of America; residue levels are therefore under strict control. However, in a developing country the situation may be quite different. This is illustrated by a study from India (Singh, 2001), which examined various food products for pesticide residues. All the Indian states were included in the study and several pesticides were examined – HCH (hexochlorocyclohexan, also called hexachlorebenzen HCB), DDT, monocrotophos, cypermephrin, quinolphos, aldrin and endosulfan. Of the 12 eggs examined, 83 percent were found to contain residues. Ninety-two percent of the livestock tissues examined were found to contain traces of pesticides. HCH, DDT and aldrin were found at toxic levels in poultry products. In addition, HCH residues were found at toxic levels in livestock feed. HCH, DDT and aldrin are still widely used as insecticides in many countries, although they have been banned in most developed countries. In addition to acute toxicity, HCH can cause hormonal disorders and liver and kidney failure in humans and other animals. Aldrin belongs to a group of organochlorides most of which are banned from use in the developed world. Aldrin, however, is still used in the United States of America as a termite pesticide.

Other chemical risk factors

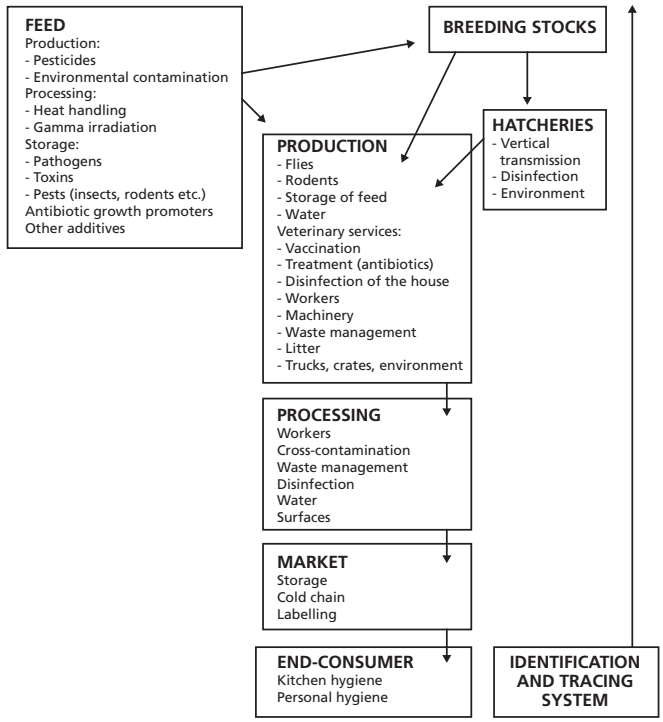
Disinfective agents used in production establishments and processing plants are also risk factors. Chlorinated water used in rinsing the carcasses has also raised concerns among consumers. In the EU the use of chlorinated water is banned, but in the United States of America it is a common practice. The use of disinfectants to clean the equipment in production and processing establishments might, as mentioned above, also give rise to a problem of resistance.

4 THE VERTICAL CHAIN

The different steps of the food production system need specific regulations. However, food-safety interventions should optimally be considered as a whole, i.e. should be coordinated through the whole vertical system (see Figure 1). The chain from "farm to fork" starts with feed production, and continues through the hatcheries to the slaughterhouses, processing plants, wholesalers, retailers and the end consumer. Between these steps there is transport and storage, during which maintaining the cold-chain is crucial. The hygienic behaviour of the end consumer, such as washing hands and kitchen utilities after handling raw poultry meat or eggs, is the final factor in avoiding the food-borne illnesses related to poultry products.

WHO formulated a three-step approach to mitigating the risk posed by *Salmonella* spp. (WHO, 1980); the terms used are also relevant for other microbiological hazards. The first step is pre-harvest control, which focuses on the feed and poultry producers. The second step is harvesting control, which covers hygiene measures at the time of slaughter; these are described in the Codex HACCP model (see Table 2 for an example). The third step is post-harvest control, which covers the product from the processing establishment all the way to the end-consumer. Each of these three stages has to be taken into consideration in order to prevent risk factors entering the chain.

FIGURE 1
The vertical chain of poultry food-products and examples of possible hazard points



It is suggested that the first step, pre-harvest control, is the most important means to prevent infection with pathogens such as *Salmonella*, as traditional control systems are unable to control for these pathogens later in the chain. Singer *et al*. (2007) describe three reasons why it is important to process only healthy animals – thus emphasising the importance of pre-harvest measures. First, a sick animal will shed pathogens into the surroundings and onto other animals; second, processing a sick animal may require additional handling in order to separate the infected parts from the carcass, which may add to the risk of cross-contamination; and third, certain illnesses lead to pathological changes in the carcass which may cause increased fragility of specific organs. *E. coli*-originated airsacculitis, which causes adhesions of the inner organs and therefore increased risk of ruptures during mechanical processing and increased risk of cross-contamination, is mentioned as an example of the latter problem (ibid.).

Poultry producers have an important role in preventing risk factors from entering the food chain. In the developed world this role has become more or less clear to the farmers as a result of official regulations and increased hygiene demands originating from consumers and retailers. The enforcement of these regulations is done through control visits by governmental authorities to production establishments, and by continuous control on the part

TABLE 2
Generic HACCP model for raw chicken: process flow diagram for slaughterhouse

INPUTS	PROCESS STEPS	EDIBLE OUTPUTS
Live birds	1. Receipt of live birds	
	2. Hanging	
	3. Stunning	
	4. Killing	
	5. Bleeding	
	6. Scalding	
	7. Defeathering	
Water (possibly with bactericidal agent)	8. Washing	
	9. Head pulling	Head
	10. Hock cutting	Feet
	11. Venting	
	12. Evisceration	Edible offal (liver, gizzard, heart)
Water (possibly with bactericidal agent)	13. Washing	
	14. Crop removal	
	15. Neck cracking/cutting of neck flap	Necks
Water (possibly with bactericidal agent)	16. Washing (inside/outside)	
Water with ice (possibly also with bactericidal agent)	17. Chilling	
	18. Re-hanging	
	19. Conveying to secondary processing area	
	20. Portioning	
	21 a. Storage	
	22 b. Deboning	
Packaging materials	22. Packaging	
	23. Chilling/freezing	
	24. Storage	
	25. Dispatch	Packed whole chicken or chicken portions

Source: MAF (2000).

of the establishments themselves. An efficient traceability system linking the food product to the farm has enabled efficient and rapid intervention measures in the event of an outbreak of a food-borne disease. It has been shown that improvements made to the health of production animals have positive effects on the safety of animal-derived food products for humans. Singer *et al*. (2007) showed that there is a strong correlation between the health

of production animals and level of food-related human illnesses. Veterinary services are also important. The non-regulated use of antibiotics as veterinary treatment might be a link to the appearance of resistant strains of pathogens posing a threat also to human health. The antibiotics used for veterinary treatment can in some cases overlap with crucial ones used to treat human illnesses.

Slaughterhouses and food-processing establishments are the next links in the chain of food safety. The post-slaughter poultry carcass is a suitable growing medium for many pathogens, including human pathogens. Hygiene procedures when handling the carcass are, therefore, crucial and should be carefully planned and monitored to avoid contamination and cross-contamination of the food products. Packaging, transport, shelf-life and storage, as well as the maintenance of the cold-chain are important considerations. The cleaning and disinfecting of the premises and transport vehicles involved in these processes should be controlled. Resistance issues should be considered in the choice of the products used. Food products are then transported to wholesalers, retailers and finally to the consumers. Many cases of food-borne illnesses could be avoided by applying good hygiene practices in the home or in restaurants. Consumer information and education is, therefore, crucial, especially in developing countries where hygiene standards are poor.

4.1 Responsibility for control

Three major stakeholders can be identified in an industrial poultry production chain– the producer, the consumer, and the government. In industrialized countries, there are strong consumer-protection organizations which directly, or indirectly through governmental institutions, put pressure on the producer to supply safe products. A shift of legal responsibility from the government to the producer has been the common trend in developed countries (FAO, 2007). According to this mindset, the optimal role of the government is as a guarantor of the system through administrative and regulatory methods – the producer being the one managing the systems. A major factor in the prevention of food-borne illnesses is to ensure that stakeholders from all sides understand their responsibilities and voluntarily introduce good hygiene practices.

5 FOOD-SAFETY REGULATIONS AND RISK ANALYSIS

5.1 Risk-analysis tools

In order to set up food-safety strategies for countries or regions, some basic frameworks have been designed by international regulators. The modern approach is to use risk analysis tools. Briefly, such tools include the following steps (Adams and Moss 2000):

- identification of the hazards (i.e. the risk factors described above);
- exposure assessment – estimating the likely intake of the agents;
- hazard characterization – quantitative and qualitative analysis of the risk factors; and
- risk characterization – estimating the probability and severity of the possible food-borne illness.

This approach has to a large extent been successfully implemented in the developed-country food production sector. However, the proper implementation of risk-analysis tools requires certain basic components. These include efficient public health institutions, sufficient laboratory facilities, properly trained human resources and functional infrastructure

(FAO, 2007). Obviously, many countries are weak with respect to one or more of these components. A careful analysis of the country or region should, therefore, be implemented before considering the application of such tools.

5.2 The international regulatory environment

Large parts of developed-world markets follow international sets of rules. The major players in the international rule-setting forum are the FAO/WHO Codex Alimentarius Commission with its Hazard Analysis and Critical Control Point (HACCP) guidelines; the World Organisation for Animal Health (OIE) with its Terrestrial Animal Health Code, and the World Trade Organization (WTO) which sets the sanitary and phytosanitary (SPS) framework for international trade. The Codex Alimentarius Commission has also set out guidelines for good agricultural practices (GAPs), good manufacturing practises (GMPs) and good hygiene practices (GHPs). These sets of rules and practices are widely accepted in developed countries and international markets.

In addition to the main rule setters mentioned above, there are several other international and regional bodies. Internationally, there is for example, the International Atomic Energy Agency (IAEA) which sets regulations concerning irradiation of food and feed, etc. Regionally, there are organizations such as the European Food Safety Authority (EFSA) and the African Regional Standardization Organization (ARSO). Regulations set by private industry should also be taken into consideration. These regulations are sometimes more stringent than those described above. Moreover, they often include regulations related to quality aspects not considered to influence human health.

The international rules are set to protect the consumer, but have been criticized for setting trade barriers that prevent developing countries from entering international markets because of the high costs associated with implementation. In particular, the private standards imposed by some parts of the industry are the target of such criticisms. Another consideration is that the international rules may be of little relevance to poor developing countries that are not involved in the international livestock trade. According to Randolph *et al*. (2007) 90 percent of the world's livestock trade is within domestic markets.

In the developed world, food products are mostly sold in large marketing systems, such as supermarkets. However, in the developing world there is a vast informal sector involving live-markets and street vendors of food. The production and slaughter systems in the developing world also differ greatly from the industrial model described above. This poses complications for the implementation and enforcement of food-safety regulations: how can the informal and the formal sectors be linked, and how can homogenous food-safety policies be implemented throughout the market?

6 FOOD-SAFETY CONCERNS IN DEVELOPING COUNTRIES

Food-borne diseases are major health problems throughout the world. According to statistics from WHO, 1.8 million people died of diarrhoeal diseases in 2005 (WHO, 2007). Motarjemi *et al*. (1999) estimate that up to 70 percent of such cases are associated with contaminated food (though not restricted to livestock products). In addition, the WHO report states that in industrialized countries up to 30 percent of the population is reported to be affected by a food-borne disease each year, implying that the proportion in developing countries might be much higher.

In developed countries, the control of food-borne illnesses has been relatively successful with the help of measures described above. Public-sector measures, such as vaccination of animals, vector control, medication, slaughter inspection, risk analysis and consumer education, have been used to advance food safety in these countries (Blancou, 2005). However, in many developing countries, attempts to use such measures have been less successful.

The public sector in developing countries faces various constraints, including poor financial resources, infrastructure and information. Mills *et al*. (2004) point out that some public health projects have failed, despite proper funding and the help from international community, as a result of a weak public sector and poor infrastructure.

Many countries, including many developing countries, have officially introduced food-safety regulations in order to meet the demands of international markets and global agreements. However, such efforts have often remained theoretical or have only been implemented in large industrial establishment that have international customers. Small producers have often not been integrated within the regulatory framework, and hence are left to operate in the informal market sector. Azevedo and Bankuti (2002) describe the situation in Brazil, where the implementation of stricter regulations has led to a growth of the informal market, resulting in more "unsafe" food being sold to the consumers. This effect is a result of the increased costs associated with producers having to upgrade to the new safety regulations (ibid.). The poor populations of developing countries are described as having a high price-sensitivity, and consequently they will readily switch to buying products from the informal market if the prices of food products in the formal, regulated, market rise.

Azevedo and Bankuti (2002), however, also describe positive experiences from Brazil: in addition to the federal regulations implemented in the export sector, other, more lenient, regulations have been introduced at state and municipality level. Establishments that follow these regulations are allowed to supply state and municipal markets, respectively. This has inevitably resulted in food produced according to different hygiene standards being sold in the national market, but it has decreased the share of the informal market as a whole. A significant number of informal slaughterhouses have moved into the formal market as a result of the introduction of the less strict state-level and municipal-level measures (ibid.).

The other major problem in developing countries is a lack of information among consumers. There are many consumer interest groups working in the developed countries, but these groups are absent, less visible or weaker in developing countries (see discussion of Bangladesh in the following section).

The implementation of international food-safety standards, such as the FAO/WHO Codex standards described above, may not seem relevant to non-exporting developing countries. However, as Randolph *et al*. (2007) point out, alarm over a zoonotic disease can quickly affect the domestic market for livestock products. For example, in Bangladesh the mere news of highly pathogenic avian influenza outbreaks elsewhere caused a temporary drop of 70 percent in the consumption of poultry products (ibid).

Even if these international regulations were to be implemented in the industrial production plants, the average developing country consumer might not benefit. Ayieko *et al*. (2005) reported that even in the more developed cities in Africa, such as Nairobi, only 8 percent of meat products were bought form supermarkets. This implies that live markets

and home-slaughtering remain widespread. Another study (Omore *et al.*, 2005) shows that lack of proper controlling institutions leads to a high prevalence of food-safety hazards, even in products sold in supermarkets.

Large regional differences exist with respect to the consumption of different livestock products, as a result of differences in culture and eating habits. This can affect the focus of food safety-related measures. For example, in Bangladesh, where fish is the most important animal product, this particular sector has been the focus of food-safety policies, while development in other sectors, such as poultry, has been slower.

7 LESSONS FROM BANGLADESH

Production of poultry meat and eggs in Bangladesh has been growing quite rapidly over the last 15 years. Poultry meat production increased from 66 000 tonnes in 1990 to 102 000 tonnes in 2005, and egg production increased from 85 000 tonnes to 160 000 tonnes over the same period (FAOSTAT). Quasem and Islam (2004) estimated the growth rate of chicken production in Bangladesh to be 5.3 percent *per annum*, and predicted that consumption of broiler meat and eggs would grow by 95 percent and 78 percent, respectively, in the period to 2020. This growth is being driven by the growth in market demand – the same pattern that is seen globally.

As poultry is not an internationally marketed commercial product in Bangladesh, few organized vertical production systems have been established. One exception is the Aftab Poultry Ltd., which produces processed poultry for the few supermarkets that exist in Dhaka and Chittagong. Most poultry is sold in live bird markets, and about 90 percent of the rural families keep small numbers of chickens (Das *et. al.*, 2008). This means that, apart from the Aftab farms, there are no processing plants or organized slaughtering. Aftab operates a system of contract farms – a total of 560 in 2005 (Begum, 2005).

In 1999, there were only two laws related to slaughter and meat – the Animal Slaughter and Meat Act (1957) and the Municipal Corporation Ordinance (1983). These two laws define animal categories allowed for slaughtering, provisions for meatless days, etc. However, they do not set out minimum procedures for slaughter (Svendsen, 1999). Moreover, they do not cover guidelines for pre-slaughter and post-slaughter inspection (ibid.) . In 2005, the Animal Disease Act and the Animal and Animal Products Quarantine Act were approved by the country's parliament.[2] However, it remains to be seen how successful the implementation of these laws will be.

One factor contributing to the slow implementation of international regulatory tools such as HACCP in the poultry sector in Bangladesh is extremely high start-up costs. For example, the cost of implementing HACCP in the shrimp industry to meet EU standards was equivalent to more than 9 percent of annual sales, which represents quite an overwhelming figure for the small producer (Cato *et al.*, 1998).

A study in 1997 recorded a 10 percent prevalence of *Salmonella* in commercial poultry farms in Bangladesh (from 1 200 farms tested) (Hoque *et al.*, 1997). *Salmonella* is in fact endemic throughout the country. Official records for the prevalence of *Campylobacter* are lacking (personal communications with P. Biswas, University of Chittagong, Bangladesh).

[2] Ministry of Fisheries and Livestock: http://www.mofl.gov.bd/MoFL_laws.aspx

The prevalence of other major microbiological risk factors such as clostridia, *Listeria, E. coli*, and *Staphylococcus aureus* is also largely undocumented.

With regard to chemical risk factors, the use of antibiotics is widespread throughout the poultry sector. Antibiotics are used for therapeutic purposes and as growth promoters in feed. The antibiotics used include oxytetracycline, amoxycillin, co-trimoxazole, gentamicin and ciprofloxacin (personal communication with P. Biswas, University of Chittagong, Bangladesh).

Despite the efforts made by the government, there are major deficiencies with respect to food safety in poultry production of Bangladesh. Consumer awareness of food-borne illnesses is quite elementary. Consumer organizations of the type that in industrialized countries exert pressure on producers to apply food-safety measures are weak or non-existent in Bangladesh (personal communication with Dr. Giassudin, University of Chittagong, Bangladesh). This may contribute to a lack of implementation of existing policies. A recent critical overview (Amjad, 2007) assessed the consumer protection legislation in Bangladesh and concluded that the main public-health problems were similar to those found in other developing countries. One of the main issues is a lack of awareness among consumers. Illiteracy is a factor. There is also a lack of awareness of consumer rights and food-safety risks. Another problem is evidently financial. Even if awareness were greater, financial limitations would still affect consumers' choices and promote the consumption of poorer quality products. Despite efforts to establish consumer-protection legislation, enforcement remains poor (ibid.). Moreover, according to some reports (e.g. Harboe, 1998), the vertical links from the government to the villages are quite weak; a given village may lack the information or the incentives necessary to apply the food-safety regulations passed by parliament.

8 DISCUSSION AND CONCLUSIONS

It is quite difficult to define a best model for food-safety practices applicable to the developing world as a whole. More country-specific data on risk factors throughout the vertical chain are needed. The political environment, the state of infrastructure and so forth should also be carefully assessed before policies are formulated.

Surveillance and data collection systems are often lacking or not functional, meaning that reliable data about risk factors are unavailable. Restructuring or establishing food-safety services may require substantial education of veterinary and the health inspectors at all levels.

A market-driven approach could be a way to achieve success in food safety, but this would need interest and large investments from the industry. There would definitely be difficulties in implementing a thorough control system, because of the existence of the vast informal sector in which animals are not slaughtered in the abattoirs but in homes or at the markets. The Brazilian model, mentioned above, might offer a way forward for some countries. The evidence presented from Bangladesh, suggests that efforts to improve food safety in poultry production should start at the local union or village level with simple regulations directed towards addressing the most prominent deficiencies in the food-safety system. Clearly, this would, again, require identification of the major risks and their entry points into the food chain. Village-level education campaigns, directed at community work-

ers such as teachers, and thus reaching the consumers, as well as at restaurants, would be essential. The main message is clear. Investment in basic education, and thus increasing consumer awareness, should be seen as a key element of food-safety strategies in developing countries.

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Risks caused by bio-aerosols in poultry houses

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SUMMARY

Aerial pollutants in confined animal houses are widely recognized as detrimental to the respiratory health of animals kept in these facilities. Primary and opportunistic microbial pathogens may directly cause infectious and allergic diseases in farm animals, and chronic exposure to some types of aerial pollutants may exacerbate multi-factorial environmental diseases. There are, however, few international field surveys paying attention to the health of the farmers and the farm personnel working in such atmospheres, and to the spread of pathogens from farm buildings. Studies reveal that up to 20 percent of farmers and farm workers report work-related symptoms of respiratory affections, such as coughing, sputum and wheezing. Some develop asthma, others develop diseases that are described as ODTS (organic dust toxic syndrome). There are indications that various pathogens can survive in ambient air for several minutes and can be distributed over long distances, (e.g. foot-and-mouth disease (FMD) virus more than 50 km, and staphylococcae up to 500 m).

This paper describes the complex nature and composition of the aerial pollutants, such as gases, dust, micro-organisms and other compounds, present in the air of farm animal houses, their potential role in the development of respiratory diseases in humans and animals, and their distribution in the surroundings of farms. Future-oriented sustainable farm animal production should (in addition to improving animal welfare, consumer protection, economy and occupational health) enhance standards aimed at preventing or reducing the aerial spread of pathogens.

Key words: air pollutants, bio-aerosols, poultry farming, disease transmission, occupational health, dust, gases, bacteria

1 INTRODUCTION

The air in modern poultry production systems contains a large variety of air pollutants, such as gases like ammonia and carbon dioxide, dust, micro-organisms and endotoxins. These pollutants, also referred to as bio-aerosols, are increasingly regarded as both aggravating and environmentally harmful. The pollutants give cause for concern for several reasons.

Animal respiratory health may be compromised by pollutants such as gases, dust, micro-organisms and endotoxins (Baekbo, 1990; Hamilton *et al*., 1993; Hartung, 1994).

It is well documented that livestock buildings, manure storage facilities, manure spreading and even free range systems are major sources of gaseous pollutants such as ammonia,

methane and nitrous oxide, which contribute to soil acidification and global warming (Jarvis and Pain, 1990; Hartung *et al.*, 1990; Ecetoc, 1994).

There is epidemiological evidence that the health of farmers working in animal houses may be harmed by regular exposure to air pollutants such as ammonia, dust, micro-organisms and endotoxins (Donham, 1987; Whyte *et al.*, 1994; Donham *et al.*, 1995; Radon *et al.*, 2002; Hartung, 2005). Providing a safe and healthy work environment for employees is an important objective for any industry – including animal farming (Cargill and Hartung, 2001).

A major reason for concern are bio-aerosol emissions, such as dust and micro-organisms, from farm buildings, which are believed to play a role in respiratory affections in people living in the vicinity of animal enterprises (Müller and Wieser, 1987; Hartung, 1995; Seedorf, 2004), and which can be transmitted between poultry houses and farms via the air (Schulz *et al.*, 2005). Scientific assessment of the risk of aerial transmission of pathogens between flocks is hampered by the fact that there is still little knowledge about the nature and composition of bio-aerosols, the tenacity (resistance) of bacteria and viruses in an airborne state, and their survival times in ambient air.

This paper briefly defines the term bio-aerosol, gives some quantitative data on air pollutants in poultry houses, presents examples of the health effects of this pollution on humans and animals, discusses the survival times of bacteria and viruses in air and the possible extent of their spread in the surroundings of farms, and reflects on "safe distances" between flocks.

2 COMMON POLLUTANTS FOUND IN FARM ANIMAL HOUSES, AND DEFINITION OF "BIO-AEROSOL"

The key pollutants recognized in the airspace of livestock buildings are particles including dust, micro-organisms and their toxins, and gases such as ammonia, carbon dioxide and more than 100 trace gases such as volatile fatty acids (Table 1). Under commercial production conditions the airborne particles will contain a mixture of biological material from a range of sources, with bacteria, toxins, gases and volatile organic compounds adsorbed to them. Hence, a more descriptive term for these airborne particles is bio-aerosol (Cargill and Banhazi, 1998). The typical character of bio-aerosols is that they may affect living things through infectivity, allergenicity, toxicity, pharmacological or other processes. Their sizes can range from aerodynamic diameters of 0.5 to 100 µm (Hirst, 1995).

TABLE 1
Common air pollutants in poultry houses

Type of pollutant	Examples
Gases	Ammonia, hydrogen sulphide, carbon monoxide, carbon dioxide, 136 trace gases, osmogens
Bacteria/fungi	100 to 1 000 colony-forming units (CFU)/litre air 80 percent staphylococcaceae/streptococcaceae
Dust	inhalable dust can reach levels of 10 mg/m³; approximately 90% is organic matter; particles can carry antibiotic residues
Endotoxin	339 to 860 ng/m³ inhalable endotoxin in poultry houses

TABLE 2
Bio-aerosol concentrations in livestock buildings

	Cattle	Pigs	Chickens
Inhalable dust (mg m^{-3})	0.38	2.19	3.60
Respirable dust (mg m^{-3})	0.07	0.23	0.45
Total bacteria (log CFU m^{-3})	4.4	5.2	5.8
Total fungi (log CFU m^{-3})	3.8	3.8	4.1
Inhalable ETOX (ng m^{-3})	23.2	118.9	660.4
Respirable ETOX (ng m^{-3})	2.6	12.0	47.5

ETOX = endotoxin; 1 ng = approx. 10 EU (endotoxin units); CFU = colony forming unit.
Sources: Seedorf *et al.* (1998): Takai *et al.* (1998).

Several studies have recorded the concentrations of key components of bio-aerosols in farm animal buildings, with particular high levels recorded in poultry production (e.g. Seedorf *et al.*, 1998).

Table 2 summarizes the results of a broad European Union-wide study on bio-aerosols in pig, cattle and poultry farms. The results show that the lowest concentrations were found in cattle production and the highest in poultry houses (ibid.). However, there are considerable differences between production systems within a given species. The highest dust concentrations regularly occur in houses for laying hens. These concentrations often exceed the occupational health limit for the workplace (in Germany) of 4 mg/m^3, particularly at times of high animal activities (Saleh, 2006). These pollutants are emitted into the environment by way of the exhaust air through the ventilation system.

3 WORK-PLACE HEALTH EFFECTS OF BIOAEROSOLS IN FARM ANIMAL HOUSES

Complaints about respiratory symptoms during and after work in animal houses have risen among farmers and employees in recent years. The number of employees who were granted an insurance pension because of work-related obstructive airway diseases caused by allergic compounds rose from about 90 in 1981 to approximately 700 in 1994, a slightly smaller increase from 8 to 50 was observed for obstructive diseases caused by chemical irritants or toxic compounds (according to the statistic of the German occupational health board in agriculture, 1996). In a study comprising 1 861 farmers in northern Germany, about 22 percent of the pig farmers, 17 percent of the cattle farmers and 13 percent of the poultry farmers admitted airway problems (Nowak, 1998). The data are detailed in Table 3. Although the causes of the relatively high incidence of health problems, associated particularly with pig farming are not yet completely understood, it seems that factors such as high concentrations of air pollutants, the composition of pig house bio-aerosols, insufficient ventilation, and poor system management may play a role. The results may also be biased by the fact that most pig farmers in Germany work on their own farms, which they do not easily abandon even in the event of health problems, while poultry farm workers can more easily change their workplace or profession.

Numerous studies have demonstrated links between dust and human ill-health in a number of livestock-related industries (Donham *et al.*, 1995). A survey of 69 full-time poultry stockpersons in the United Kingdom found that although occupational health and safety guidelines were adhered to, 20 percent were exposed to levels of dust 2.5 times higher than the 10 mg/m3 recommended under occupational health and safety guidelines (Whyte *et al.*, 1994). Findings such as these have led to the introduction of strict codes to protect people involved in the intensive livestock industries in several countries including Denmark and Sweden. Guidelines have also been recommended to the Australian pig industry (Jackson and Mahon, 1995).

The first reports indicating health hazards for humans working in intensive livestock production systems were published over 20 years ago (Donham *et al.*, 1977). A number of syndromes have been recognized in workers in the intensive animal industries. They range from an acute syndrome, which develops within a few hours to days of exposure to animal sheds, and which is accompanied by a variety of clinical signs including lethargy, a mild febrile reaction, headaches, joint and muscle aches, and general malaise, to more chronic responses. In some cases, the initial attack is so severe that the employee terminates his or her employment within a matter of days. In general, episodes last 12 to 48 hours, with chronic fatigue and congested respiratory passages being reported as the most common clinical signs. The condition has been referred to as organic dust toxic syndrome (ODTS) or toxic alveolitis. The prevalence of ODTS has been quoted as ranging from 10 to 30 percent of workers, depending on the type of intensive animal production and the facilities used (Donham, 1995).

A range of acute respiratory symptoms, described by employees following contact with their work environment, but not necessarily associated with a generalized clinical syndrome, have also been documented (Brouwer *et al.*, 1986). The more common clinical signs include an acute cough, excess sputum or phlegm, a scratchy throat, discharging or runny nose, and burning or watery eyes. Other more generalized clinical signs that may or may not be present include headaches, tightness of the chest, shortness of breath, wheez-

TABLE 3
Frequency of workplace-related respiratory symptoms in livestock farmers/employees in Lower Saxony, Germany

Animal species		Number of persons surveyed	Percentage of persons with complaints
Pigs	Sow	619	22.7
	Fattening	799	21.9
	Weaner	551	23.0
Cattle	Cow	1 245	17.4
	Beef	895	17.2
	Calf	1 190	17.8
Chickens	Laying hens	279	14.7
	Broilers	47	12.8

Source: Nowak (1998).

ing and muscle aches. In several studies in North America, and Sweden, the prevalence of acute symptoms was found to be 1.5 to 2 times higher than chronic symptoms. However, in a similar study in the Netherlands, the prevalence of chronic and acute symptoms was reported to be similar (ibid.).

Exposure to dust produces a variety of clinical responses in individuals. These include occupational asthma due to sensitization to allergens in the airspace, chronic bronchitis, chronic airways obstructive syndrome, allergic alveolitis and ODTS (Iversen, 1999).

The suggestion that the primary clinical problem is an obstruction of the airways is supported by various studies in which workers have been subjected to lung function tests. Although the forced expiratory volume-in-one-second (FEV1) was not changed in most people studied, decreases in the FEV1/forced vital capacity (FVC) ratio and flow rates support this hypothesis. In a series of studies of workers over a period of time, the greatest decrease (4 to 12 percent) occurred in forced expiratory flow rates (Hagland and Rylander, 1987). In both Swedish and American workers, significant changes were also recorded in FEV1 and flow rates. Although the changes reported in these studies were modest on a population basis, a significant clinical reduction in FVC was recorded in 14 percent of Canadian workers (Dosman *et al*., 1988) and 20 percent of Dutch workers (Brouwer *et al*., 1986).

Exposure to bio-aerosols has also been shown to cause broncho-constriction, hyper-responsiveness and increased inflammatory cells in bronchial alveolar lavage fluids in naïve subjects (Malberg and Larsson, 1992). It is assumed that broncho-constriction followed by reduced ventilation of the lungs can be caused by inhaled endotoxin. Experiments using nasal lavage show that pig-house dust containing different concentrations of endotoxins increases the inflammatory reaction of the nasal mucous membranes of humans, distinctly (Nowak *et al*., 1994). The broncho-constrictive effects of bio-aerosols have also been demonstrated in guinea pigs (Zuskin *et al*., 1991) as well as in stockpersons in Sweden and North America (Donham, 1995).

Further studies are needed to improve understanding of the building features and animal husbandry practices that increase the concentration of airborne pollutants in buildings housing animals, and to determine the key pollutants involved. The evidence collected in farm animal buildings suggests that issues such as hygiene and stocking density (kg biomass/m^3) are key factors, but that the composition of pollutants or bio-aerosols may vary significantly from shed to shed depending on a range of factors (Banhazi *et al*., 2000); these factors include hygiene, dietary composition, as well as the type of bedding and effluent disposal system used. The severity of specific occupational health problems might be more affected by the composition of bio-aerosols within an animal-house atmosphere than just by the concentration of airborne particles.

4 TRANSMISSION DISTANCES OF BIO-AEROSOLS

There are few experimental data available on transmission distances of bio-aerosols from animal houses. From epidemiological studies, it is known that FMD virus can travel over distances of more than 50 kilometres (e.g. Donaldson and Ferries, 1975; Gloster *et al*., 2005). Experiments around farms revealed elevated levels of dust particles and bacteria between 50 and 300 m downwind of animal houses compared to upwind control meas-

TABLE 4
Reported transmission distances of bio-aerosols emitted from livestock buildings

Component	Distance (m)	Reference
Dust particles	50	Schmidt and Hoy (1996)
	115	Hartung *et al*. (1998)
Bacteria	50	Platz *et al*. (1995)
	100	Sarikas (1976)
	200	Köllner and Heller (2005)
	200–300	Müller and Wieser (1987)

urements (Table 4). These figures are far from being safe distances, because they do not reflect the spread of specific pathogens or allergenic components (e.g. feather fragments), which may be transported much longer distances, and which can cause health risks even in small quantities.

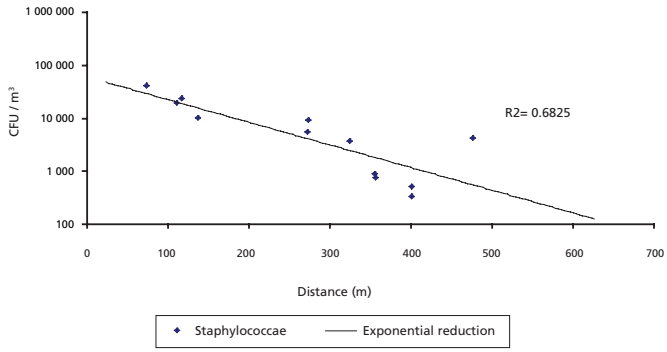
Most important for the possible transmission of a pathogen is its ability to survive in an airborne state over a longer period. Table 5 presents some data showing that micro-organisms are strongly influenced by environmental conditions such as temperature and humidity of the air; other factors include radiation, sunlight and additional chemical compounds in the air.

Recent investigations in and around broiler houses have shown that the travel distance of staphylococcae downwind can be more than 500 m from the source. Under stable wind

TABLE 5
Loss of viability of various pathogens in air at varying temperature and humidity

Pathogen	Relative. humidity (%)	Temperature (°C)	Loss of viability after 250 seconds in air (%)
Escherichia coli (O78)	15–40	22	14
Mycoplasma gallisepticum	40–50	25	up to 3
Salmonella enteritidis	75	24	up to 20
S. newbrunswick	30	10	38
S. newbrunswick	70	21	11
S. typhimurium	75	24	up to 20
Staphylococcus aureus	50	22	up to 1
Influenza A virus	50	21	more than 70
Influenza A virus	70	21	more than 66
Newcastle disease virus	10	23	No loss detectable
Newcastle disease virus	35 and 90	23	20

FIGURE 1
Decreasing concentrations of staphylococcae with increasing distance downwind from a broiler barn with 30 000 birds



Notes: Sampling 1.5 m above ground. Animals in second half of production cycle. Air temperature about 16 °C, wind speed between 1.7 m/s and 6.3 m/s. n = 12. CFU = Colony forming unit.
Source: Seedorf *et al.* (2005).

conditions more than 4 000 CFU/m³ were found 477 m downwind of the barn (Seedorf *et al.*, 2005). Staphylococcae are typical bacteria in broiler house air (Figure 1). They can probably serve as indicators for bacterial pollution, because they do usually not appear in relevant concentrations in normal outside air.

These results show that there is a considerable distribution of micro-organisms from poultry houses into the surroundings.

5 STRATEGIES TO MINIMIZE THE RISK FOR EMPLOYEES AND ANIMALS

Several approaches to reducing air pollution in animal houses and protecting employees on the job are available. These include wearing protective gear, reducing exposure levels within the buildings, and eliminating pollutants at source. Employees should be encouraged to wear dust masks (or ventilators) and eye protection when working in sheds, particularly in straw-based shelters when handling or moving animals. As a minimum, a mask that can be shaped for individual nasal structures, with two head straps (above and below the ears) should be used. Reliable protection requires the use of ventilated masks. The disadvantage is the weight of the helmet with the filter system and the battery-powered ventilator. Employees who wear glasses may need to consider contact lenses while wearing a mask and eye protection. A recent survey is given in the book KTBL Schrift 436 (Anonymous, 2005).

Various strategies have been recommended for reducing the concentrations of air-borne pollutants in animal houses. These include management measures as well as strict hygienic rules and direct reduction techniques such as fogging sheds with oil and water (Pedersen, 1998; Banhazi *et al.*, 1999). All these methods have to be carefully investigated as to whether they may cause side effects in the animals, the environment or meat quality (Cargill and Hartung, 2001). End-of-pipe techniques such as biofilters and bioscrubbers,

which filter the exhaust air and reduce the pollution of the surroundings of the farm, are recommended in some countries. These techniques are, however, still rather expensive, and are presently largely restricted to sensitive situations such as when farms are located very close to residential areas.

Reducing air pollutants in animal houses is an urgent requirement for the development of future poultry production. It will provide a safer and healthier work environment for employees, and a better atmosphere for the animals – improving their health, welfare and performance. Reducing emissions will at the same time reduce the risk of transmission of pathogens indoors as well as between neighbouring farms. Future-oriented sustainable farm animal production should (in addition to improving to animal welfare, consumer protection, economy and occupational health) also enhance standards aimed at preventing or reducing the aerial spread of pathogens via the air.

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Veterinary services for poultry production

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SUMMARY

The current highly pathogenic avian influenza (HPAI) crisis has brought poultry production to the focus of public attention. Poultry production takes place in two basic systems: the industrial sector and the small-scale production system at village level. The level of involvement of veterinary services differs greatly between the two systems. While private veterinary services are important in the industrial sector, there is only limited provision of veterinary services in small-scale production systems. This has consequences for the success of disease control measures.

As HPAI is a zoonotic disease, its control is undoubtedly a public good and ultimate responsibility for this should lie with the official veterinary services. However, as both public and private sectors are contributing to disease control, this paper suggests strengthening national animal health systems and ensuring that all service providers have clearly defined roles and responsibilities under the leadership of the official veterinary services. Evidence gained during Newcastle disease control projects at village level, indicates that a paradigm shift in disease control is needed, promoting strong involvement of communities in policy development. This requires a multidisciplinary approach that enables a better understanding of this specific sector to be obtained. The Food and Agriculture Organization of the United Nations (FAO) is implementing pilot projects in different countries to better understand virus spread, value chains, the role of poultry in livelihoods, and the species and breeds kept. Broader knowledge, will allow the impact of control measures in this sector to be assessed, and national HPAI preventive and control policies to be adjusted as needed.

Key words: disease control, poultry, multidisciplinary, small scale

1 INTRODUCTION

Since the outbreak of highly pathogenic avian influenza (HPAI) H5N1 in poultry, in 2003/2004, in Southeast Asia, and its subsequent spread to more than 50 of the world's countries, poultry production has come sharply into the focus of the international community's attention. This heightened awareness is in large part due to the zoonotic potential of HPAI H5N1-V. The present virus strain has a relatively low ability to spread from poultry to humans, but evidence shows that once this transfer occurs the virus causes a very high mortality rate. More importantly, there is a fear that a new strain will emerge and cause a human flu pandemic.

Right from the beginning, the challenge for governments and technical agencies was

to ensure early detection and control of the disease. Even with the improvements in detection achieved over the last three years, there is still need to strengthen surveillance systems further and institutionalize them within national animal health systems.

In this paper, existing poultry health systems are described and an outlook is tentatively given as to how to improve the linkage between poultry owners, and private and public veterinary services.

2 VETERINARY SERVICES IN POULTRY PRODUCTION

Two basic systems of poultry production can be identified and are present in most countries: an industrial poultry sector and a small-scale production system. It is recognized that other classification systems exist (see Rushton and Ngongi (1998) for early versions and more recently FAO (2004) for a classification based on a notional idea of biosecurity). The approach and level of involvement of veterinary services in poultry production differ greatly between the industrial sector and the small-scale production system.

The industrial sector, which often operates in international markets, has a high use of variable inputs, mainly concentrate feed, and significant investments in infrastructure. This sector has developed its own poultry health schemes to ensure the productivity and health of the birds, a development crucial to avoiding production losses resulting from diseases and ensuring that disease-related market shocks are minimized. These requirements apply at farm level, but in the case of diseases that are notified under international agreements, also apply at national level. Notification to the World Organisation for Animal Health (OIE) generally entails international market bans, and in the case of zoonotic diseases also gives rise to internal market shocks. Another relevant consideration is that companies often use their poultry health schemes as a sales argument when negotiating with their clients.

Even though private poultry health schemes may vary in their details, implementation is organized mostly in the same way in all countries. The schemes are conceived for all participants in the chain – hatcheries, producers (broilers, pullets and layers), slaughterhouses, transporters and feed mills. It includes biosecurity (bioexclusion) measures at farm level, sampling at critical control points in the chain, vaccination schemes and other prophylactic measures for the animals. These activities and the results of control measures are internally recorded. The veterinary services (diagnostic, prophylactic and therapeutic) are generally provided by private veterinarians, either employed by the company or contracted with specific terms of reference. It is common for diagnostic work (detection of pathogens and residues) to be carried out in laboratories that are often owned by the poultry companies. In an integrated poultry chain it is mandatory for poultry producers to be part of a poultry health scheme, whatever their contractual status. This approach ensures maximum consistency in the quality of the produce and the services provided; it allows a fast and targeted reaction in the case of hazards. It also maintains high levels of productivity as the large quantities of inputs involved (mainly feed) are used by healthy flocks.

The role of the official veterinary services in this context is mainly to ensure that moral hazards affecting consumers are kept to a minimum and that there is an effective framework for research and dissemination of knowledge that has a strong public good nature. The responsibilities of the official veterinary services can be derived from agreements such as the World Trade Organization's Agreement on the Application of Sanitary and Phytosani-

tary Measures (SPS Agreement)[1]. There are defined responsibilities set out in the *Animal Health Codes* of OIE for disease surveillance[2]; prevention, control and eradication of highly contagious diseases; and movement controls and quarantining. The diseases covered by these provisions have serious consequences in terms of socio-economic impact, trade and public health. Regarding food and feed safety, the basic roles of the state are defined in the Codex Alimentarius[3] which covers official inspections regarding food hygiene, including controls on residues.

For some aspects of the above-described animal health system in the industrial poultry sector, the respective roles of service providers can be clearly defined. For example, flock treatments to increase flock productivity have a strong private good component and are best left to private veterinary services. However, the maintenance of low levels of drug residues in food is clearly a moral hazard issue, which state veterinary services need to address to protect consumers. Some other issues are less clear, and require careful coordination between public and private veterinary services. For example, there are strong incentives for producers to prevent the entry of a disease agent, but if a disease agent enters a flock, the private incentives for containment are not clear and the state needs to play a strong role. Dividing tasks between private and public services requires a close relationship between the two sectors to ensure appropriate roles, cooperation and implementation.

The small-scale/backyard sector operates in a completely different setting. The most important differences with regard to disease control are as follows:

- very diverse organization of the sector in different regions;
- minimal or no external inputs;
- poultry flocks that are generally managed by women, who may well own the birds and market the produce;
- production exclusively for household consumption, or local or national trade; and
- no integration of the associated market chains.

The use of veterinary products and services are limited in this sector because:

- losses due to diseases are common and often considered inevitable; and
- many poultry producers are poorly connected to veterinary product distribution and advice networks – making the transaction costs involved in obtaining such goods very high.

Where there is a possibility to get regular access to markets and therefore to generate income, small-scale poultry producers will make investments in inputs, including veterinary services. Such services are frequently provided by non-veterinarians, such as trained paravets or other knowledgeable people in the villages. In some countries where private veterinary services are under development, the official veterinary services may provide clinical services at village level.

The roles and responsibilities of public and private sectors in animal health service delivery have been described by Leonard (2000) and Ahuja (2004). The latter author provides a useful analysis of the public and private good nature of animal health services, which has

[1] http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm (December 5, 2007).

[2] http://www.oie.int/eng/normes/en_mode.htm?21d10 (January 22, 2008).

[3] http://www.codexalimentarius.net/web/index_en.jsp (December 5, 2007).

been used to develop a list of the roles and responsibilities of public and private sectors in animal health delivery (see Table 1).

According to the classification set out in Table 1, non-zoonotic, highly contagious poultry diseases, such as Newcastle disease or duck plague, should only be part of official control programmes when they may endanger international trade. This is the case, for example, in the European Union, North America and Japan. These regions/countries have important market interests in the international poultry sector, and trade bans have consequences for their economies. In other regions of the world, there is no official programme to control these diseases although they are notifiable to the OIE. Their control is generally not considered a public good according to the above-described classification (Ahuja, 2004).

TABLE 1
Suggested channels for animal health functions

Animal health function	Appropriate delivery channel		Economic characteristic
	Public	Private	
Disease surveillance, prevention, control and eradication of highly contagious disease with serious socio-economic, trade and public health consequences	√	√	Public good
Disease surveillance, prevention, control and eradication of diseases of low contagion		√	Private good with externalities
Quarantine and movement control	√		Measures to correct for externalities
Emergency responses	√		Public good
Veterinary inspection	√		Measures to correct for "moral hazard"
Wildlife disease monitoring	√		Public good
Zoonosis control	√		Measures to correct for externalities
Disease investigation and diagnosis	√	√	Private good with externalities
Drug/vaccine quality control	√		Require measures to correct for "moral hazard"
Production and distribution of drugs and vaccines		√	Private good
Vaccination and vector control	√	√	Private good with externalities
Research, extension and training	√	√	Public and private
Clinical diagnosis and treatment		√	Private good
Food hygiene and inspection	√		Measures to correct for "moral hazard"
Residue testing	√		
Food safety tasks	√		Public good
Compliance and monitoring	√		Public good

Source: modified from Ahuja (2004).

3 EXPERIENCE IN COMBATING NEWCASTLE DISEASE AT VILLAGE LEVEL

As poultry production can be considered an important development tool for promoting food security at household level, there have for a many years been various initiatives to improve production and to provide veterinary services such as vaccination to protect animals from Newcastle disease (Copland, 1987; Sagild and Haresnape, 1987; Ideris *et al*., 1990; Jagne, 1991; Rweyemamu *et al*., 1991; Spradbrow, 1993; Rushton in FAO, 1993; Rushton in FAO, 1995; Rushton in FAO, 1996; Bell *et al*., 1995; Alders and Spradbrow, 2001) and other diseases (Permin and Pedersen, 2002).

International development agencies and NGOs have initiated extended activities to control Newcastle disease in village poultry (e.g. French initiative in West-Africa, the initiatives of the Australian Centre for International Agriculture Research). Key elements in these initiatives are vaccination, communication and information, and monitoring and evaluation (Dolberg in FAO, 2007). Although the design of such programmes may differ, success depends in all cases largely on the involvement of the national government and its veterinary service, and of producers and their veterinary services provided by private veterinarians or paravets.

As the programmes mainly address very poor people, national governments and public veterinary services have to be involved. Their role is to provide an adequate policy framework – for example, introducing village poultry production into national poverty eradication programmes, designing and conducting information campaigns, and initiating vaccination campaigns (including making the decision as to the type of vaccine to be used).

The producers and their associated veterinary services have to recognize the programme as something that adds value to their poultry production. This requires medium- to long-term programme implementation in order to build up trust and ensure sustainability.

A Newcastle disease control programme will only be successful and sustainable if there is a win–win situation for both sides. Therefore, there is a need for reliable national policies and commitment from the public sector. One way to meet this requirement would be to integrate the programme in national livestock policy. In addition, there is a need to involve the international donor community and the development agencies. These actors will be required to assist the programme, at least at the beginning, especially in developing the initial vaccination and information campaigns – including training, logistics (procurement and distribution of the vaccine, and monitoring the success of the vaccination) and disseminating the results. This requires the mobilization of additional funds.

The experience gained in developing and implementing Newcastle disease control programmes could be utilized for the control of HPAI, even though the nature of the disease requires the use of other control tools.

4 THE EMERGENCE OF HPAI H5N1

HPAI H5N1 has changed the situation for the poultry sector tremendously. This virus is panzootic, zoonotic and has the potential to become pandemic. All the criteria for a public good apply to the animal disease caused by this virus. Therefore, there is urgent need for national veterinary services to be involved in the control of this disease. While this occurs more or less successfully in the industrial system, it appears to be very difficult in the small-scale sector.

The classical tools utilized to control highly contagious diseases (biosecurity at farm level, movement bans/restrictions, culling and vaccination) first require some basic planning data on the poultry sector:

- species and approximate numbers of birds;
- type of production;
- marketing and distribution systems;
- slaughterhouses; and
- locations of production and marketing, including hatcheries, slaughterhouses and wet markets.

These data are generally available for the industrial sector, but rarely for the small-scale sector. Moreover, as in most of the affected countries there is no official registration system for small-scale production units (in some, registration does not exist even for the industrial sector), they are unlikely to become available in the short or medium term.

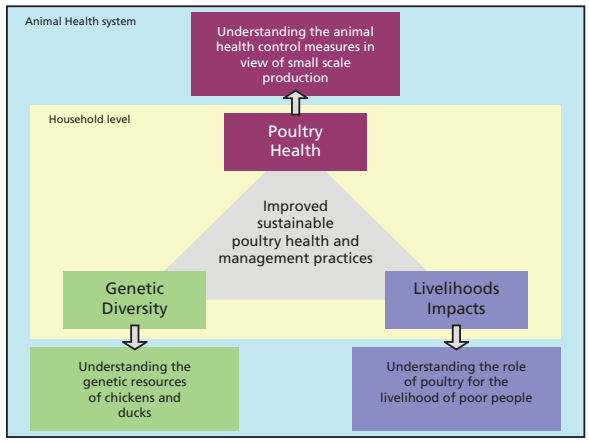
The lack of data and surveillance for the small-scale sector might be one reason why the control of HPAI in the industrial sector is quite successful, while the virus persists for longer in the small-scale sector. In addition, small-scale/backyard producers regularly experience substantial losses in their flocks due to contagious diseases such as Newcastle disease, but also malnutrition, parasites and predation. As they rarely receive help to prevent such losses, they will generally not report an event even if it might be an HPAI outbreak. Even worse, experience teaches the villagers that if by chance the official veterinary services become aware of an HPAI outbreak, birds are destroyed, production and marketing is limited, and access to any sort of compensation maybe limited or non-existent. For these reasons, possible outbreaks in backyards are rarely reported by the poultry owners and are often only detected after investigation of outbreaks in commercial farms, as the result of an active surveillance exercise ("Participatory Disease Search" programme in Indonesia, market surveillance in Viet Nam) or when a human case occurs.

It is obvious, therefore, that a paradigm shift is needed in approaches to combating HPAI in small-scale/backyard systems and to create a win–win situation in which both the needs of producers at community level and the concerns of the international community are addressed (BMELV/GTZ, 2006).

5 MULTIDISCIPLINARY APPROACHES TO DISEASE CONTROL

Based on experience of poultry development programmes for villagers (including the above-described Newcastle disease campaigns), and experience of HPAI control to date, it can be concluded that the classical disease control measures (biosecurity at farm level, movement controls, culling and vaccination) will have only limited impact on the disease in this sector. Rushton and Ngongi (1998) note that interventions rarely work if they are implemented in isolation. Interventions need to be supported by a package of measures covering health, husbandry and marketing. As in the implementation of Newcastle disease control programmes, long-term strategies developed through a multidisciplinary approach and involving the communities will be critical for HPAI control. This was acknowledged by the Technical Meeting on Highly Pathogenic Avian Influenza and Human H5N1 Infection, held in Rome in June 2007.

FIGURE 1
Conceptual framework[4] for the Animal Health, Breed Diversity and Livelihoods (AHBL) project



A contribution to this new approach is a project, funded by Germany[5] and currently being implemented by FAO in three pilot countries: Cambodia, Egypt and Uganda. The project aims to promote policies and strategies for prevention and control of HPAI that are sensitive to the needs of smallholder producers, especially poor rural families, and to poultry genetic resources. It considers, in a multidisciplinary manner, three main fields of concern: animal health, poultry breeds and livelihoods. The project will contribute to creating a safe production environment for smallholders, which supports sustainable livelihoods and poultry genetic diversity.

The knowledge needed to implement the approach will be generated during the pilot studies which aim to increase understanding of how animal disease control measures affect livelihoods and poultry genetic resources at country level.

Three main objectives for the studies have been identified:

- understanding chicken and duck genetic resources in the respective country;
- understanding animal health control measures from the perspective of small-scale poultry production; and
- understanding the role of poultry in the livelihoods of poor people.

The focus of the studies will be on the communities involved, collecting information through participatory methods and sampling of birds. This will allow characterization of the breeds and assessment of the disease situation in the village sector. Based on the resulting comprehensive data on the livelihood impacts of animal health control measures, including impacts on poultry genetic diversity, it is planned:

[4] Developed by Karin Schwabenbauer, Badi Besbes, Jonathan Rushton and Olaf Thieme (FAO).

[5] GCP/INT/010/GER "Promoting strategies for prevention and control of HPAI that focus on smallholder livelihoods and biodiversity"

- to propose improved sustainable poultry health and management practices at household level;
- to define the involvement of the smallholder sector in national animal health systems; and
- to contribute to strengthening veterinary services through public–private partnership.

It is intended that this will provide a baseline for improved reporting and surveillance systems for HPAI.

6 CONCLUSIONS

Poultry production takes place in two different settings: the industrial sector, operating nationally, regionally and in some cases globally; and the small-scale sector, operating with minimal inputs and with products mainly aimed at household consumption or local markets. The types of veterinary services demanded by and provided to these two basic types of poultry production are very different. This influences the effectiveness of disease control measures. The classical tools (biosecurity at farm level, movement control, culling and vaccination) are likely to have an impact in the case of an outbreak in the industrial sector, but are far less successful in the small-scale sector.

It is argued in this paper that in order to strengthen national animal health systems, institutional arrangements for animal disease control need to reflect the incentives of the public and private sectors in the different components of poultry production systems. This requires well-defined roles and responsibilities which take into account the fact that animal health measures generate both public and private goods, but also that the leadership for the animal health system should rest with the official veterinary services.

In addition, improvements in animal disease control in small-scale village poultry production require a better understanding of this sector, regarding virus spread, value chains, the contribution of poultry to livelihoods, and the species and breeds kept. Based on broader knowledge, the impact of control measures in this sector can be assessed and the national HPAI prevention and control policy adjusted, as needed. Building trust in improved veterinary services based on a public–private partnership is critical for this process. This will not be realized at short notice, and requires strong involvement of communities in policy development and strong commitment from the public sector. This is a major challenge.

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Risks and opportunities for poultry production

SUMMARY OF DISCUSSIONS

The threat posed by highly pathogenic avian influenza (HPAI) gave rise to numerous comments. Particularly emphasized were the challenges of ensuring communication and cooperation among stakeholders (particularly across the dividing line between human and animal health) and of developing effective strategies for small-scale production systems and for locations where the infrastructure for disease control is inadequate. It was noted that inappropriate media coverage of HPAI can sometimes present a problem for those working on the control of the disease. Cooperation between the public and private sectors was considered to be essential for effective disease control, and some positive developments in this area were mentioned. It was also noted that there are lessons to be learned from the control of other diseases such as Newcastle disease. Communication among all stakeholders, including the consumers, was emphasized as a means to foster trust and openness. The need to clarify the role of vaccination in the control of HPAI was noted, as was the need for a better understanding of the roles of wild birds and the transport and trade of poultry in the spread of the disease.

The future of small-scale poultry production was also discussed. Its important contribution to the livelihoods of the poor was recognized, as were the challenges of controlling diseases such as HPAI in this production system. It was noted that there is a need to learn more about the livelihoods and priorities of poor poultry keepers – without this understanding, attempts to introduce new technologies would have little impact in terms of poverty reduction. There was a call for improvement of community-based animal health systems, backed by adequate training and community participation in the financial aspects of such schemes. The need to develop effective early-warning systems at the community level was noted.

With regard to the environmental impacts of poultry production, it was argued that the real problem is not a lack of technologies to deal with the problems, but the costs of implementing them and a lack of incentives and regulations to enforce their use. It was also suggested that pollution costs and other externalities should be taken into account when assessing the relative efficiency of different production systems.

Other challenges brought up during the discussion included food safety, changing consumer demands (possible future increase in consumer demand for breast meat in developing countries), rising input costs, the use of feed crops for biofuel production, and loss of genetic diversity in the poultry population.

PART 3

Poultry as a Development Tool

Poultry production for livelihood improvement and poverty alleviation

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SUMMARY

Millennium Development Goal Number One is to halve the number of poor people in the world by 2015. The present paper contains a discussion, based on the livelihoods framework, of how and under what conditions small poultry units can contribute to the achievement of this and other Millennium Development Goals. The paper presents the livelihoods framework along with its micro- and macro-level features. Subsequently, it discusses the role of poultry in asset creation and as an entry point to improved livelihoods. A series of cases are presented: from Afghanistan, Bangladesh, Egypt, the Lao People's Democratic Republic and Swaziland, which illustrate various arguments related to the use of poultry for livelihood improvement and poverty alleviation. Strategies that use poultry production for livelihood improvement and poverty alleviation will be most relevantly applied in the countries where it has been most difficult to get development moving. These countries are variously described by development agencies as low-income countries under stress (LICUS), highly indebted poor countries (HIPC), low-income food deficit countries (LIFDCs), or countries that are placed low on the UN Human Development Index. The smallholder poultry approach is biased towards poor women; one estimate is that it is relevant for 160 million women and their families. However, it will not be easy to reach these potential beneficiaries, as bad governance and weak institutions characterize many of the countries where they live. Against this background, it is concluded that international organizations and networks have a particularly important role to play as storehouses of knowledge and technical expertise. Awareness among planners and decision-makers of the potential of poultry as a tool in poverty alleviation seems to be low. Improving knowledge among these stakeholders and strengthening the human and institutional capacity needed to implement the concepts are priorities.

Key words: poultry, livelihoods, poverty, LICUS, HIPC, LIFDC.

1 CONTEXT AND BACKGROUND

In 2000, world leaders agreed to the Millennium Development Goals (MDGs), with Goal One being to halve the number of poor people by 2015. According to the World Bank (2005) there were 1.1 billion people subsisting on an income of less than US$1 a day in 2005. The MDGs Report for 2006 notes that there is still much to do to combat poverty; 824 million people in developing countries were affected by chronic hunger in 2003, with

the problem being particularly acute in sub-Saharan Africa and South Asia (UN, 2007).This situation challenges all sectors – including the poultry sector and the livestock sector more broadly – to reflect on the contribution they can make to poverty reduction.

A comprehensive review of 800 livestock projects (Ashley *et al*., 1999) concluded that there were many problems with regard to the impact of such projects in terms of poverty reduction and livelihood development. It was argued that livestock development professionals and governments were biased towards large animals and their owners, who typically are not among the poorest.

The United Kingdom's Department for International Development (DfID), in an effort to speed up the achievement of poverty reduction targets, has adopted the livelihoods approach[1] at a general level. Where livestock and livelihoods are concerned, there are experiences on record of attempts to use poultry as a tool in poverty alleviation work (Dolberg in FAO, 2003a). There have also been attempts to document the loss of livelihoods faced by poor people when a disease such as highly pathogenic avian influenza (HPAI) strikes (Geerlings, in FAO/UNDP/WFP, 2007).

HPAI is a cause of considerable global concern (Otte *et al*., 2007). By 29 June 2007 the disease had resulted in 191 human deaths, from 317 cases (WHO, 2007). However, contrary to the general assumption that smallholder backyard poultry flocks are at higher risk than confined flocks, the only analysis so far of empirical data from Thailand indicates that backyard flocks are at lower risk of HPAI infection than commercial-scale operations keeping broiler or layer chickens or quail. What has been overlooked in the discussion so far, according to Otte *et al*. (2007), is the capacity of microbes to enter and leave commercial operations despite the implementation of standard biosecurity measures. This observation, based on references to scientific work, is supported by the patterns of infection during the 2002 Newcastle disease epidemic in Denmark, which provided evidence that questioned whether smallholder backyard flocks are in fact at higher risk from epidemic diseases than commercial operations (Danish Veterinary and Food Administration, 2003).

Taking this background into consideration, the following sections present the basic livelihoods concepts and framework and illustrate how poultry can be used as a tool in poverty alleviation.

2 POULTRY AS AN ENTRY POINT TO IMPROVED LIVELIHOODS

Many poor women in developing countries are involved (and skilled) in poultry keeping. Thus, the link between poultry interventions and improvement of women's status – along with the associated improvements in terms of nutrition and other benefits for the entire family (Quisumbing and McClafferty, 2006) – seems to be direct. The scavenging poultry production system is the most common animal production system among poor households in rural areas of developing countries. It is a system in which the birds collect most of their feed free of cost, but it is not a system that generates a huge income. Interventions to improve these modest levels of production may be justified, as they can help women and their families to generate social capital (see below) and enter a positive spiral of events that may move them out of poverty (Jensen and Dolberg, 2003). The explanation for this is that

[1] http://www.livelihoods.org/info/info_linksevents.html

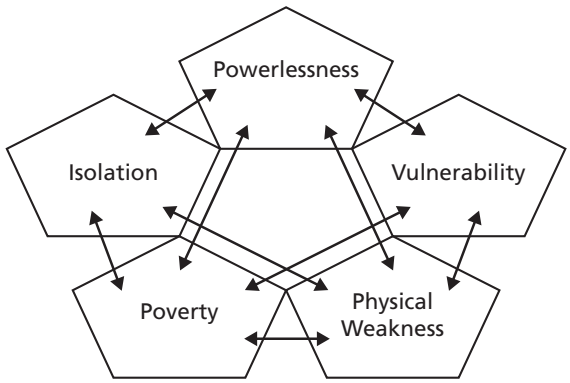
poverty is not only a question of money – the causes are frequently multidimensional. Figure 1 illustrates how several factors, including physical weakness, isolation, lack of power and vulnerability, may reinforce each other and deepen poverty.

Sen (1981) demonstrated a strong relationship between poverty, vulnerability and assets. Vulnerability may relate to risks such as bad weather (e.g. extended dry periods or floods) or to unexpected occurrences in the family such as sickness, loss of employment or death. In many countries, social networking entails meeting the high costs associated with events such as marriages and funerals; networks may be lost if these expenses cannot be met. There are also expenses associated with the education of children (Chua *et al.*, 2000). The many factors that lead to vulnerability may interact and reinforce one another in a downward spiral; Chambers (1983) has termed this the deprivation trap (Figure 1) or integrated rural poverty.

Processes that may lead to escape from the trap require an entry point. This is where poultry development may prove to be a useful tool, as keeping poultry is an activity in which many poor women are involved (see Table 1).

The data in Table 1 are from an impact study (Riise *et al.*, 2005) of twelve years of Danida experience with support to three smallholder poultry projects in Bangladesh: the Smallholder Livestock Development Project-1 (SLDP-1) 1993–1998 with donor support from the International Fund for Agricultural Development (IFAD) and Danida; the Participatory Livestock Development Project (PLDP) 1998–2003 with donor support from Asian Development Bank and Danida; and the second Smallholder Livestock Development Project 2000–2007 with Danida as sole donor. All projects focused on poultry, and it is therefore unsurprising that most households kept poultry. However, the widespread ownership of poultry, across many countries, is well known (De Lasson and Dolberg, 1985; see also Tables 3 and 4 and Box 3). Moreover, the impact study took place seven years and two years, respectively, after the closures of the SLDP-1 and PLDP projects (SLDP-2 was ongoing at the time of the study). All projects provided micro-credit. Studies, notably Seeberg (2003), have

FIGURE 1
The deprivation trap



Source: adapted from Chambers (1983).

TABLE 1
Entry point: presence of poultry, other livestock and non-livestock activities in a sample of households in Bangladesh

Project	Number of households (the projects were for the women)							
	In total sample		With poultry		With livestock other than poultry		With income from non-livestock activities	
	Number	%	Number	%	Number	%	Number	%
SLDP-1	232	100	223	96	98	42	58	25
PLDP	224	100	196	88	74	33	68	30
SLDP-2	211	100	205	97	39	19	74	35

Source: Riise *et al.* (2005).

documented that loans were used for investment in many items other than poultry. It is clear from the table that poultry keeping was the most common livelihood activity among the poor women and their families, and hence frequently offered an entry point for efforts to improve their livelihoods.

As well as an entry point, improving the livelihoods of women and their families requires a process, and access to assets and to organizations and institutions at both micro and macro levels. It is in mapping the stakeholders to involve and the paths to follow that the concepts of the livelihoods framework can be helpful – as will be discussed in the following section.

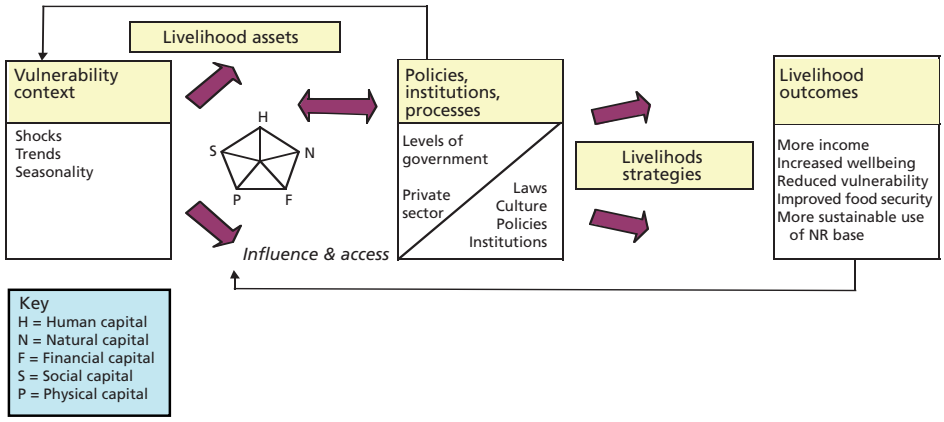
3 DEFINITION OF A LIVELIHOOD

The livelihoods concept gained prominence as a result of the report published in 1987 by the Brundtland Commission entitled *Our common future* (WCED, 1987). According to Chambers and Conway (1991) capabilities and equity are important components of the concept. In the view of the latter authors, a livelihood in its simplest form is a means of gaining a living; capabilities as well as equity are ends as well as being means that enable a better livelihood to be obtained. Accordingly, Chambers and Conway (1991) define a livelihood as comprising:

"The capabilities, assets and activities required for a means of living."

There is nothing in this definition that points towards a particular set of economic activities or institutions. However, as most poor people live in rural areas (FAO, 2006) and keep poultry, there is a case for considering the ways in which poultry can serve as a tool in poverty alleviation and add to the menu of tools (such as the housing index) (Simanowitz *et al.*, 2000) that are used in microfinance programmes to identify the poorest clients. The housing index is based on scores for the size of the house, its structure, roof and wall material, ownership of the house, cooking material, etc. To these criteria, it is suggested, could be added ownership/lack of ownership of animals or ownership only of scavenging poultry.

FIGURE 2
Sustainable livelihoods framework



Source: adapted from DfID (undated).

3.1 The livelihoods framework

The livelihoods framework (Figure 2) lists important factors that influence people's lives, such as the vulnerability context in which they live, and the assets to which they have access. These are important indicators according to Sen (1981). The framework includes policies, institutions and processes; it indicates how such factors shape livelihood outcomes, and how these components influence one another. In the present context, it is important that links between the micro level and the macro level are also included, as there is a tendency to neglect institutional and organizational analysis in discussions of the potential of smallholder poultry production as a tool in poverty alleviation and in associated areas such as food security and gender equality.

3.2 The micro level

At the micro level, the livelihoods framework utilizes the concept of livelihood assets. It involves going beyond a narrow, conventional concept of capital that is limited to financial capital, to a more inclusive concept that also encompasses human, natural, physical and social capital, i.e. five types of capital (see the pentagon in Figure 2). Each type of capital has a set of indicators; examples are provided in Table 2.

The indicators can be used to identify entry points for development interventions at household level (where poultry production is one option). In the best-case scenario, the first intervention will stimulate other initiatives within a household and the production of other types of capital. Women involved in poultry programmes often mention the importance of the opportunities they acquire for gaining social capital in the form of networking. This stimulates self-confidence and may lead to an expanded set of activities and accumulation of other forms of capital. This accumulation of capitals may, in turn, create opportunities to access and influence the processes that affect policies and institutions at the macro level.

TABLE 2
Types of livelihoods capital and indicators

Type of capital	Examples of indicators
Natural	Food security situation, ownership or rent of land, homestead and livestock
Physical	Living: house or no house, quality of house and clothes
Financial	Access to funds: money lender, relatives, microfinance or formal bank
Human	Confidence, motivation, education, nutritional status, health and fitness
Social	Family, social network outside family, membership of groups and organizations

Source: adapted from Dolberg (in FAO 2003a).

Certain minimum levels of political, health and economic stability are preconditions for positive outcomes of this type.

A case with a negative outcome is provided in Box 1, which is drawn from the work of Geerlings (in FAO/UNDP/WFP, 2007) on the impact of HPAI in Egypt. The case demonstrates well the negative spiral of events that a woman and her family faced as a result of HPAI.

3.3 The macro level

Policies are decided at the macro level; their presence or absence influences all administrative levels in a country. They have a strong effect on the access that people have to various types of capital (Table 2) and on the links between the micro and macro levels. Policies may prescribe the sizes and roles of the public and private sectors, and the role of civil society. Policies may be formulated to promote or discourage particular economic sectors – such as different types of agriculture and livestock production – some of which will offer greater opportunities for the poor, while others will be less accessible. Policies may affect opportunities for the establishment of people's organizations or non-governmental organizations (NGOs) that work for the benefit of the poor. Sanitary standards may be set that poor producers cannot meet.

The following quotation, taken from a section on lessons learnt in hunger reduction in FAO's report *The State of Food Insecurity in the World 2006*, is relevant to this discussion:

"Agricultural growth is critical for hunger reduction. Some 70 percent of the poor in developing countries live in rural areas and depend on agriculture for their livelihoods, either directly or indirectly. In the poorest of countries, agricultural growth is the driving force of the rural economy. Particularly in the most food-insecure countries, agriculture is crucial for income and employment generation ... Combating hunger requires an expanded commitment to agriculture and rural development." (FAO, 2006).

In the present context, agriculture is taken to include poultry production and promotion of the smallholder poultry sector, as well as the organizations that create an environment

BOX 1

Impact of HPAI on a poultry producer in Egypt

Samira's family is composed of three sons and three daughters, five of them attend primary and preparatory schools; the youngest son is still under school age. Her husband is unemployed for health reasons. Samira is the only breadwinner in the household. Samira trades poultry and rabbits for the people in her village. She collects the animals on her rounds through the village and sells them at different village markets six days a week. The villagers and Samira agree on the minimum amount that they would like to receive for their animals, and any extra money above the minimum set price is hers to keep. Because of HPAI Samira is heavily in debt. Last year she borrowed 350 Egyptian pounds (EGP) – US$63 – from an NGO and invested that amount in poultry. Her small backyard poultry flock was composed of 32 chickens, 90 Pekin ducks, 16 Balady ducks and 2 turkeys. All these birds died of avian flu. Samira still has to repay the debt, topped-up at a high interest rate. Because business was so bad last year with hardly any birds to trade, she had to get a second loan of EGP450 (US$82) from another NGO to cover part of the interest of the first loan and to restock. Her restocked flock comprised 11 Balady ducks, 9 Pekin ducks, 11 geese, 9 chickens, 3 turkeys and 24 pigeons. For the second time, her flock was infected and the birds died. Now she has three loans from different NGOs. The third loan amounted to EGP 400 (US$78) to cover part of the interest of the two loans and to buy a blanket for the winter season. Although the flock died, this woman has an outstanding debt to pay to the NGOs. In order to be able to pay this debt, she obtained a loan from a private moneylender with less interest and less paper work than the NGOs. Samira's household can be considered extremely vulnerable; six children and one husband depend entirely on Samira's income. Poultry is the main source of income and food, with no alternative sources. The family was not able to restock again. Samira is heavily in debt and cannot afford to take another risk. She stopped producing poultry at home, but kept trading in poultry. This is in spite of the restrictions imposed on the transportation of poultry between villages – not without risk because last year Samira almost got caught by the police for illegally transporting live birds. She was trying to get in a taxi with all her wooden cages containing birds. The police saw her and chased her. Samira dropped her cages and ran away, but in doing so she fell and seriously hurt her hip. She had to stay home for a couple of months. She couldn't earn any income in those months and depended on charity. The food consumption of this family was relatively moderate and the HPAI adversely affected their consumption pattern. Poultry consumption was halved, with almost no eggs being eaten. She cannot afford to buy eggs for her six children. The family now depends more on frozen sources of animal protein (e.g. fish and meat) because of their reasonable price.

Samira continues to trade poultry for the villagers and business slowly seems to pick up again. She says that this is the only thing she knows she can do well, and that the villagers know her and trust her to do a good job.

Sources: Geerlings (in FAO/UNDP/WFP, 2007).

that is conducive for the sector to flourish. The formation of marketing infrastructure and financial and veterinary services will, in the terminology of Figure 2, influence people's livelihood strategies, which in turn might promote income opportunities for poor women and their families. Subsequently, this may promote the formation of other types of capital. For example, the physical capital embodied in the living house might be improved, as might human capital as better food is bought, children are sent to school and health services are accessed. This may, given time, influence the vulnerability context by diminishing unfavourable social trends or mitigating harmful seasonal factors such as lack of employment in the dry season. Combined, the enhanced resources and influences may lead to better livelihood strategies and livelihood outcomes for the household.

4 THE ROLE OF POULTRY IN ASSET CREATION IN COMPARISON TO OTHER ANIMALS

Utilizing the livelihoods concepts presented above, this section compares the role that rural scavenging poultry plays in asset creation to that played by other animals. The International Livestock Research Institute (ILRI) published in 2002 a report commissioned by DfID entitled *Investing in animal health research to alleviate poverty* (Perry *et al*., 2002)[2]. This study includes a summary of how animal species contribute to household asset creation in developing countries. It should be noted that the study is based on the livelihoods perspective, and accordingly assets are categorized according to the five-capital classification shown in Figure 2.

According to Perry *et al*. (2002) all animals contribute to financial asset formation through sales of produce such as milk, meat, eggs and live animals and services (mainly transport). Animals also contribute to human capital formation through the positive influence that consumption of food of animal origin has on poor people's health (see Box 2).

According to the interpretation put forward in the above-mentioned report, only large animal species such as camels, buffaloes, cattle and yaks contribute to physical assets – in the form of working animals (ibid.). They are also associated with prestige. There is no prestige attached to keeping small animals like goats, sheep, pigs and poultry. Both small and

BOX 2
Nutrient content of food of animal origin

Poverty normally leads to a diet that is predominantly vegetarian, which studies show may be low in vitamin A, vitamin B-12, riboflavin, calcium, iron and zinc, and which may lead to anaemia, poor growth, rickets, impaired cognitive performance, blindness, neuromuscular deficits, and in the worst cases death. Foods of animal origin are particularly rich sources of all six of these nutrients, and relatively small amounts of these foods, added to a vegetarian diet, can improve the quality of the total diet substantially (Murphy and Allen, 2003). Note that this positive effect at the low end of the income scale should not be confused with the negative impacts of excessive consumption of food of animal origin seen in many rich countries today.

[2] http://www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/InvestAnim/Book1/index.htm

TABLE 3.
Animal species and their contribution to household assets

Species	Type of assets				
	Financial	Social	Physical	Natural	Human
Cattle, buffalo and yaks	Sales of milk, meat, hides, animals, draught power services, transport and savings instrument	Networking mechanism and social status indicator	Draught power for crop cultivation and transport.	Manure for maintaining soil fertility	Household consumption of milk and meat.
Camels	Sales of milk, meat, hides, animal, transport services. Savings instrument.	Networking mechanism. Social status indicator.	Draught power for transport.	-	Household consumption of milk and meat.
Donkeys and horses	Sales of animals, draught services, and transport (especially water).	-	Draught power for crop cultivation and transport (especially water).	Manure for maintaining soil fertility.	Provision of household water supplies.
Goats and sheep	Sales of milk, meat, hides and animals.	Networking mechanism.	-	Manure for maintaining soil fertility.	Household consumption of milk and meat.
Pigs	Sales of meat and animals.	-		Manure for maintaining soil fertility.	Household consumption of meat.
Poultry	Savings instrument. Sales of eggs, meat and birds.	Networking mechanism.	-	Manure for maintaining soil fertility.	Household consumption of eggs and meat.

Source: Perry *et al.* (2002).

large animals, importantly, contribute to social capital by facilitating human networking. The role of small animals, such as poultry, as entry points into a process aimed at creating a positive spiral of asset creation is not discussed in the report (ibid.).

5 GENDER

Neither the ILRI study (Perry *et al.*, 2002) nor the livelihoods framework (Figure 2) mention the role of small animals such as poultry as an entry point for poverty alleviation; moreover, both are silent on gender aspects. Accordingly, it is useful to note some points made by Quisumbing and McClafferty (2006) in an International Food Policy Research Institute (IFPRI) publication which summarizes the organization's considerable body of research on gender. Salient observations include:

- increasing resources controlled by women has beneficial effects on agriculture, health and nutrition; and
- increasing women's resources helps achieve successful development outcomes.

Small animal production, and especially smallholder poultry production, is in many countries overwhelmingly controlled by women. Linking this fact to the IFPRI findings implies that the benefits that can be derived from small animals are much larger than their inherent economic value would suggest, as they contribute disproportionally to human capital formation.

Indirect support for this conclusion can be found in data from Namibia. Matsaert *et al*. (1998) clearly indicate that ownership of cattle is associated with relative wealth – cattle owning households had an annual cash income of more than US$1 000, while households without cattle earned around US$200. Hans Askov Jensen found a similar trend in Malawi (personal communication), as did Charlotte Vesterlund Pedersen in Zimbabwe (personal communication).

6 THE PLACE OF POULTRY AS AN ASSET: EXAMPLES FROM DEVELOPMENT PROJECTS

In visiting country after country (not least as a member of missions by IFAD[3]) the author of the present paper has observed that among the poorer sections of the rural population, poultry are among the few assets that households have. This is illustrated in the following with examples from Swaziland and the Lao People's Democratic Republic. With regard to these two examples, it should be noted that many national statistical departments have problems collecting accurate data on rural poultry, and that therefore the results of the project surveys presented here may not always agree with national statistics; in some cases they represent the first careful collection of data on rural poultry undertaken in these particular areas. Following these two examples, the use of poultry as an entry point will be illustrated with a case from Afghanistan. Finally, the income-generating potential of indigenous birds will be illustrated with a case from Bangladesh.

6.1 Swaziland – poultry are widely owned

The data presented in Table 4 clearly show that poultry were the most widely owned animals among rural households – 92.5 percent kept poultry, as compared to 50 percent, 46 percent and 16 percent, who kept cattle, goats and pigs, respectively.

TABLE 4
Ownership of animal species in rural Swazi households

Species	Cattle	Goats	Pigs	Poultry
Percentage of households	50.0	46.0	16.3	92.5

Source: IFAD (2001).

[3] http://www.ifad.org/governance/index.htm

6.2 Lao People's Democratic Republic – with increasing wealth the trend is towards larger animals

Surveys in Bangladesh (Dolberg in FAO, 2003a) and the author's visits to rural areas in many countries have shown that poultry keeping is also widespread among the rural poor in Asia. The data in Box 3 illustrate that with increasing wealth, households move towards larger animals such as cattle and buffaloes. The data are from the IFAD-sponsored *Xieng Khouang Agricultural Development Project* in the Lao People's Democratic Republic. The strength of this documentation is that it is based on data covering a 23 year period from 1975 to 1998.

6.3 Afghanistan – poultry as an entry point

FAO has had livestock projects in Afghanistan since 1995. These projects had a poultry component. The following discussion is based on an interview with Dr Olaf Thieme[4], who worked for FAO in Afghanistan during the period 1997 to 2005. In brief, experiences in Afghanistan offer a number of important lessons that connect to the above arguments related to the use of small poultry units as a tool in human development. Relevant conclusions include:

BOX 3

Change in the animal species kept by farmers in a Province in the Lao People's Democratic Republic from 1975 to 1998

According to the Xieng Khouang Provincial Livestock Section's survey data, in 1975 there were 9 037 buffaloes, 8 575 cattle and 118 207 poultry in the province. In other words there were 13.1 head of poultry for each buffalo and 13.8 head of poultry for each head of cattle. In 1975 the economy was in poor shape as a result of the bombings that had taken place during the recent war. By 1998 the number of poultry had risen to 441 126, or by a factor of 3.7 as compared to 1975. However, over the same period, the cattle population had increased disproportionally, meaning that by 1998 there were only 5.5 times more poultry than cattle. The number of cattle increased to 79 260 in 1998, or by a factor of 9.2. The number of buffaloes went up to 38 897 in 1998, or by a factor of 4.3. This increase is less than that for cattle because buffaloes, used for work in lowland agriculture, were under competition from tractors, while cattle retained their role as a store of wealth for upland farmers. These relationships between poultry numbers and cattle and buffaloes numbers illustrate that vulnerable and poor households tend to keep poultry rather than large ruminants (assuming the households were more vulnerable during the war and poorer in 1975 than in 1998). This conclusion is supported by the findings of the IFAD Interim Evaluation's socio-economic survey of the Xieng Khouang Agricultural Development Project, which showed that buffaloes and cattle tend to be kept by the more well-to-do; the richest 2 percent of households kept as many buffaloes and more cattle than the poorest 27 percent of households. By contrast the poorest households kept more pigs and much more poultry than the well-to-do households (based on Dolberg, 1998).

[4] Animal Production Officer (Avian Influenza), FAO, Rome.

When the focus is on technical matters like poultry keeping, it is possible, in very religiously conservative areas, to work with women and contribute to their empowerment. The women appreciate the opportunity to participate in a poultry programme as it provides opportunities to meet and network with other women. In other words, they do not only benefit in economic terms, but they earn social capital in livelihoods terms.

Understanding with the government is needed in order to reach out to the women. Once this precondition is met, there will remain a need for the programme to create institutional mechanisms that facilitate the organization of groups of women for training and ensure supply of inputs and sale of outputs. Outreach may be through NGOs or producer organizations or – something that did not happen in this experience and remains a challenge in Afghanistan and other countries – a federation of village women's poultry groups.

Government veterinary and animal husbandry staff are more interested in big farms and big animals – this reflects the findings of the review by Ashley *et al*. (1999). Government staff need to be exposed to, and trained in, the poultry concepts; however, cannot be expected to lead the process as they lack training, experience and motivation. Process leadership may be an important role for FAO in similar programmes in Afghanistan or other countries in the future.

The successes were: (i) sale of eggs; (ii) vaccination and increased survival; (iii) the social capital formed through networking; (iv) four months of training for individual vaccinators and group leaders; and (v) it was realized that there was a need for a two-year follow-up for group leaders. New ideas included the women's request that the programme develop savings schemes. In the terms of the livelihoods framework, the women wanted to expand their activities into other types of income generation and capital accumulation.

7 CONDITIONS FOR USING POULTRY FOR POVERTY ALLEVIATION AND LIVELIHOOD IMPROVEMENT

The great advantage of egg production is that, although output may not be large, the household is provided with frequent if not daily provision of nutrients of high biological value (see Box 2 above); ideally this is consumed by pregnant or lactating women and young children. In economic terms, eggs are highly divisible and less lumpy than meat, and when marketed they can provide important small earnings that can be used to cover daily needs such as food to improve and diversify the diet, or other household items such as soap.

7.1 Without interventions there is little surplus for human consumption

Without intervention there are few eggs to eat or sell. Several studies document that in the absence of interventions most eggs go into the reproduction of the flock, with some birds used for meat or used in a social context as a gift or for a ceremony. This point is made by Smith (2001) on the basis of a study by Matthewman in Nigeria that was published in 1977; the tendency is confirmed by studies published in recent years.

While more than 75 percent of the households in a study in Ghana reported sale of chickens for meat, only 8 percent of the men and 7 percent of the women reported any sale of eggs (Aboe *et al*., 2006). A majority of the households – more than 60 percent –

reported that they consumed only 25 percent of the eggs, as most were used for hatching. A study in Zimbabwe showed that 38 percent of eggs were eaten in the producing household, but less than 1 percent were sold (Muchadeyi *et al*., 2005). A study in Senegal showed that all eggs produced were used for hatching and none for human consumption in the producing household or for sale (Missohou *et al*., 2002).

Tadelle *et al*. (2003b) report more positive results from a study in Ethiopia – 50 percent of the eggs going for hatching, 23 percent for consumption and 27 percent for sale. Tadelle *et al*. (2003a) found that following improvements to the traditional system, the farmers in the area covered by the study were in the habit of using methods to shorten the broody period; thus increasing egg production by 80 percent. This may explain the higher proportion of eggs available for human consumption and sale. However, it is not known how widespread the practice is, as it is only reported by this one study. Earlier Hossain (1993) had shown, on station, that when chicks were removed at four weeks of age, egg production in local breeds in Bangladesh went up by 60 percent. There are real possibilities for increased egg production based on these practices, as will be shown below.

7.2 Can the scavenging system be improved?

The question that will be addressed in this section is that of what may be achieved on the basis of applying simple interventions to the traditional, scavenging system with indigenous chickens. Vaccination against Newcastle disease is the first step. A large survey of Danida projects in Bangladesh (Riise *et al*., 2005) indicated that this is generally accepted even if the vaccination has to be paid for. Other possible interventions include weaning of chicks at an early stage of life to reduce the brooding period of the mother hen, and creep feeding in low-cost baskets or houses to increase the survival rate of the chicks. Such interventions may often be talked about, but they have rarely been tried in practice. If they have been tried, they have been poorly documented. Nevertheless, the studies by Hossain (1993) and Tadelle (2003a) indicate that there is a potential for increased egg production through early weaning; such interventions were recently used in the Danida supported SLDP-2 project in Bangladesh (Sarkar and Bell, 2006).

The project's approach was derived from the

"… common perception among poultry specialists that the production potential of indigenous chicken is very low due to its inherent genetic characteristics, and consequently their contribution to income generation and household nutrition security is obviously not efficient and satisfactory. But results from field studies reveal that indigenous or deshi chickens are able to contribute efficiently and economically, if small interventions are made in a few aspects of their traditional husbandry practices. In the traditional management system, hens are over-burdened with a wide range of activities and tasks. They lay a clutch of eggs, hatch chicks, brood and rear them for a considerable period of time and thus accomplish a production cycle within 125–130 days. Altogether only 3 production cycles can be achieved from a hen in a year. In a production cycle, a hen is able to contribute less time for productive purposes and spends much time undertaking tasks like brooding and rearing of chicks." (Sarkar and Bell, 2006).

The rationale was that minimum balanced feed supplementation, along with weaning and creep feeding in a low-cost house, helps to reduce the length of production cycles and

to maximize the laying performances of scavenging hens. Higher chick survival rate and more eggs per hen per year increase income and provide more eggs for human consumption in the households that raise chickens. Table 5 shows the consumption levels of chicken eggs and meat for a sample of participant households in the SLDP-2 project and compares these figures to the national averages.

According to Table 5, the potential, relatively speaking, for increasing production is highest for eggs, where the average increase is from one to six eggs per capita per month, while meat output is almost doubled from 310 to 584 grams per capita per month. The study also showed that out of a total monthly average poultry production value of US$21, sales represented US$13, while the average value of the domestic consumption was US$8. In other words, 62 percent of the production was sold and 38 percent consumed in the producing household. The question remains: for what is the income from the sales used?

The answer may be found in other studies from the same series of poultry projects in Bangladesh, which show that sales may have an important effect in terms of human nutrition. Alam (1997) studied 1 000 households that had begun project activities one to two years previously. The study found the main nutrition effect to be indirect. Most of the eggs were sold and the income used to buy other food items such as fish, rice, milk, beef and goat meat. From a human capital perspective, the increased consumption of different types of food of animal origin is important for young children and for pregnant and lactating women in particular, as these foods are rich sources of essential amino acids like lysine and methionine which are found only at low levels in plant foods. The other point to make is that increased income in the hands of poor people increases the demand for animal products like milk, mutton, beef, fish, in addition to poultry eggs and meat.

Following the study by Alam (1997), a study covering another 1 082 households broadly confirmed the results (DARUDEC and DANIDA, 1997). The latter study found an increase in vegetable consumption as a result of the purchases enabled by the income from the poultry. The study also looked more closely at who within a household gets to consume the eggs. It found that children have more eggs than the adults; among children, boys have more eggs than girls; and children above five years have more eggs than children below five. However, these trends varied depending on which NGO was responsible for field implementation – indicating the importance of the nutrition education given by the NGOs. The data suggest that more can be done through education to stress the benefits that expectant mothers, and young children of both sexes, can derive from the regular consumption of eggs and meat.

TABLE 5
Monthly per capita consumption of eggs and chicken meat

Items	National average	Results from 168 sample project households		
		Minimum	Maximum	Average
Eggs (number)	1	2	10	6
Meat (grams)	310	374	1 103	584

Source: Sarkar and Bell (2006).

Both Alam (1997) and DARUDEC and DANIDA (1997) report that the women invested in their children's education, including the girls' education, and in assets like rickshaws for their husbands, bicycles, sewing machines and in some cases even land. They confirmed the trend for investments to go from chicken and ducks to goats and cattle, with cattle being the most prestigious livestock investment.

7.3 The need for external inputs and actors that can provide them

As mentioned above, Newcastle disease vaccine is a critical external input needed to improve small-scale poultry production. Australian scientists have developed vaccines, and manuals and procedures for field application (Alders and Spradbrow, 2001). So far this has relied mainly on government or donor funding, and on government veterinary services for implementation. Groups based in France have worked on the supply of Newcastle vaccine mainly to African countries, with a strong commercial emphasis (Fermet-Quinet, undated) for several years. However, although there are procedures established to achieve this, there remains a need for government funding in the early stages, not the least for communication and awareness raising. It can be concluded that, while there are these established procedures and techniques from which lessons can be learned, large-scale, routine application of Newcastle disease vaccination of poultry belonging to poor women and remains far below the level required. There is urgent need for regular vaccination programmes in many countries, with the main challenge being to identify a viable institutional form to ensure implementation. This could involve private, commercial supply chains and village vaccinators (Riise *et al*., 2005; Fermet-Quinet, undated) to enhance long-term viability.

There will also be a need for other inputs such as training and extension services. This will involve – to stay with the examples used in this paper – making people aware of the ways in which they can protect their young chicks and feed them when they are weaned early, and conveying the idea of improving egg production by cutting the brooding period. There may also be a need for some loans to finance activities, at least in their early phases. However, in most developing countries, the smallholder systems have a low priority among government professional livestock staff – there has been little change since the analysis published by Ashley *et al*. (1999). The priority is also low among NGOs and commercial companies (Dolberg, in FAO, 2007a).

However, there are actors that have worked with the concepts and approaches needed to use poultry as a tool for poverty alleviation. These include FAO and the International Network for Family Poultry Development (INFPD), Veterinarians without Borders, the LAPROVET laboratory which is involved in work on Newcastle disease vaccination, and increasingly private veterinarians from West African countries. There is also the Australia-based International Rural Poultry Centre (IRPC), which is now the repository of experience gained by Australian scientists and development workers with Newcastle disease vaccination research and development. During the past ten years the Danish Network for Smallholder Poultry Development has worked on the subject from a multidisciplinary perspective, which has generated important insights (Riise *et al*., 2005; Kryger *et al*. in FAO, 2007b). Manuals on village poultry keeping can be downloaded from the site of the Network (in English and some in French).[5] The development NGO BRAC from Bangladesh has several years of

[5] http://www.poultry.kvl.dk/Information_resources/Manuals.aspx

experience with poultry programmes for poor women in that country. It is now involved in programmes in other countries such as Afghanistan, India, Sri Lanka, Uganda, the United Republic of Tanzania and Sudan; the number of countries is likely to increase. The commercial company Kegg Farms, in India, has been inspired in its approach by BRAC's key component, the Chicken Rearer, who serves an important role in enhancing the survival rate of young chickens. Dolberg (in FAO, 2007a) presents a more detailed analysis of the roles of these actors.

Although there are actors at the international level, and a few at the national level, who can provide inputs and support to small producers, the situation is institutionally and technically fragile in most countries where implementation of a smallholder poultry programme would be relevant. It is hard to avoid the conclusion that the biggest challenge for the future in these countries is in the institutional sphere. The challenge is to create organizations with sufficient administrative and technical capacity and with the necessary political support to implement poultry programmes as tools in human development. A first step may be to raise awareness among decision-makers in national governments and donor agencies. This would seem to be logical in view of the close match that exists between several of the Millennium Development Goals and the gains that can be achieved through smallholder poultry production.

7.4 Constraints and opportunities for future smallholder poultry production

In the future, poultry production for livelihood improvement and poverty alleviation will be needed in countries and regions of the world where there are comparatively large numbers of poor people. Paul Collier, former director of Development Research at the World Bank and now leader of the Centre for Studies of African Economies at Oxford University, in his book *The bottom billion,* (Collier, 2007) analyses the situation in about fifty states with a total population of about a billion people, where it has proven very difficult to get development moving. He describes the states as "failing", as most of them suffer or have suffered from extended periods of bad governance or civil war, with mismanagement of revenues from natural resources such as oil; or they may be landlocked with few natural resources. While the situation is bad, Collier argues that it is in these countries that the real development challenge lies. It is typical for these countries that most of the population is rural, and that many women and their families would benefit from interventions in support of smallholder poultry production. If it is assumed that out of the one billion people, 80 percent live in rural areas, that an average household consist of 5 people including an adult woman, and that adult women are the primary target group for this type of intervention, it can be estimated that 160 million women and their families would stand to benefit.

7.5 Opportunities, number of people and categories of countries

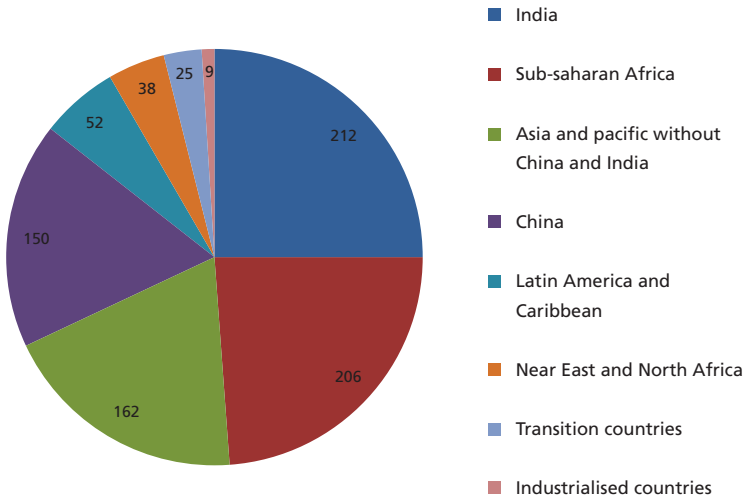
Development organizations are aware of the problem that Collier (2007) presents, although they may use other words to describe the situation. In World Bank terminology the difficult countries are called low income countries under stress (LICUS)[6] or highly indebted poor

[6] http://www.worldbank.org/licus

BOX 4
Countries for smallholder poultry in human development

The following countries – the list is not exhaustive – are among those that for some time will have large proportions of poor people. In Asia: Afghanistan, Bangladesh, Cambodia, the Democratic People's Republic of Korea, India, Indonesia, the Lao People's Democratic Republic, Nepal, Pakistan, the Philippines, Viet Nam; in Africa: Benin, Burundi, Central Africa Republic, Chad, Cameroon, the Congo, Côte d'Ivoire, the Democratic Republic of the Congo, Eritrea, Ethiopia, Ghana, Guinea, Guinea-Bissau, Guyana, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Togo, Uganda, the United Republic of Tanzania, Zambia and Zimbabwe. In Latin America there will not be many such countries, but Bolivia, Honduras and Nicaragua may need attention.

FIGURE 3
Distribution of undernourished people in 2001–2003 (millions)



Source: FAO (2006).

countries (HIPC)[7], while they are placed low on the UN's Human Development Report's Human Development Index[8]. FAO uses the expression low-income food-deficit countries (LIFDCs)[9].

The number of undernourished people is estimated to be above 854 million by FAO (2006), while the World Bank (2005) estimates the number of people living in the LICUS countries to be more than 400 million. The majority of people in either of these categories live in South Asia and sub-Saharan Africa. These countries are listed more fully in Box 4.

In all regions, wars and other disasters will very likely add new countries to the list set

7 http://www.worldbank.org/hipc
8 http://hdr.undp.org/
9 http://www.fao.org/countryprofiles/lifdc.asp?lang=en&iso3=LIE

out in Box 4, while stable and good governance combined with economic growth may remove countries from the list.

The distribution of the 854 million undernourished people in the world in 2001–2003 is shown in Figure 3.

7.6 Constraints

One important constraint is that – if Poverty Reduction Strategy Papers (PRSPs) are any guide – there appears to be limited awareness among planners and policy-makers about the possibility of using smallholder poultry production as a development tool. The HIPC countries are required to produce PRSPs to obtain concessional lending from the World Bank for their development. Yet, from the perspective of the present paper, there is much that needs to be improved. As poultry and other small livestock are kept particularly by poor people, it would be reasonable to expect that PRSPs allocated a role for livestock development; but this has not been the case in most instances. In the first working paper published by the FAO Pro-Poor-Livestock Initiative (FAO, 2003b), 61 countries were examined with regard to the degree to which livestock (not to mention poultry) had been included in PRSPs. The conclusions drawn in this paper include the following:

- that livestock is generally under-represented in PRSPs;
- that greater attention is given to commercial operations than to species and structures relevant to the poor;
- that recommendations are far too general, and therefore unlikely to lead to improved outcomes;
- that often the format of the PRSP process will not lead to accurate descriptions of the situation of livestock producers;
- that despite attempts at a participatory and consultative process, recommendations are mostly central and top-down; local opinion may therefore be sought but not incorporated; and
- that the joint staff assessment procedure does not lead to any increased representation of livestock.

In the introduction to this paper, a reference was made to Ashley *et al*. (1999), who in their review of 800 livestock development projects showed that there was a bias towards large animals in development work; on the basis of the evidence provided by the analysis of the PRSPs (FAO, 2003b) the situation has not improved. In view of the lack of consideration given to livestock in the PRSPs, the situation may in fact have become worse.

7.7 The market situation

The marketing situation with regard to smallholder poultry production has recently been reviewed by Kryger *et al*. (in FAO, 2007b). The market situation will be closely linked to developments in the economy, which in turn is linked to the political situation in a country or region (Collier, 2007); extreme forms of political unrest, war and mismanagement lead to economic stagnation and depletion. Conversely, economic growth will lead to an increase in the demand for poultry products, and that demand boost will be particularly strong in the lower income groups. Raha estimated this effect for Bangladesh (Table 6).

It is interesting to note that according to Table 6 the income elasticity of demand is

TABLE 6
Income elasticities[10] of demand for poultry products and distribution of income groups

Income group (in Bangladesh Taka per household)	Percentage of households by income group (national figures)	Percentage of households by income group (figures for rural population)	Elasticity of demand	
			Eggs	Chicken for slaughter
<4 000	55.0	61.5	1.627	2.887
4 001–6 000	19.7	19,1	1.168	2.575
6 001–8 000	9.3	7.8	1.127	2.552
8 001–10 000	5.5	4.7	0.651	1.172
>10 000	10.5	6.9	0.496	0.294

Note: US$1 = 68.7 Bangladesh Taka on July 18, 2007.
Source: Raha (2003) as quoted in Riise *et al.* (2005).

much higher for chicken meat than for eggs, but that for both eggs and meat the elasticity is particularly high at the lower income levels. The conclusion that increases in income lead to an increased demand for food of animal origin reflects the findings of the study on the "livestock revolution" produced by Delgado *et al*. (1999).

Meat from indigenous birds commands a premium price in many countries. In the case of Bangladesh, Riise *et al*. (2005) found this premium to be 60 percent. There was no price difference for eggs – although it may be argued that a 40 gram egg from an indigenous hen traded at the same price as a 60 gram egg from an exotic bird is 50 percent more expensive on a weight basis.

7.8 The political and economic situation decides whether there is a niche or a major market

At times price differences between the eggs and meat of indigenous and exotic birds lead to discussions about possible niche markets for some products. The question of the size of such a market then has to be considered. According to the comprehensive review by Kryger *et al*. (in FAO, 2007b), reliable data on the volume of this niche market is unavailable "and the relation to the broiler meat market in terms of price elasticities appear[s] not [to be] being researched".

In countries where economic development has difficulty to take root – home to 1 billion people according to Collier (2007) – there is another dividing line. Poultry production based on the traditional scavenging system will be the dominant form until economic development begins to take off, at which point, commercial types of poultry production will begin to supply a predominantly urban market which will grow with time.

Factors that influence farm gate prices include distance to the market, population density, transaction costs and marketing structures. There will, for example, be differences in the share of the consumer price that an intermediary will expect (and hence the price that

[10] The income elasticity of demand measures the increase in the quantity demanded of a good that results when people increase their income.

the farmer will get) between a country such as the United Republic of Tanzania that has a low population density (41 people per square kilometre) and long distances to markets, and a country such as Bangladesh, where a very high population density (985 people per square kilometre) will provide a much more ready demand and access to the market.

While there have been studies of aspects of smallholder poultry marketing (Mlozi *et al*., 2003; Riise *et al*., 2005; Kryger *et al*. in FAO, 2007b), there seems not to have been any that have studied whether, under a range of marketing conditions, the prices charged by intermediaries are "fair" or whether there is any need for interventions in this area.

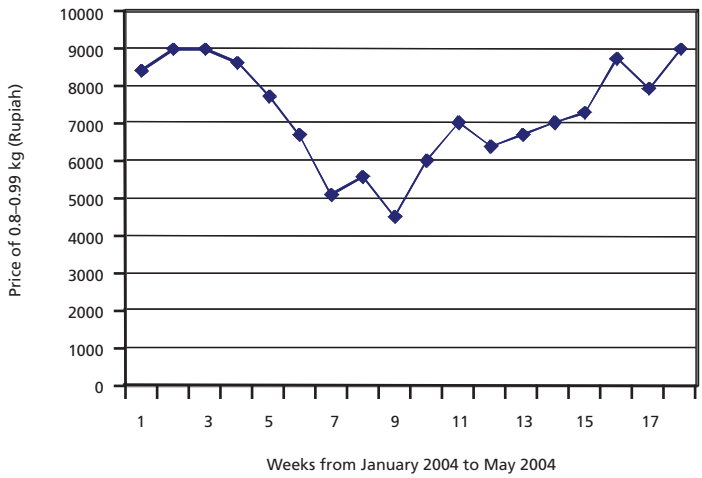
In conclusion, the question of marketing needs more detailed studies with regard to the influence that the political and economic situation in a country or region has on poultry production systems and the chain from the producer to the consumer. This will help to inform decisions about the most appropriate interventions.

8 THE MARKET RESPONSE TO HPAI

The HPAI problem is expected to last for some years. Poultry producers have to expect that consumer reaction to the problem will, from time to time, influence the marketing situation – although demand can be expected to recover after some time. This effect is illustrated in Figure 4. The figure is based on data from the first outbreaks in Indonesia in 2004, but the pattern of consumer reaction has been the same in other countries in later outbreaks (McLeod, personal communication).

Small poultry producers will also face problems when governments decide to restructure markets as a result of HPAI. This effect was being seen in Viet Nam at the time of writing.

FIGURE 4
Jakarta broiler prices from news of outbreak in January till May 2004



Source: Dr. Hartono, Indonesian Poultry Information Centre.

9 CONCLUSIONS

As this paper has outlined, the particular purpose of using poultry production for livelihood improvement and poverty alleviation is to benefit poor women and their families. Increases in egg and meat production are significant, but this is not the most important measure of success. Important evaluation criteria (Figures 1 and 2) include whether the women and their families have enhanced their capabilities to cope with the difficulties that poor people typically meet (diseases, hidden hunger, pressure on their assets, etc.), whether they have stronger social networks, and whether they are better able to feed their children and keep them in school. Poultry production in the sense that it is discussed here is only one of the tools that can be used, but it adds to the menu of options available to livelihood improvement and poverty alleviation projects or programmes.

The rationale – based on the evidence provided in the paper – for a poverty alleviation strategy that embraces smallholder poultry production is that it will reach, more successfully than cattle-based projects, the people that pro-poor development is meant to benefit. The evidence is that this leads to a situation of greater food security, in which people consume more of their own produce, and exchange – via the market – the remaining high-value poultry meat and eggs for milk, other meat, fish, cereals or vegetables. This results in several benefits. Poor people take their first steps into the development mainstream, they and their children become better nourished and the demand for all animal products increases. In short, poultry production offers a means to distribute more equally the benefits of development as defined within the livelihoods approach (described in Section 3 above).

The primary constraint to up-scaling poultry production for livelihood improvement and poverty alleviation is institutional and organizational. It is poor women and their families who run the smallholder poultry production system, but they are not organized and most government veterinary and extension systems do not reach out to them. They are, therefore, left in an organizational vacuum with poor guidance from the national governments. Taking into account Collier's (2007) analysis of the general economic and political conditions in many of the countries where the smallholder poultry approach would be relevant, this situation will not be easily remedied.

10 RECOMMENDATIONS

The need for smallholder poultry work in the future will be in the countries in the World Bank's LICUS or HIPC categories, FAO's LIFDC category, those placed low on the UN Human Development Index, or in the countries that are home to what Collier (2007) calls "the bottom billion". In none of these countries can a strong organizational capacity to reach out to poor women and their families be expected. Accordingly, the most important challenge is to find the organizational means to reach these poor people. This may be through government extension programmes, producer organizations, community-based organizations, NGOs, private companies, or a combination of these actors. A decade ago, Ashley *et al*. (1999) documented the problems that livestock projects had in reaching poor people; such problems will persist for some time in the countries where the smallholder approach is relevant.

10.1 Identify the roles and responsibilities of the public and private actors

The poultry sector, whether commercial or based on a scavenging village system is a private sector. It would not make sense in countries with a weak public sector – including weak veterinary and livestock services – to allocate to the public sector responsibilities that can be handled equally well or better by private companies, producer organizations or NGOs. A relevant analysis of the roles of public and private sector actors in the provision of livestock services is provided by Ahuja (2004). Ahuja's analysis draws a distinction between public and private goods, and uses this distinction to identify the appropriate delivery channels for various livestock services. According to this analysis, public goods include surveillance, prevention, control and eradication of highly contagious diseases with serious socio-economic, trade and public health consequences; emergency responses; wildlife disease monitoring; food-safety tasks; and compliance monitoring. Research, extension and training are classified as having both public and private good characteristics. Disease investigation and diagnosis, and production and distribution of drugs and vaccines are among the activities placed in the private good category.

10.2 Roles of international organizations and networks

International organizations such as FAO have a clear role to play as providers of technical expertise. The countries for which the smallholder approach is relevant will be short of technical expertise, so there is a role for an international technical organization like FAO to act as a storehouse of knowledge, as a provider of technical assistance, and through support to INFPD. An immediate task is to create awareness among decision-makers in the relevant countries about the potential of the smallholder poultry approach as a development tool. The same role is foreseen for the other organizations that focus on smallholder poultry as a tool in poverty alleviation such as the Veterinarians without Borders, the LAPROVET laboratory that is involved in the work on Newcastle vaccination, the Australia-based International Rural Poultry Centre and the Danish Network for Smallholder Poultry Development. The expansions of the development NGO BRAC from Bangladesh into other countries is likely to involve work with poultry and should be followed and supported as appropriate, not least to learn from the institutional modalities that may be applied. Knowledge about the use of small stock in development is stored in the Smallstock Toolbox, a Web site supported by several donors (http://smallstock.info).

10.3 Roles of NGOs, community-based organizations and membership organizations

The limited outreach of government veterinary and extension services in the countries where the smallholder poultry approach is relevant allocates an important role to NGOs and community-based or membership-based organizations, which should be supported as far as possible. However, this is easier said than done for the following reasons: (i) the number of NGOs with interest in using the approach is limited (Crafter in FAO, 2004); (ii) many of the countries for which the smallholder approach is relevant are not democracies and they may not allow the freedom to organize that is required to create NGOs, community-based or membership-based organizations. However, these constraints should

not prevent support to such organizations, where this is possible. One option may be collaboration between international organizations and networks and international NGOs, as international NGOs are sometimes permitted to work in countries that do not allow the existence of national NGOs or other types of civil society organization.

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Smallholder family poultry as a tool to initiate rural development

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SUMMARY

Smallholder family poultry (SFP) straddles production systems 3 and 4, as defined by the Food and Agriculture Organization of the United Nations (FAO), and makes up about 80 percent of the total poultry population in most developing countries. There are various models of the use of SFP as a tool for development. Examples of scavenging models tested over several years are the Smallholder Semi-Scavenging Poultry Model in Bangladesh and the *Projet pour le Développement d'Aviculture Villageois in Burkina Faso*. An example of a small-scale intensive model is the Nigerian Union of Local Government Employees model, which has been tested for only a short period.

Highly pathogenic avian influenza (HPAI) is the greatest current biosecurity threat, the management of which requires incentives, compensation and education of the producers to create prevention awareness. The carrying capacity of the range, concerns about food safety, and the policies of governments and institutions are other threats to SFP in the twenty-first century. Reports show that the realization of SFP as a tool for poverty alleviation and social development brought forth innovative and supportive policies for SFP from governments and international development institutions. While all the four FAO-defined poultry systems can co-exist within the same locality and remain viable, it is the development of SFP that is the most pro-poor option.

The most important lesson learned from all the models is that training and advocacy are key to the initiation of sustainable development through SFP. The need for training is widespread: from government officials through service suppliers, NGO officials, smallholders, intermediaries and consumers. Such training must be sustained in quantity and quality through the use of information and communication technology to record, store and reproduce or remotely offer training modules via, radio, television, CD, DVD, MP3 or the Internet. Such a training tool kit is an international public good that is the responsibility of various international organizations and governments.

Key words: poultry, tool, rural, development

1 INTRODUCTION

Smallholder family poultry (SFP) can be defined by the production system, input source, output allocation, flock size and location. SFP is raised extensively or semi-intensively in

relatively small numbers (usually less than 100 in any flock); there is minimal investment in inputs, with most being generated in the homestead; labour is drawn from the family, and production is geared essentially towards home consumption, income and savings (Sonaiya, 1990a). In many developing countries, small flocks of poultry (especially commercial hybrid chickens) are raised in complete confinement in suburban, peri-urban and urban areas (classified as FAO poultry production system 3) while scavenging poultry (system 4) is the type held by most farm families. Hence, SFP straddles poultry production systems 3 and 4 (FAO, 2004a) and accounts for 30 to 80 percent of the total poultry population in most developing countries.

This paper discusses the linkages between SFP and general development of rural areas in developing countries, and the action required from donors and international agricultural research and development institutions to support SFP as a tool for rural development.

2 THE ECONOMIC IMPORTANCE OF SFP PRODUCTION TO THE RURAL POOR

The World Bank defines poverty as "a pronounced deprivation of well-being related to lack of material income or consumption, low levels of education and health, vulnerability and exposure to risk, and voicelessness and powerlessness." Mitchell and Shepherd (2006) differentiated the rural poor into three categories: "small producers for global markets", "workers" and "marginal producers for domestic markets" to reflect their differing productive strategies, access to assets and engagement with global economic processes. SFP producers fall into the third group – marginal producers for domestic markets. Their contribution to general community development may be better assessed by the use of the value chain analysis approach. Value chain activities bring a product from its conception to its end use and include production, marketing and distribution, which may be confined to a single geographical location or spread over wider areas (Porter, 1985).

The value chain approach contributes to reducing poverty when it supports the role of the poor within the value chain by fostering associations, skills development and learning, or by facilitating contract arrangements and supporting information and service delivery. Often, it is necessary to combine value chain promotion within a livelihoods perspective, with local economic development or with vocational training so as to enable the poor to enter (and stay in) commercial markets. The first role of economic importance that SFP performs in general rural development is that it creates market access, an obligatory step in value chain development.

2.1 Provision of market access to the vulnerable

SFP provides marginal producers – the poor, the weak (due to diseases like HIV/AIDS), the displaced and refugees, and other disadvantaged people (such as widows, former child soldiers and militants) – with access to the market. Chickens are usually the first livestock to establish themselves in refugee camps, in resettlement camps or after natural disasters. The fact that women own a large proportion of SFP emphasizes its importance as a means of improving their livelihoods. SFP easily integrates into the main occupation (crop agriculture) of the rural poor, who are more likely to keep poultry than larger livestock (IFAD, 2004) because poultry require little in terms of land area and other production factors. In

countries where a proportion of the rural people are landless, these landless people can still keep system 4 SFP, which depends purely on scavenging and so provides the landless poor with an output – birds or eggs – that can be marketed. The role and limitations of SFP in creating market access is illustrated in the following case reports from Myanmar, Bolivia, Solomon Islands, the United Republic of Tanzania and Uganda.

Myanmar, an economy dominated by agriculture, with 75 percent of the population or 36.6 million people living in the rural areas, has 52 million village chickens which are raised predominantly for income and household consumption. Improving the general welfare of the rural SFP producers requires identifying and reducing the constraints to village chicken production and enhancing their production, quality and marketing, i.e. increasing the value of the SFP products in the local markets (Henning *et al.*, 2007).

In Bolivia, the commercial poultry sector is well organized around the cities of Cochabamba for broilers and Santa Cruz de la Sierra for layers. The market prospects for SFP would be expected to be restricted because there are efficient market channels for broilers and layers to other cities and small towns in the country. SFP, however, is found in most rural areas, but is much more important in the valley areas where the traditional food crop is maize, and scavengeable feed resources are available. With an average SFP flock size of 20, rural households can afford a few birds to be sent to the urban markets, where birds from the backyard systems are sold for about US$2 each, a price that is stable and uniform throughout the large country of 1.1 million km^2 (Rushton and Viscarra, 2005).

More than 80 percent of the 400 000 people of Solomon Islands live in the rural areas. There have been ethnic conflicts which resulted in a number of students dropping out of school to join the militias; these individuals are now demobilized, jobless and without employable skills. For this vulnerable group, SFP birds and eggs that are surplus from home consumption provide valuable marketable goods and help to rebuild self-confidence and encourage a return to studying (or, in the case of other demobilized militia men, the uptake of new studies) (Parker, 2004).

In Dar es Salaam, United Republic of Tanzania, the Mama Mkubwa (respected elder aunt) programme looks after orphaned and street children in the homes of women volunteers. These women are helped to set up backyard chicken flocks, which the children look after. They sell the eggs and birds in the market and use the cash income to buy food (Macha, 2005).

Community Integrated Development Initiatives, a non-governmental organization, implemented a SFP project in Rakai, a rural district of Uganda where the care of HIV/AIDS orphans is a big challenge. Within two years, the project had achieved an increase in flock turnover; an increase in egg sales, with some households able to sell about 6 000 eggs in a year; and an increase in chicken sales, with households able to sell 200 growers and 30 adult birds in a year (Kyarisiima *et al.*, 2005).

In country after country, it has been demonstrated that selling SFP eggs and birds provides market access to the hard core poor, enabling them to develop market linkages, though these linkages are often hampered by the low production output of individual SFP households. On the positive side, prices of SFP chickens are often higher than those of commercial broilers, creating a great incentive for SFP producers and reflecting consumer preferences for local chickens raised on the free range. While imports and commercial poul-

try products sometimes saturate the urban markets with devastating effects on prices for domestically produced commercial broiler and eggs; the prices for SFP are often relatively stable throughout the year although prices may peak during festive seasons.

2.2 Contribution to household income

Though SFP is not seen as a primary occupation by any of the producers, it is a source of small but significant income to rural families throughout the developing countries. A major comparative advantage of SFP for poorer, more remote, rural communities is the conversion of labour into cash in a shorter time, with less capital requirement and with less risk than is the case with other livestock species or other uses of labour. The following discussion is illustrated with the reports of SFP contribution to family income in Bangladesh, Burkina Faso, Nigeria, Senegal and the United Republic of Tanzania.

In Nigeria, none of the women surveyed in southwestern Nigeria by Sonaiya *et al*. (1992) using participatory rural assessment techniques viewed SFP as a main occupation; but they recognized it as a source of significant income. Atteh (1990) reported that in the western middle belt zone of Nigeria, 10.5 percent of SFP keepers stated "source of income" as their sole objective in keeping chickens, but 65.7 percent had "source of income" as one of their objectives.

Among the Yoruba people in southwestern Nigeria, women marketers (called Alarobo) who collect eggs (and other collectibles such as plastic and glass bottles, and tin containers) from chicken-keeping households and sell them in urban markets, earn some income from this activity. Ouandaogo (1990) calculated that the export of eggs of guinea fowl eggs from Burkina Faso to Côte d'Ivoire earned about CFA 2 billion annually for SFP producers in Burkinabe villages. Kushi *et al*. (1998) reported that the 94 women SFP owners they surveyed in Bauchi State, Nigeria earned an average income equivalent to about US$3 per month from poultry keeping, which accounted for about 9.5 percent of their total monthly family income. Chitukuro and Foster (1997) calculated that in central United Republic of Tanzania an SFP flock comprising five adult chickens enabled women to earn US$38 annually, which amounted to about 10 percent of their annual income.

Alabi and Aruna (2005) used econometric models to investigate the contribution of SFP to the total income of women in the Niger Delta area of Nigeria. The econometric analysis indicated that wages, trade and SFP were the significant determinants of income of women in the area studied. SFP contributed 18 percent of total annual income and was rated third in terms of its influence on women's income in the study area.

In the Sahelian area of Thies, 70 km from Dakar, Senegal, Missouhou *et al*. (2005) studied system 3 SFP. With an average of 16.5 birds per household managed by women, and with the birds fed a 4 percent supplement based on maize, sorghum, millet or cereal brans, even with 44 percent mortality, poultry's contribution to household incomes was 21 percent of total annual income.

The 10 percent increase in the contribution of SFP to African rural family income within a decade may be indicative of the worsening economic opportunities for vulnerable rural dwellers. The capital investment required to start the smallest enterprise has continued to rise sharply with the general cost of doing business at any scale in most African countries. SFP may, therefore, have increased its comparative ability to generate income for a very small outlay of investment.

In Bangladesh, the three SFP projects supported by Danida, the International Fund for Agricultural Development (IFAD) and the (Asian Development Bank) ADB (SLDP-1, PLDP and SLDP-2) over 12 years included up to 1 million women beneficiaries and reached out to approximately 5–6 million people. Evaluation of the project showed that the level of monthly income from SFP eggs sale among beneficiaries, though low ($4 per month) was for the majority of the women the only income source, and had a positive impact on the livelihoods of the beneficiaries (Kryger *et al*., 2005).

2.3 Meat and egg supply

In 2005, close to 60 percent of the 900 million people in Africa lived in the rural areas; they had available to them 1 356 million chickens, 16 million ducks, 12 million geese and guinea fowls, and 9 million turkeys, producing 2 180 125 tonnes of hen eggs, 7 143 tonnes of other poultry eggs, 3 257 292 tonnes of chicken meat, 56 619 tonnes of duck meat, 55 340 tonnes goose and guinea fowl meat and 66 252 tonnes of turkey meat (FAO Statistics cited by Guèye, 2007). On average, 80 percent of all poultry classes are in the SFP sector.

Because SFP is available in such a large number, it makes a notable contribution to the nutrition of both the rural and the urban populace in Africa. The SFP contribution to animal protein supply in developing countries is decreasing in urban areas but remains quite strong in rural areas. The edible products of poultry (meat and egg) are always in high demand in rural areas because they are widely accepted in virtually all cultures as they suffer no or few taboos. Although some cultures influence who in the family consumes the poultry products, they are nonetheless a cheap and ready source of animal protein for the family.

The International Food Policy Research Institute (IFPRI) forecasts that by 2015 poultry will contribute about 40 percent of the total animal protein consumed globally (IFPRI, 2000). In the villages of developing countries SFP becomes a source of meat when the chickens are slaughtered during festivals, celebrations and sacrifices. Fresh eggs are seldom eaten, they are kept to be hatched, but unfertilized egg are harvested and eaten by the family.

Mbugua (1990) reported that in Kenya, although SFP produced 71percent of both the eggs and the poultry meat in the country, only 10 percent and 40 percent of the eggs and meat, respectively, are marketed, the rest is presumably consumed by the family. Kabatange and Katule (1990) demonstrated the value of SFP in meat production in the United Republic of Tanzania. They calculated that if a family has two hens, the two hens lay 60 eggs in a year, and there is 50 percent hatchability of the eggs, at the end of a five-year production period, the meat production from the flock that derived from the original two hens will be far in excess of meat from a range-fed cow, which usually takes 5 to 7 years to reach slaughter. Boki (2000) reported that the poultry meat and egg demands in the rural areas of the United Republic of Tanzania were met entirely by SFP which also supplied 20 percent of the poultry meat and egg demands of the urban areas.

3 STEPS AND PROCESSES IN REALIZATION OF THE POTENTIAL OF SFP

SFP is everywhere in developing countries and has economic and social significance in the rural areas. Hence, it can be used as a tool in the eradication of poverty, as a means of economic empowerment, as a way of ensuring food security for rural families, as a vehicle

for demonstrating the appropriate application of science and technology to solving problems, and as a unique opportunity for technical cooperation among developing countries. A report from the Consultative Group on International Agricultural Research (CGIAR, 2004) provides concrete examples of how scientists in industrialized and developing countries are producing new technologies to boost crop yields, increase rural incomes and reduce the use of pesticides. SFP is an ideal tool for the CGIAR to deliver international public goods to the developing countries in livestock production sciences.

If the potential and importance of SFP is to be realized, it must be protected from diseases and epidemics like Newcastle disease (ND) and highly pathogenic avian influenza (HPAI). With this protection comes an increase in the sizes of family flocks, which must be managed in a sustainable way for higher output. The requirements for this enhanced performance include development of appropriate simple technology for the health and husbandry of family flocks, improved management and productivity of the birds, acquisition of appropriate market skills by the SFP producers, and a viable microcredit scheme for SFP development.

3.1 Animal health

There is a consensus that if SFP is to thrive anywhere, the control of ND is the number one priority (Thitisak *et al*., 1989; Sonaiya, 1990a; Alexander, 1991; Spradbrow, 1993; Copland and Alders, 2005). ND control programmes that allow SFP owners to be trained in vaccine delivery become a means of economic empowerment for those who are trained to do this work (GRM International, 2005). Reduction in mortality is achieved both through vaccinations conducted by trained community vaccinators (Ouandaogo, 1990; Alexander *et al*., in FAO, 2004b; GRM International, 2005) and through improved management that protects young chicks for the first six to eight weeks of their lives. The study carried out by Sonaiya *et al*. (2002) showed that for greater productivity, vaccination (against ND) must be accompanied by improvements in other management practices (such as supplementary feeding). This implies a holistic system approach to SFP development.

Currently, the control of HPAI has become the greatest priority for all poultry production systems including SFP. A reduction of overall mortality in village poultry by vaccination against endemic killer diseases such as ND, fowl cholera and duck plague, with rapid and effective disposal of dead birds, points the way to a cost-effective approach to the long-term prevention and control of HPAI (Alders *et al*., 2007).

3.2 Housing and hatching

The state of the housing available to SFP exposes the birds to accidents, predation and theft, resulting in an annual loss estimated at 852 million birds in Africa (Sonaiya, 1990b). Simple predator deterrents can be constructed to protect the chickens when they are sleeping during the night and when they are scavenging during the day (Sonaiya, 2000a). Such improved housing may also protect them from the spread of HPAI.

Low-technology incubators such as the Chinese rice-husk incubator allow day-old chicks to be produced within the locality of the SFP producers. The advantages of such technology include generating self-employment for some SFP producers in the rural areas and reducing the down time for the hens which results in greater egg production and, hence, increased income.

3.3 Nutrition and management

System 4 SFP depends on scavenging the feed resources available on the free range. Estimating this scavengeable feed resource base (SFRB) and making the most economical use of it is very important to the productivity of SFP (Roberts., 1992; Gunaratne *et al*., 1993; Olukosi, 2002; Sonaiya *et al*., 2002; Sonaiya, 2004). In order to increase productivity, it is invariably found necessary to provide supplemental feed. Sometimes, selective supplementation (e.g. of laying hens alone) is adopted as well as the use of creep feeders which allows the chicks preferential access supplemental feed and affords them additional protection against predators.

Supplemental feeding is better based on locally available feed resources (which may be unconventional to the intensive poultry system), especially agricultural by-products and by-products of homestead food preparation (Prawirokusumo, 1988). The assessment of the quantity and nutritive value of such unconventional feed resources is a continuous process (Musharaf, 1990; Sonaiya, 1995).

While chickens are the main poultry in the villages, there are advantages in keeping other poultry species in SFP production. For example, in the savannah or dry-land areas of Africa, where guinea fowl are kept, there is better usage of the SFRB, as guinea fowl are better scavengers than chickens. In the lowland rice-based farming systems of Asia, ducks predominate in SFP. Ducks have better mothering abilities than chickens and can utilize the rice paddies more effectively, thus increasing the gains from scavenging systems. Under the threat of HPAI, there is need to separate poultry species to avoid cross infection and virus evolution.

3.4 Market development in the value chain

There is need to shift the focus of SFP production from simply increasing the number of chickens in the flock to profit maximization (Sonaiya, 1996). The flock size of SFP in the villages more often than not exceeds the carrying capacity of the range in terms of feed resource base and this leads to competition and heavy mortality, particularly of the chicks and growers (Roberts, 1992). The SFP owners need to learn flock management and hatch dynamics, including regular harvesting of excess eggs (beyond the number that the brooding hen can cover) for family consumption or sale, and the sale of grower chickens rather than only the older chickens. If profit maximization becomes the focus, then marketing development skills such as record keeping, egg grading and branding, as well as egg processing become important (Sonaiya, 1996). The work of Conroy *et al*. (2005) shows that there are low-technology approaches to the proper management of hatchable eggs in the rural areas.

4 MODELS OF SFP AS A TOOL FOR DEVELOPMENT

4.1 Scavenging family poultry production models

Outstanding success has been achieved in the long-term use of family poultry for rural development through the Smallholder Semi-Scavenging Poultry Model in Bangladesh and the *Projet pour le Développement d'Aviculture Villageois* (PDAV) in Burkina Faso.

The Bangladesh Semi-scavenging Poultry Model (2002)

The concept behind the Bangladesh Semi-scavenging Poultry Model was developed during the 1980s by the government of Bangladesh's Department of Livestock Services (DLS) and

the non-governmental organization Bangladesh Rural Advancement Committee (BRAC). Extensive validation of the model took place under the first Smallholder Livestock Development Project (SLDP-1) supported by Danida and IFAD, the Participatory Livestock Development Project (PLDP) funded jointly by Danida and the ADB and the second Smallholder Livestock Development project (SLDP-2) in southern Bangladesh funded by Danida.

The basic principle of the Bangladesh Model is to provide the poorer segments of society with the possibility of generating an income and improving the status of women through rearing improved hens to produce table eggs. To ensure regular supply of birds and feed and to reduce mortality due to diseases by vaccinating the birds, beneficiaries were selected, trained and encouraged to provide the standard services available under intensive systems of poultry production.

The Bangladesh Model focuses on small holdings of chickens as a vehicle for poverty alleviation and socio-economic development for rural peoples. It has been reported to reduce the number of poor beneficiaries by 32 percent per year among the poorest of the landless poor (Jensen, 1996). The Model used in the PLDP, as depicted in the Appraisal Report, is essentially a value chain involving the following elements:

(a) Primary producers

Model Breeder: small low-cost parent farms with a breeding stock of 18 Fayoumi hens and two Rhode Island Red (RIR) cocks received either from the project site or directly from government poultry farms. The Model Breeders are to produce quality fertile eggs to be sold to the Mini Hatcheries. (36 Model Breeders per Area Office).

Mini Hatchery: small low-cost hatcheries operated with solar energy and kerosene. Each hatchery has a capacity to hatch 700 chickens or ducklings per month. The day-old chicks are sold to the Chick Rearers. (9 Mini Hatcheries per Area Office).

Chick Rearer: small rearing farms, each with a capacity of 200–300 chickens/batch and 4 batches per year. The day-old chicks are supplied by the Mini Hatcheries, and at eight weeks of age the chickens are sold to the Key Rearers. (57 Chick Rearers per Area Office).

Key Rearer: women having five cross-bred layers for the production of table eggs. The hens are kept under semi-scavenging conditions and fed with 30–70 percent supplementary feed. This group constitutes 95 percent of the beneficiaries. (about 5 716 Key Rearers per Area Office).

(b) Market-oriented support services

Poultry Workers: women trained and equipped to vaccinate poultry against the most common poultry diseases. The vaccine is bought either through the Sub-district (Upazilla) Livestock Office, NGO Area Office or on the local market. (100 Poultry Workers per Area Office).

Feed Sellers: procure various feed ingredients (including pre-mixes) available on the local market or supplied by the supporting NGO and sell compound feed or feed ingredients to the poultry keepers. (10 Feed Sellers per Area Office).

Egg Seller: buy eggs from the producers and sells them to the market. She is also expected to be the marketing link between the Model Breeder and the Mini hatcheries. (10 Egg Sellers per Area Office).

(c) Technical support

Non-Governmental Organization (NGO): the NGO forms poultry producer groups, arranges the training of members and provides technical support to, and credit for, the various operations.

DLS: the DLS staff provides technical support during training and operation, particularly for the Model Breeders, Chick Rearers, Poultry Workers and Feed Sellers. The government poultry farms supply Fayoumi pullets and RIR cocks to the Model Breeders and Sonali pullets to areas where these hybrids are not being produced in the villages.

The model has been recognized globally as an excellent tool for income generation among poor farmers/destitute women and for stimulation of private enterprise development. Stakeholders from several countries have visited Bangladesh to study the model for possible adaptation and adoption.

Assessment of the impact of the Model on the beneficiaries who were involved as various poultry cadres showed that the project had a positive impact on overall household income and that there was a positive increase in food consumption, clothing, school expenses and savings (Alam, 1997; Nielsen, 1996). On the whole, the Egg Sellers are the beneficiaries that benefited mostpersonal communication. They were among the poorer segments of the group, but they understood the benefit of buying eggs from individual households and selling them on the market.

The majority of households reported that they had increased food consumption in general and quite a number of the beneficiaries actually increased the number of meals from two to three per day. For all households the main increase in food intake has been through eggs and chickenpersonal communication, and whereas red meat was previously an occasional diet in most households it has become a more regular item in the weekly diet.

The Bangladesh Semi-scavenging Poultry Model is an appropriate tool for poverty alleviation and general development. For the hard core poor, the size of the microcredits is manageable and the technology promoted is simple and adaptable. In areas where the service providers are performing according to expectations, Key Rearers can relatively quickly initiate investments in other income-generating initiatives while maintaining the small flock of hybrid birds.

Loans have been a key element in the success of the Model. The beneficiaries have highly appreciated having a technological package attached to the loan, even though 50 percent or more of the loan was used for other initiatives (Alam, 1997; Nielsen, 1996).

Projet pour le Développement d'Aviculture Villageois (PDAV) in Burkina Faso

The famous *Projet pour le Développement Aviculture Villageois* (PDAV) in Burkina Faso, funded by Coopération Francaise, concentrated on the training and placement of "*vulgarisateurs villageois volontaires*" (VVV) although its broad objective was to improve the hygiene, housing and feeding of family poultry (guinea fowl) and the transport and marketing of its products (Ouandaogo, 1990). In ten years (1979 to 1989), 1 821 VVV were trained; they administered 13 million ND vaccinations and 1.2 million antihelminth treatments, among others. It is estimated that in three years, the programme resulted in the production of 1 million additional poultry. The last years of the programme were devoted to training and retraining of VVV, publicity campaigns through slide shows in the villages,

debates in schools, pamphlet distribution, VVV meetings, farmers' visits to livestock centres and technical conferences of livestock agents. This large programme covered 15 provinces (out of 30 in the country), 4 378 villages (out of 7 500) and 5 646 125 beneficiaries. A major factor responsible for the success of the programme was political will and the commitment of the government to rural development in general and agriculture in particular (Sonaiya and Aklobessi, 1991; Sonaiya, 1992).

4.2 Small-scale Intensive Poultry Production Model

Most government employees in Nigeria live in the urban and peri-urban areas. Among the largest group of government employees in Nigeria are those in the service of the 774 local government areas (LGA) in the country, who are members of the National Union of Local Government Employees (NULGE). With an average of approximately 300 employees per LGA, NULGE has a membership of about 240 000 Nigerians. The average family size in Nigeria is 6, and hence intervention at this level will benefit about 1.4 million Nigerians.

The NULGE leadership in Osun State requested a programme designed to use poultry for income generation (i.e. poverty reduction). A subsidiary of the union, the NULGE Cooperative, financed the smallholdings of its members, while the Obafemi Awolowo University's Family Poultry Research Project (FPRP) (Sonaiya, 2005) provided consultancy and support services free of charge. Through the NULGE Cooperative, a loan was made available to individual members who had shown sufficient motivation and interest in smallholder poultry enterprise. The loan was given in kind and in cash and consisted of provision of cages, point-of-lay pullets and a take-off grant for the purchase of feed and veterinary drugs for 60 layers. In the first pilot phase, which started in November 2002, there were a total of 39 beneficiaries which included nine women. The second phase, which started in April 2003, had 72 beneficiaries. The third phase, which started in November, 2003, had 120 beneficiaries. It has since been running without recourse to the university.

In order to ensure quality of feed, cages and birds, FPRP identified a local poultry-inputs supplier, who was then contracted by the NULGE to supply cages, point-of-lay pullets and feed to the beneficiaries in the outreach. A training programme in poultry production was organized for the beneficiaries. The training covered general poultry and health management, handling and marketing of products, and sustainability issues. The training was held at the Teaching and Research Farm of Obafemi Awolowo University. The training included instruction in the farm classroom and practical training at the farm's Poultry Unit. A 16-page training manual/workbook was prepared for each of the beneficiaries.

After the training but prior to stocking of the beneficiaries' cages, a team of technicians visited the proposed sites to ensure their conformity to the standard recommended by the FPRP and to offer suggestions and recommendations to the beneficiaries. Point-of-lay birds that were supplied by the contractor achieved 30 percent hen-day production within the first month of lay. FPRP continues to receive feedback from the beneficiaries about the satisfactory performance of the birds and the economic benefits of the enterprise.

Periodical visits are made to all the beneficiaries to monitor the progress they have made and to address the challenges facing them. Refresher courses are mounted on request to address new challenges and provide pertinent information.

5 SFP STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS

An analysis of the two types of model and a few of their adaptations in various countries is presented below to demonstrate lessons learned, requirements for success and the limitations of the models and their adaptation.

5.1 The biosecurity threat

According the FAO classification, SFP, which straddles systems 3 and 4, has low to minimal biosecurity at the farm level. At the local, national and regional levels, the low biosecurity becomes a threat to SFP and non-SFP production in relation to all epidemic diseases such as ND and HPAI. Scavenging is a necessary condition for SFP in system 4 which makes the implementation of biosecurity virtually impossible. The current disposition towards the eradication of SFP is a great threat to the very existence of this production system. What is required includes incentives, compensation and producer education for prevention. This awareness is critical for the survival of the SFP producers themselves in the event of a HPAI pandemic (Rushton *et al*., 2005).

5.2 The scavengeable feed resource base (SFRB) carrying capacity.

The scavenging imperative which makes biosecurity near impossible also places a limit on the expansion of SFP production within a village or settlement. Whenever the carrying capacity of the SFRB is exceeded, morbidity and mortality ensue, particularly among the chicks and growers. The logical step is to provide supplements to supply the nutrient shortfall or to cull the excess birds (Roberts, 1992; Gunaratne *et al*., 1993). Research into the development of unconventional feedstuffs that are available in SFP localities is a step in the right direction (Idowu, 1992; Sonaiya, 1995).

5.3 Dual- or single-purpose production

SFP producers, particularly in system 4, raise mixed species of poultry some of which are better egg layers while others are raised mainly for meat. The lack of specialization is deliberate in many cases, but it also constitutes a constraint to the scale of SFP production. The threat of HPAI could be used to nudge SFP towards specialization in either egg or meat production especially as it relates to mixed species for the different purposes.

5.4 Genetic source of birds

Genetics has not been established as a factor in SFP production. Indigenous poultry races are well adapted to the SFP production systems and are the dominant genotypes all over the world. Whenever hybrids have been introduced either deliberately or accidentally, they have done well under system 3 conditions but not so well under system 4 (de Vries, 1995). Where indigenous races have been improved by selection and crossed with exotic races, there has been improved productivity if the management level has been similarly improved (e.g. Fayoumi in Egypt and Sonali in Bangladesh). Indigenous races have been selected for production under systems 3 and even 2, but all such efforts have not been able to remove the advantage of commercial hybrids (Nwosu, 1979).

5.5 Concerns about food safety

There are concerns about food safety related to salmonella and other bacteria on eggs produced under FAO poultry system 1 conditions. Such concerns become even graver in the case of products from systems 3 and 4. Fortunately, many tropical cuisines require meat and eggs to be very well cooked before eating. With access to more urban markets, SFP products could become a source of food infection to consumers more used to poultry products from systems 1 and 2 which are usually broiled. The danger of HPAI comes mostly from people eating undercooked meat from infected poultry (Rushton *et al*., 2005). Hence, with regard to food-safety concerns, the requirement for clear labelling is very important. While not all SFP products can qualify as organically grown, system 4 products are free range products and can be so labelled and treated by the consumer the same way as commercial free range products are treated.

5.6 Policies of governments and institutions

Driven by rural and urban consumer demands and donor preference, the policies of governments and institutions towards SFP are, with some notable exceptions, generally lukewarm. Some officials in some developing countries seem to be less interested in SFP and regard it as backward and archaic. A few conspiracy theories have been floated to the effect that SFP is being supported by western donors as a way to prevent competition for the system 1 products that are "dumped" on the local markets through unfair trade. Such thoughts arise when SFP is treated simply as having the sole aim of producing meat and eggs for the urban consumers, a job for which it is not well suited. It is the realization of SFP as a tool for poverty alleviation and social development in the rural areas that brings forth innovative and supportive policies for SFP by governments, as in Bangladesh and Burkina Faso, and by international development institutions such as FAO, IFAD, the Australian Centre for International Agricultural Research (ACIAR), AusAid and Danida.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Specific need to promote SFP

As long as there are villages, SFP will survive. If it is to be saddled with the additional responsibility of placing "the poorest of the poor" on the first rung of the ladder of development by giving them access to the market, then it must be given specific assistance through special programmes such as the Bangladesh poultry model. A lesson learned by all who have tried to replicate this model in other countries is that there is need for extensive adaptation to suit local conditions and realities. Chinombo *et al*. (2001) discuss the Malawi smallholder poultry production model which was a poverty reduction strategy but which failed at the adaptation stage. For example, Malawi has a much lower population density than Bangladesh and a less-developed NGO infrastructure.

To ensure success, there is need for basic, applied, action and participatory research all along the SFP value chain. The significant effect of Danida in Bangladesh and West Africa is a result of the implementation of specific programmes dedicated to SFP, which were coordinated by the Danish Network for Smallholder Poultry Development. A much fuller discussion of the imperatives for specific SFP programmes is available in the following workshop and conference proceedings: Dolberg and Petersen (editors) (1999) and Sonaiya (editor) (2000b).

6.2 Training, institutions and support services

Another lesson learned in virtually all the models is that training and advocacy are keys to sustainable SFP development. The need for training is widespread – from government officials through service suppliers including NGOs, to smallholders, intermediaries and consumers. More importantly, such training must be sustained in quantity and quality. To ensure this, it is necessary to employ information and communication technology to record, store and reproduce or remotely offer the training modules via, radio, television, CD, DVD, MP3 or the Internet. Development of such training tool kits can be most suited to international research and development institutions.

It has been fairly well established that most support services that are purely commercial (e.g. feed, vaccination, chicks, growers, sales) can be allocated to the private sector, while those with a high content of public good, such as development of genotypes, vaccines and housing prototypes, have to be provided by government, donors or international organizations. As pointed out above, close study of the Bangladesh model indicates that microcredit is vital to the success of the model. This microcredit is provided by the NGO that also provides training and other services. Without this credit support, most SFP producers will not adopt the innovations that are critical to the success of the SFP development programme.

Training and advocacy: an example

In August 2003, the FPRP was contracted by the FAO-supported Special Programme on Food Security in Nigeria (SPFS) to provide training in smallholder poultry production to farmers, extension agents and livestock policy-makers in the six geopolitical zones of Nigeria over a four-week period. A training manual was developed along with other illustrations, and all the training schedules were fulfilled. The trainees then trained others in their respective geopolitical zones.

The Cross River State government, one of the states in the south-south zone of Nigeria, sponsored the first national workshop on SFP in August 2004. The FPRP and the International Network for Family Poultry Development (INFPD) organized the workshop in collaboration with two NGOs – the Enterprise Nigeria Foundation, (ENF) and Poverty Reduction Initiatives Nigeria (PRIN) – and the organized private-sector organ, the Nigeria Economic Summit Group (NESG). The Danish Network for Smallholder Poultry Development sent its Director and three other resource persons to the workshop. Within the country, all relevant organizations, institutions and individuals were involved either as resource persons or delegates to the workshop. A national consensus was reached on some important SFP parameters, and modalities for implementation of SFP development programmes in a community-development scenario.

6.3 SFP development and pro-poor livestock production

Some countries (e.g. Brazil, Côte d'Ivoire and Thailand) seem to have little tolerance for SFP, although there may be site differences. In Brazil, the vast system 1 export-oriented poultry companies, though physically located in the suburban, peri-urban or even rural areas, are economically dislocated from their surroundings, as their products are hardly available in the local market. SFP not only supplies the poultry needs of the villages, but often that of the shanty towns around the big cities. In Côte d'Ivoire, consumer demand in Abidjan

for imported SFP guinea fowl provides a decent income for landlocked Ouagadougou in Burkina Faso. Thailand, as the fourth most important poultry meat exporter in the world, does not even present official figures for backyard poultry and the important fighting cock sector, yet it has the largest number of domestic birds per rural person. In 2004, of the five Southeast Asian countries, Thailand had the highest GDP per capita and urban GDP per capita and the lowest rural GDP as a percent of urban GDP per capita (Rushton *et al.*, 2005). In some countries, urban bias and rural aversion combine to obliterate any pro-poor livestock production support.

In most countries, the profile of poverty shows clearly that the development of SFP is the most directly pro-poor aspect of livestock production. Using SFP indices, such as very small flock size, a scavenging production system and low credit maximum, which is a much lower credit limit allowed to the poorest of the poor, helps to target accurately the poorest of the poor. It has been repeatedly demonstrated that all the four FAO poultry systems can co-exist within the same locality and remain viable – as, for example, in Bolivia (Rushton and Viscarra, 2005). In many countries, SFP products occupy a niche market into which poultry products from systems 1 and 2 cannot be admitted. Issues of taste, cultural value and medicinal purposes give SFP, especially system 4, products a price advantage because of the very low volume available to the market.

Promoting SFP to initiate rural development

The aim of development is to reduce poverty, i.e. improve income and nutrition, increase levels of education and health, empower the vulnerable, reduce their exposure to risk, and give a voice to the voiceless. To promote SFP is to optimize the productivity of systems 3 and 4 without converting to system 2. Such promotion on a long-term basis will improve family food security and nutrition, create income and employment opportunities within the SFP value chain, conserve indigenous genotypes of birds and the natural ecosystem, and promote social equality by empowering vulnerable widows, orphans and physically challenged or weakened people who are able to raise SFP.

The promotion of SFP first requires that the entire farming system of the SFP producers be fully understood so that various aspects of the system can be carefully modified. For example, vaccination against ND can increase chick survival rates from 30 to 70 percent; simple housing and other predator protection reduce mortality among chicks and growers; supplementary feeds help to extend the carrying capacity of the range and the SFRB; different poultry species optimize different ecosystems. Priority must be placed on the development of appropriate technologies, the provision of training, credit, inputs and market supply (Sonaiya and Swan, in FAO, 2004c).

FAO used its Technical Cooperation Programme to support many SFP development activities between 1979 and 1993. In 1994, FAO launched the Special Programme on Food Security (SPFS) and in 1997 identified SFP as a major activity of the SPFS diversification component. The target coverage of SPFS is for 100 countries within which South–South cooperation in the field of SFP is encouraged through the use of Technical Cooperation between Developing Countries (TCDC) experts. In addition, individual countries are also supported by FAO's Telefood programme, which provides up to US$10 000 per group for small-scale projects (Branckaert and Guèye, 1999; Branckaert *et al.*, in FAO, 2000).

What is now required is collaboration between the various international organizations such as FAO, IFAD, the United Nations Development Programme (UNDP), IFPRI, the International Livestock Research Institute (ILRI), INFPD and the World Poultry Science Association (WPSA) to develop a long-term programme of promotion for SFP. The collection of reliable SFP data is absolutely crucial and is a task that INFPD and WPSA members in different countries can accomplish with logistical support from donors and international organizations. Data analysis and interpretation can be carried out with the facilities of the international organizations. Closely matching the SFP data with the rural poverty profile, country-specific programmes can be developed and implemented with involvement of all the stakeholders, while monitoring and evaluation can be carried out by the international organizations and the INFPD.

6.4 Conclusion

SFP is produced by both rural and urban dwellers because it requires little in space and investment. The development of SFP is threatened by HPAI, rapid urbanization and food-safety concerns. Results of family poultry research, development and outreach efforts should be made available to all the relevant stakeholders – government, non-government, organized private sector and SFP producers – for objective evaluation and implementation as may be necessary for general social development.

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Scope and space for small-scale poultry production in developing countries

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SUMMARY

In recent years there has been growing recognition among the development community of the role of small-scale commercial poultry production in accelerating the pace of poverty reduction and reaching out to the poorest of the poor. There is also growing evidence to demonstrate the role of small-scale poultry in enhancing the food and nutrition security of the poorest households and in the promotion of gender equality. At the same time, the market and production context of poultry production has been changing rapidly over the last two decades. Rapid economic growth and urbanization in developing countries has resulted in fast expansion of industrial, large-scale, vertically integrated, poultry production, especially in Asia. Opportunities have also expanded for small-scale poultry enterprises, resulting from improved market access and infrastructure, and a preference structure that may still favour free-range birds and eggs. As a result, there has been increased market orientation even among small-scale poultry enterprises. These changes have brought large and small production systems into overlapping competitive space, which has created both challenges and opportunities.

These changes have raised concerns about the sustainability of small-scale poultry production systems due to: (i) intensified competition from large-scale producers who can exercise significant control over the poultry value chain (including concentrated holding of genetic stock of industrial poultry by a few transnational corporations); and (ii) the public perception that small units of production may be dangerous reservoirs of diseases, specially in the wake of recent outbreaks of highly pathogenic avian influenza (HPAI). Against this background, this paper attempts to summarize the nature of small-scale poultry production, and brings together evidence regarding the viability of small-scale poultry production in the context of the expansion of large-scale production characterized by substantial economies of scale, well-organized and integrated supply chains and the ability to respond to various types of risk.

The paper argues that the main challenge for small-scale/rural poultry is organizational, not technical. Based on a review of available evidence, the paper concludes that it is important to continue to promote village poultry as a means to promote household nutrition security and livelihood support, but that concerted efforts must be made to find organizational solutions to minimize public-health risks and provide appropriate extension support on issues such as disease prevention, predation and improving hatchability. Unfor-

tunately, most government extension programmes in developing countries are not oriented towards addressing the needs of poor households. Some private-sector organizations (such as Keggfarms in India) have invested significantly in the development of fast-growing and more productive birds that do not require significant additional inputs, and have also made sufficient investment in developing the distribution network for the birds. However, extension and public health support systems remain a weak point, resulting in vulnerability to exogenous shocks. A well-orchestrated public policy response in support of small-scale poultry production is, therefore, required.

Key words: small, poultry, organizational, private, public

1 INTRODUCTION

Small-scale poultry production systems – in the form of small, semi- or fully scavenging, household flocks, or slightly larger more intensive units – have developed in a large number of developing countries around the world as a source of livelihood support for the rural poor. In recent years there has been growing recognition among the development community of the role of small-scale commercial poultry production in accelerating the pace of poverty reduction and reaching out to the poorest of the poor. There is also growing evidence to demonstrate the role of small-scale poultry production in enhancing the food and nutrition security of the poorest households and in the promotion of gender equality (Dolberg, in NDDP/FAO 2004a; NDDP/FAO, 2004b) (see also the Web site of the International Network for Family Poultry Development (INFPD) http://www.fao.org./ag/AGAInfo/subjects/en/infpd/).

The market and production context of poultry production has been changing rapidly over the last two decades. Rapid economic growth and urbanization in developing countries has resulted in fast expansion of industrial, large-scale, vertically integrated, poultry production, especially in Asia. Opportunities have also expanded for small-scale poultry enterprises due to improved market access and infrastructure, and a preference structure that may still favour free range birds and eggs (Conroy *et al.*, 2005). As a result, there has been increased market orientation even among small-scale poultry enterprises. These changes have brought large and small production systems into overlapping competitive space which has created both challenges and opportunities.

These changes have raised concerns about the sustainability of small-scale poultry production systems due to: (i) intensified competition from large-scale producers who can exercise significant control over the poultry value chain (including concentrated holding of genetic stock of industrial poultry by a few transnational corporations); and (ii) the public perception that small production units may be dangerous reservoirs of diseases, especially in the wake of recent outbreaks of highly pathogenic avian influenza (HPAI). Governments are already beginning to emphasize the possible public-health risks associated with small-scale (especially household) poultry and are discounting their contribution to income and nutrition support in poor households. A number of informed observers and researchers have, however, argued that our understanding of the epidemiological role of the different sectors is poor, and that, therefore, the emphasis on small-scale production as a source of risk may be exaggerated or misplaced (Branckaert, 2006; Rushton *et al.*, in FAO, 2005; Otte, in FAO, 2006a; Otte, *et al.*, in FAO, 2007). Such developments can have serious impli-

cations for poor peoples' livelihoods, as governments, in their search for politically feasible solutions, chose easier ways out.

This paper attempts to summarize the nature of small-scale poultry production, and brings together evidence regarding the viability of this type of poultry production in the context of expanding large-scale production characterized by substantial economies of scale, well-organized and integrated supply chains, and the ability to respond to various types of risk.

The paper is structured as follows. The first section presents a broad characterization of the stakeholders in small-scale commercial poultry production, including a brief analysis of the importance of this type of poultry production in different countries. The second section presents a few models of household poultry production that may be considered to represent good practice for small-scale commercial poultry production. The third section discusses emerging challenges for small-scale poultry producers and the policy response required; it ends with some concluding remarks.

It is important to point out that the paper is based primarily on documented literature that is in public domain. Although there is a moderate amount of literature now available on small-scale poultry production, there is unfortunately a real dearth of rigorous field-based evidence on aspects of ongoing structural change in global and regional poultry production. Without making the claim of being comprehensive, it is hoped that this paper can raise some pertinent questions and further the debate on the viability of small-scale poultry production systems.

2 CHARACTERIZATION OF SMALL-SCALE POULTRY PRODUCTION SYSTEMS

We begin with a broad overview of small-scale production systems. The Food and Agriculture Organization of the United Nations (FAO) has classified poultry production systems in four categories (sectors) based on the level of integration of operations, the marketing system and the level of biosecurity.[1] The scope of the discussion in this paper is limited mostly to Sector 4, with occasional references to Sector 3.

In a large number of low-income countries, backyard/household production (Sector 4) is the largest system of poultry production and a critical source of income and nutrition for poor households. In Ghana, for example, rural poultry accounts for 60–80 percent of the national poultry population (Aning, in FAO, 2006b). Kushi *et al.* (1998) reported that in northeastern Nigeria more than 70 percent of rural households kept chickens.[2] Information from Bangladesh and Nigeria, where detailed disaggregated data on the structure of poultry population is available, indicates that Sector 4-type production accounts for more than 90 percent of the poultry population. Even in countries with a relatively large modern industrial poultry production sector – India for example – free ranging chickens running around in the backyards of rural households are a common sight especially in areas with

[1] Sector 1 refers to the large-scale integrated commercial systems with high commercial orientation and high biosecurity. Sector 4, at the other extreme, refers to village-level production systems with households raising few birds for their own consumption or for local markets, and minimal levels of biosecurity. Sectors 2 and 3 fall in between these two extremes depending on the level of market linkage and the level of biosecurity.

[2] Cited in Sonaiya (2007).

high incidence of poverty, and account for a very large proportion of the national poultry population. Similarly, in Viet Nam, approximately half the households keep chickens in the backyard, with an average flock size of about 16 birds (Otte, in FAO, 2006a). Guèye (1998) and Rushton *et al.* (in FAO, 2005) provide approximate figures for the proportional contribution of birds kept under small-scale family production systems to the total poultry population in selected African and East Asian countries. The figures are presented in Table 1.

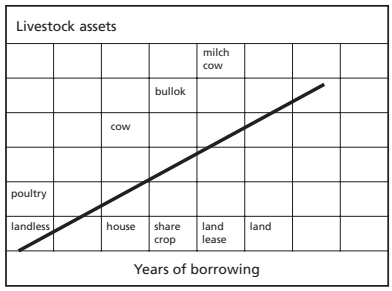
The majority of producers in Sector 4 comprise poor households with almost zero asset base, and highly vulnerable and insecure livelihoods. In India, for example, household poultry has found special favour with the poor (landless, marginal and small farmers) and among tribals, scheduled castes and other backward caste communities (Shinde and Srivastava, 2006; Mandal *et al.*, 2006). These households have traditionally relied on small-scale, low-cost, poultry production systems to supplement and enhance their livelihoods and to begin the process of asset accumulation to climb the poverty ladder. Todd (1999) inves-

TABLE 1
Proportion of national poultry flock accounted by family poultry production

Country	Percentage of national poultry population in family poultry production
Cameroon	70
Central African Republic	80
Côte d'Ivoire	73
Ethiopia	99
Gambia	90
Kenya	70
Malawi	90
Mali	90
Nigeria	93
Senegal	70
Sudan	75
Togo	70
Uganda	80
United Republic of Tanzania	70
Zimbabwe	25–30
Cambodia	90
Indonesia	64
Lao People's Democratic Republic	90
Thailand	10*
Viet Nam	70

*In the early 1990s, almost 99 percent of chickens in Thailand were in the backyard production system (Kehran, 1999)
Sources: Guèye (1998); Rushton *et al.* (in FAO, 2005).

FIGURE 1
Sequence of investments



Source: Adapted from Todd (1999).

tigated the relationship between years of borrowing and the type of livestock assets the households invested in, and found that households in early phases of borrowing, especially landless households with an extremely poor asset base, invested in poultry before moving on to other livestock enterprises (Figure 1). Thus, the households used poultry enterprise as an entry point to take the first step towards capital accumulation and poverty alleviation.

In general in this system, the poultry are kept under low-input, low-output conditions and managed by the women and children of the household (Shinde and Srivastava, 2006; Sethi, 2007). Typically, flock size ranges between five and fifty birds, with the birds being raised under a traditional extensive scavenging system without special inputs in terms of feeding, housing or labour. Mainly non-descript birds are reared, although in some specific areas, local breeds and cross-breeds derived from them are reared. There is little or no linkage with input and output supply chains, and the chicks are usually obtained by hatching home-produced eggs for home consumption or for limited trade within the village. The production performance of these birds is relatively poor, with 40–60 eggs and about 1–1.5 kg meat at the end of the production cycle. The birds are generally free ranging, with few or no inputs being provided. Housing in these systems is rudimentary and mostly built with locally available materials such as wood, mud bricks, sugarcane stems, bamboo and cereal stovers.

Biosecurity measures are more or less absent; although some observers believe that the natural genetic diversity found in this system provides adequate resistance to diseases and the ability to withstand disease outbreaks – unlike intensive systems. Others, however, argue that the absence of biosecurity and disease-prevention measures poses a real threat to public health and livestock production in developing countries, and emphasize the need for a more stringent and formal regulatory and production systems. Losses caused by predators and diseases are high in this system. Global estimates of such losses are not available, but Sonaiya (1990) put forward an estimate of approximately 825 million for the number of chicks, guinea keats and ducklings dying each year in Africa as a result of diseases and predation.

Survival and growth in the extensive scavenging system is affected by competition for

feed resources in the villages (household waste, material gathered from the environment, crop residues and fodder materials, by-products from local industries, etc). Thus, the scavenging system works well where there is abundance of biomass. However, in areas where there is scarcity of natural resources, poor rainfall, and high livestock density, competition with other species for natural resources/surplus material can be severe, making it difficult for poultry to grow and survive (both due to stunting and poor ability to escape predators). Roberts (1995) argues that starvation associated with dwindling biomass availability in villages is an important factor contributing to poor growth and survival in village poultry. Under these circumstances, simple interventions, such as supplementing feed using creep feeders, can significantly enhance the survival and growth of chickens. Similar arguments and results are presented by Sarkar and Bell (2006). Other reasons for low productivity include management system (leading to overburdening of chickens with a variety of tasks, such as brooding and rearing chicks, leaving little time for productive purposes) and variability in the quantity and quality of feed (Sonaiya, 1995; Goromela *et al.*, 2006).

Estimates of the contribution of family poultry to overall household income vary widely. Rauen et al. (1990) reported that in the Dominican Republic, family poultry contributed approximately 13 percent of household income. Setioko (1997), on the other hand, estimated family poultry's contribution to exceed 50 percent of total household income in the transmigrant farming system in East Kalimantan, Indonesia. A survey undertaken by Riise et al. (2005a) estimated monthly income level from poultry among households to be around 200–250 taka in Bangladesh. These authors further note that this average nominal figure has been constant for almost a decade, indicating that real income from poultry has fallen over time. They observe that with a relatively low profit margin and a downward propensity, smallholder poultry farming is mainly attractive to people with low opportunity costs, i.e. those who have limited opportunities for alternative income streams.

Irrespective of the direct contribution to household income, small-scale poultry is often recognized as an important contributor to overall livelihood security. A recent study of household poultry systems in India assessed main reasons for keeping poultry by rural households. The sample comprised three categories of households: small and marginal farmers keeping poultry within the home compound; small and marginal farmers, keeping poultry in a nucleated settlement; and landless people keeping poultry in and around the house. In Tamil Nadu, a state in southern India, generation of planned and regular income was identified as the main reason for poultry keeping, whereas in Rajasthan in northwestern India, poultry were almost wholly kept for household consumption[3] (Conroy *et al.*, 2005). Studies from other parts of the world have also reported similar results. For example, Aning (in FAO, 2006b) reports income supplementation and augmentation of domestic meat supply to be the primary reasons for keeping poultry in backyards in Ghana. A number of children from poor African households have reported that payment of their school fees is dependent on the income derived from their poultry micro-enterprises. Similarly, rigorous field studies of the impact of household poultry production in Bangladesh have found significant increases in consumption of several food items (not just meat and eggs) among the beneficiaries. Nielsen (1998) found that the control group had lower

[3] This is, at least in part, reflected in the larger aggregate market in southern India that results from a larger proportion of non-vegetarians in the population and relatively higher incomes.

initial consumption levels and significantly lower consumption increases during the project period. Further, Nielsen *et al.* (2003) found that starvation during the lean season declined by almost 75 percent in the case of poultry-rearing households. Similar results have been reported by a number of other authors.

Small-scale commercial poultry production farms, falling under Sector 3, are generally characterized by medium-sized flocks (ranging from 50 to 500 birds) of local breeds or cross-bred stock. Farmers usually provide housing structures made of local materials, purchase part of their feed, use vaccines and veterinary services whenever available, and may even have minimal biosecurity systems in place. Such systems are more prevalent in urban and peri-urban areas; output is usually sold to nearby urban centres, with varying degrees of organization in the marketing system. While some poultry growers have relatively formal marketing contracts, others usually rely on verbal contracts. Such contracts are restricted to sale–purchase agreements and have no effect on the choice of technology, input supplies or any other service support. These systems usually serve as the transition phase between Sector 4 and large-scale commercial systems characterized by large vertically integrated production and processing units and more formal contracts with farmers growing between 1 000 and 20 000 chicks.

Both Sectors 3 and 4 have a special place in the economy of developing countries, as they contribute towards poverty alleviation by drawing under-utilized labour resources into production. While most studies acknowledge the direct impact on income generation and nutrition security, it is the impact of the subsequent multiplier effect – with farmers spending their increased income on the goods produced in the non-tradable, non-agricultural sector – that contribute even more to poverty reduction (Mellor, in NDDP/FAO, 2004c)[4]. However, these units do face significantly higher transaction costs, and as such require policy support in terms of physical infrastructure and technology transfer through extension.

3 COMMERCIAL VIABILITY, SUPPLY CHAIN AND COMPETITION WITH LARGE OPERATORS

A large proportion of household poultry production (Sector 4) is still subsistence oriented and thrives on the absence of alternative supply sources for animal protein and a lack of alternative livelihood opportunities. Traditional backyard poultry systems with low input and low output are usually characterized by a rudimentary supply chain of input suppliers and traders. A large proportion of farmers allow the hens to hatch most of the eggs produced; surplus (mostly male) birds are consumed within the household, and there is very little market linkage. Given very low productivity and low levels of marketed surplus, supply chains are difficult to build and sustain. Semi-commercial systems, on the other hand, do have market linkages on both the input and output sides, but the chains remain informal and coordination of various activities in the chain is largely based on personal contacts.

[4] Mellor (in NDDP/FAO, 2004c) notes that the rural non-farm sector, which includes about half the rural population, produces goods that for quality and transaction-cost reasons cannot be sold in international markets. Thus, the expansion of the rural non-farm sector critically depends on growth in local demand. Growth in local demand comes from growth in the farm sector (including livestock). Given that demand for the goods and services produced by the rural non-farm sector is highly income elastic, growth in the farm sector creates a multiplier effect which contributes significantly towards poverty reduction – not just that of farm households, but also that of other households on whose services these households depend.

Studies that have examined financial aspects of household poultry production generally report a favourable cost–benefit ratio. For example, Parthsarthy (1996) studied units of 100 layers in central India and reported a net profit of Rs 10 per 100 eggs. Another study (Johri *et al.,* 2002), conducted in 18 villages in northern India where crosses of exotic with indigenous breed were distributed and chickens reared as scavenging-type backyard units, reported a benefit–cost ratio of 3:1. Several studies of small poultry units conducted by banks in India have indicated a profit of Rs 0.80 to Rs 1.00 per layer per month and Rs 1to Rs 2 per broiler depending upon the market demand and the efforts made by the farmers to find a market for direct sale of their produce. "Back of the envelope" calculations from Viet Nam suggest an annual rate of return to capital of more than 700 percent (Otte, in FAO, 2006a).

Most such studies have, however, examined backyard poultry production in isolation from the larger changes in global and national poultry production. While it is useful to study the structure of costs and benefits arising from small-scale poultry production, the question remains whether these systems can remain viable at a commercial scale in the wake of the expansion of large-scale poultry production.

In the absence of sustained commercial viability, small-scale poultry production will not provide a viable mechanism for asset accumulation and poverty alleviation. We did not find any study addressing the question of the commercial viability of small and large-scale production in overlapping competitive space. Most practitioners, however, continue to maintain that village/backyard poultry is commercially viable due to significant savings on feed costs and distinct preferences for meat and eggs from local birds, resulting in significant price mark-ups over and above broilers and industrial eggs. In some cases, the price mark-up has been reported to be as high as 100 percent. Observers and practitioners also maintain that markets for the product of household and commercial systems are highly segregated and that it is unreasonable to expect that the two will come into overlapping competitive space in the foreseeable future.

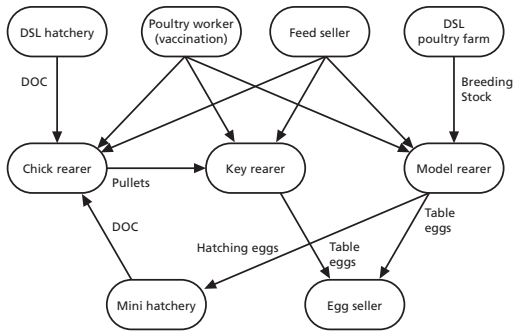
According to this view, markets for village poultry are limited to neighbourhood consumers and to rural and small urban market clusters, whereas commercial poultry is mostly focused on medium- to large-scale urban markets with sufficient scale and growth opportunities; this segregation is expected to continue to provide the necessary space for small-scale poultry to coexist with large-scale operators. While the argument may hold in some countries, there are also examples of situations in which large units have displaced small-scale production. In Thailand, for example, the share of small-scale production has gone from over 95 percent a couple of decades ago to less than 10 percent now. Indeed, even the native chickens are no longer limited to backyard production by rural households and are beginning to be produced on a large commercial scale. Export of native chickens is also being contemplated by commercial native chicken producers (Change, 2004). Thus, some native products that have been immune from foreign and large-scale competition may no longer remain so in future. Modern technology, improving physical infrastructure and aggressive marketing strategies have the potential to penetrate any market as long as there is sufficient demand and profits to be made. It appears that smallholder poultry can survive only as long as markets remain segmented.

The question of "overlapping" versus "segmented" markets for small and large produc-

ers is an interesting one, as it will define the role of public policy in protecting, promoting and expanding the market space for small producers. In areas with high poverty incidence, poor market linkages and where markets for small and large producers are highly segmented, developing market linkages can pay rich dividends in terms of enhancing poor peoples' livelihoods. But, this can also result in new competitive pressures leading to exclusion of smallholders from emerging and existing markets if they are not adequately equipped to meet the complex and dynamic demands of emerging markets. In regions where market linkages are already fairly well developed, the public policy challenge is to promote institutional innovations that can integrate small producers into the value chain (by helping them to meet food-quality and safety standards) without imposing disproportionate transactions costs. A number of such models – farmer cooperatives, producer companies, self-help groups, contract farming – have been successfully tried across the globe and have delivered good results in terms of integrating small producers into the value chain. In addition, this will also require market reform policies that encourage smallholder investment and discourage differential subsidies to large-scale operations, and provision of public goods such as research, extension and infrastructure.

The debate about "large" versus "small" notwithstanding, a number of development projects and private agencies have recognized the potential offered by small-scale poultry, either as a means of breaking the vicious cycle of poverty or as a business opportunity offered by the bottom of the poverty pyramid. Most these experiences have involved attempts to provide the institutional architecture and technological support needed to enhance productivity and to provide the necessary market linkage and service support. While there is some variation in the models across projects and organizations, most of these initiatives are geared towards ensuring a steady supply of chicks, feed and credit, as well as providing forward linkages with the market. These experiences offer important lessons for adapting/promoting institutional innovations in other parts of the world. In this paper we discuss two such initiatives from South Asia – the DANIDA, International Fund for Agricul-

FIGURE 2
Elements of the Bangladesh poultry model



Note: DOC = day-old chicks.
Source: Dolberg in NDDP/FAO (2004a).

tural Development (IFAD) and Asian Development Bank (ADB)-supported household poultry model in Bangladesh, and the Keggfarms-supported Kuroiler model in India.

4 THE BANGLADESH POULTRY MODEL: A QUICK OVERVIEW

The Bangladesh poultry model – perhaps the most widely known chicken-based development experience – evolved out of a food aid project supported by the World Food Programme and the Department of Livestock Services (DLS). BRAC (Bangladesh Rural Advancement Committee) joined the initiative partly to provide credit support; they included the poultry model in their Rural Development Programme during the years 1983 to 1986. Three smallholder livestock development projects, SLDP1, PLDP and SLDP-2, were all designed based on this model.

The model has adapted and evolved, internalizing the lessons learned from within and from similar initiatives elsewhere. In principle, the model combines packages of technical training, credit and market linkages; it emphasizes promotion of backyard poultry to target the poorest female-headed households. The model also emphasized promotion of individual entrepreneurs such as feed sellers, and egg collectors. The approach was to identify target-group households with less than half an acre (approximately 0.2 ha) of land, organize village groups, provide them with training, credit and a supply of inputs, and undertake necessary supervision and monitoring. The model consisted of an integrated system of production, marketing, input-supply and service-support subsystems. Each component of the system engaged poor households and provided necessary organizational support. Most of the activities were carried out by the women themselves. The key players in the system included: (i) poultry extension workers – who provided vaccination, some basic treatment, and advice on poultry management; (ii) poultry rearers – the target group for the project, who reared layers and broilers in their backyards; (iii) chick rearing units – which reared day old chicks to six weeks; (iv) feed sellers – who provided supplementary feed; and (v) egg collectors who provided the link with market.

The model has been documented extensively in the literature. Therefore, this paper avoids repeating specific details. Essential elements of the model are illustrated in Figure 2 and Box 1. Evaluation studies of household poultry projects in Bangladesh and other countries have demonstrated that the approach has a pro-poor bias, has a significant impact on the economic and nutritional status of the poor – especially women and girls, and has a favourable benefit–cost ratio. For example, Haque (1996) reported a benefit–cost ratio of 3.1:1 at the level of the household, and close to 4:1 for the key rearer (Table 2). Encouraged by these results, new pilots based on the model have been tested in a number of countries including Benin, Burkina Faso, Eritrea, Kenya, Malawi, Senegal, South Africa, the United Republic of Tanzania, Viet Nam and Zimbabwe. Studies from various parts of the world have also shown that household poultry production has a much greater outreach to the poorest households and can therefore be an effective targeting tool.

Critics have raised questions about the sustainability of the Bangladesh model after withdrawal of donor support (see for example, Riise *et al.*, 2005a). Still, it remains beyond doubt that the experience has demonstrated the potential offered by smallholder poultry to enhance the livelihood security of the poor. Suffice it to say that the sustainability of the model is an area of genuine concern, which in turn depends on the economic environment and support systems.

BOX 1
Beneficiaries in the Bangladesh poultry model supply chain

Model Breeder – Small low-cost parent farms with a breeding stock of about 50 Fayoumi hens and the requisite number of RIR cocks received either from the project site or directly from government poultry farms. These were raised under a semi-scavenging system with balanced rations for producing high-quality fertile eggs for hatching. These eggs were to be sold to mini hatcheries and to key rearers who would hatch them under local broody hens.

Mini Hatchery – Small low-cost hatcheries operated with solar energy and kerosene stove. Each hatchery had a capacity to hatch 1 000 chicks per month. The day-old chicks were sold to the chick rearers and key rearers.

Chick Rearer – Small rearing farms with a capacity of 200–300 chickens per batch and four batches per year. The chickens were reared in low-cost houses from one day old to eight weeks of age. These chickens were fed with balanced feed and sold to key rearers at about eight weeks of age.

Key Rearers – Small farms with about five cross-bred layers for the production of table eggs. The hens were kept under semi-scavenging conditions with 30–70 percent supplementary feed. Additionally, four local hens were kept to hatch eggs, preferably from model breeders, and rear chicks from mini hatcheries.

Poultry Workers – A number of poultry workers were trained to vaccinate the birds to control diseases. The vaccine was supplied free by the DLS through the Area Office of BRAC, and the poultry workers charged a vaccination fee for providing the service.

Feed Seller – The feed sellers were trained to mix feed or sell pre-mixed feed as supplementary feed for the poultry.

TABLE 2
Benefit–cost ratios for various players in the Bangladesh poultry model

Activity	Benefit–cost ratio	Percent poverty alleviation*
Chick rearer	1.29:1	31.67
Key rearer	3.86:1	28.59
Model rearer	1.52:1	32.50
Mini hatchery	1.60:1	00.00
Feed seller	1.06:1	25.00

* Percent households below the poverty line without the model (control) — percent households below the poverty line in model area.
Source: Haque *et al.* (1996).

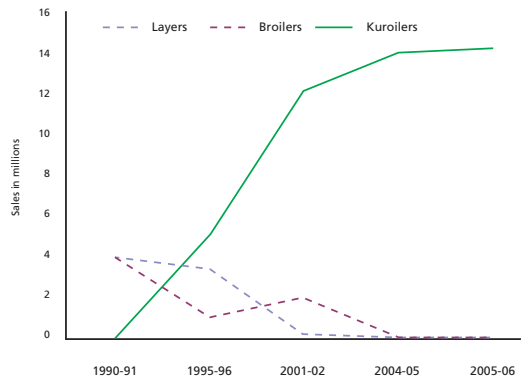
5 THE KUROILER: A BIRD OF HOPE?

Faced with increasing competition from large-scale integrated transnational poultry production units, Keggfarms – a small-scale company on the outskirts of New Delhi – decided to venture into the rural market and exploit the potential offered by backyard poultry, for its own survival. After an intense study of poultry-husbandry practices in rural India, the company decided to breed a dual-purpose bird which would be as hardy as a local village bird, but would nonetheless produce many more eggs and grow significantly faster. In addition, it had to retain the feather colours for camouflage, be sufficiently agile to run away from predators, and be as disease resistant as the local birds.

Keggfarms launched the "Kuroiler" = "Kegg + Broiler" in 1993 and sold more than a million day-old chicks in the first year.[5] By 2005–2006, the number had already reached the 14 million – a phenomenal annual growth rate of almost 22 percent sustained for more than a decade. The bird completely transformed the company in terms of geographical presence, clientele, distribution channel and so on. It shifted its operations from agriculturally prosperous areas to areas with a high incidence of poverty and vulnerable livelihoods. The company which had been in the commercial broiler business for more than three decades, completely phased out broilers and layers by 2005/2006 (Figure 3). Most important of all, however, the Kuroiler emerged as the "bird of hope" for hundreds of thousands of extremely poor families with little or no other support for sustaining their livelihoods.

Estimates of how far the Kuroiler has travelled are imprecise at best. Recent reports (DVAHEE, 2006) suggest that the Kuroiler has already touched the lives of about a million households in some of India's poorest regions. Kegg supplies its day-old chicks to 1 500 mother units across the states where it operates – directly or through its appointed deal-

FIGURE 3
Sale of day old chicks by Keggfarms: 1990/1991 to 2005/2006

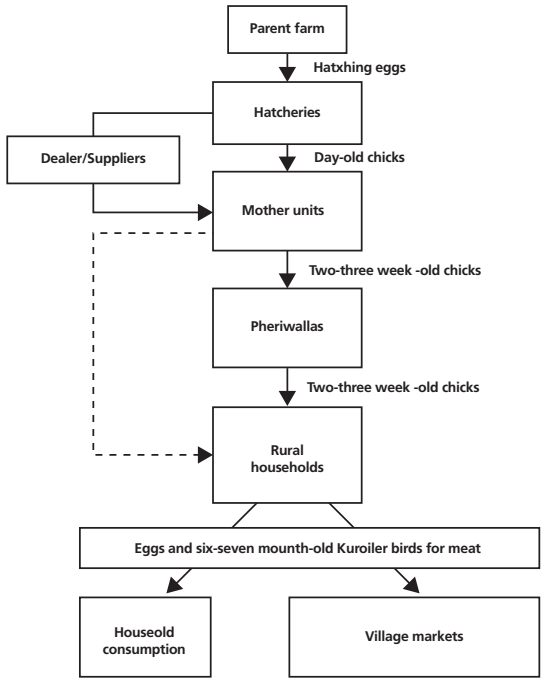


[5] The "K" in the Kuroiler also derives from "curry", the generic term for spice mix and the style of Indian cooking. Due to the hardy character of Kuroiler meat, it takes a little longer to cook, allowing the "curry" to permeate deep inside the meat, giving it a distinct taste and aroma specially suited to the Indian palette.

ers/suppliers. The mother units are operated by local entrepreneurs who keep anywhere between 300 and 2 000 birds at one time. They rear the day-old chicks up to about three weeks of age, vaccinate them if necessary, and then sell them to vendors (pheriwallas). Pheriwallas then travel to villages and sell the chicks to households at the price of about Rs 20 (US$0.5) per chick. Typically, the mother unit entrepreneur and the pheriwallas make a profit of approximately Rs 3 per bird. Finally, the rural households make Rs 250–300 (US$6.5–7.5) per month as supplementary income.[6] They trade in the eggs and also sell the birds for meat (see Figure 4 for a schematic representation of Kegg's distribution channel).

As Kuroiler day-old chicks are raised to two to four weeks of age at the mother units before being sent to village households, the husbandry, nutritional and health practices observed at mother units play an important role in the efficiency of these units and the performance of chicks down the chain. Thus, operators of mother units need training in basic brooding, husbandry and health practices. Keggfarms provides this training, either through its field staff – most of whom have prior husbandry exposure – or through structured courses in mother-unit management. When needed, Keggfarms sends experienced hus-

FIGURE 4
Kuroiler distribution channel



[6] Measured in purchasing power parity dollars, monthly income from Kuroiler raising will be approximately 32–35 dollars.

bandry personnel from its units to advise field staff on any problems that may have arisen. Additionally, field staff also provide commercial guidance to mother units, when required, with regard to sourcing/quality of feed, medicine, vaccines, market knowledge, etc.

Because of the fragmented and remote nature of beneficiary households, Keggfarms is unable to maintain any active contact or out-reach to the village households that rear poultry from three weeks onwards. This represents a critical gap, and provides an important avenue for public–private partnership related to the public-health and poverty-reduction implications of household poultry. Although this remains a critical gap, the fact that Kuroilers are performing efficiently in village conditions is now well demonstrated by the ongoing and increasing demand for them. As a policy, Keggfarms does not supply day-old chicks to villages, as this would result in huge "infant" mortality. When birds are sent at two to four weeks of age, the liveability improves dramatically.

Sustainability of the Kuroiler model derives from the interdependence of livelihoods at all levels – like the Bangladesh model in the ideal case. Sustainability of pheriwallas depends on sustainability at household level. Sustainability of mother units depends on pheriwallas; finally the sustainability of Keggfarms depends on that of all those in the chain. Unlike externally supported rural poultry projects, everyone in the Kuroiler chain is independent, and yet their livelihoods are dependent on each other. This characteristic of the Keggfarms model prompted the jury of "Business India Innovation Awards" to note that "[The business is] sustainable because it has created rural entrepreneurs. A great deal of scalability happens when such entrepreneurship is created."[7]

With regard to the threat of competition from larger players and other risks posed by public health and biosecurity considerations, the company believes that given the very different nature and characteristics of large-scale commercial and small-scale household production systems, the two systems are likely to continue to operate in segmented markets. Further, it is argued that the public-health risks posed by large-scale commercial systems are far greater than household-based village poultry production due to inherent resistance to diseases, biodiversity provided by the mixed gene pool in local birds, and the scattered nature of production; this minimizes, if not eliminates, the risk of large-scale outbreaks. Effective control measures taken by the Government of India in rapidly containing the recent outbreaks (instead of blaming backyard poultry production) demonstrate that well-orchestrated public–private partnership in disease prevention and control can contribute substantially towards minimizing public health risks emanating from small-scale scattered poultry production (see also Otte *et al.*, in FAO, 2006c and FAO, 2007).

No systematic study has yet analysed the economic and livelihoods impact of the Kuroiler[8]. However, crude "back of the envelope" calculations suggest that a household unit with approximately 20 birds can get additional cash income of Rs 500 per month. For an agricultural labourer earning anywhere between Rs 1 000 to Rs 1 500 per month, this additional cash income is an immense support. Similarly, the pheriwalla, with an initial

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[7] Kegg Farms was recently conferred an "Innovation for India" award in Social (Business) category (http://www.businessworld.in/content/view/729/784/).

[8] A detailed household survey of households, mother units, pheriwallas, and selected dealers and suppliers was underway

capital outlay of a bicycle and a basket to hold the chicks, and a working capital of about Rs 2 000 to purchase the chicks, could generate a net profit of about Rs 6 000 per month – more than twice that of a family living below the poverty line.

6 FUTURE CHALLENGES FOR SMALLHOLDER POULTRY AND THE POLICY RESPONSE

Most backyard poultry production systems have little in the way of linkages with formal value chains. But with retailing undergoing rapid transformation in a large number of developing countries, especially in Asia, there is potential and opportunity for linking these small backyard producers to larger markets via more formal value chains. However, that would also bring small producers and industrial poultry into more overlapping competitive space, raising questions about cost competitiveness and sustainability. This would also perhaps raise costs of complying and competing in the increasingly safety- and quality-conscious market. In such a context, as noted above, the big policy question pertains to the integration of small-scale commercial poultry production systems into expanding value chains and the required policy interventions – such as promotion of farmer organizations (cooperatives, producer companies, contract growers, etc) – to increase opportunities for small producers and to minimize pains during transition to large-scale poultry production. Recent studies have shown encouraging results with regard to private companies developing newer models to integrate small producers into the value chain instead of displacing them.

The main challenge for small-scale/rural poultry is, therefore, organizational not technical. It is important to continue to promote village poultry to contribute to household nutrition security and livelihood support, but concerted efforts must be made to find organizational solutions to minimize public-health risks and provide appropriate extension support on issues like disease prevention, predation and improving hatchability. Unfortunately, most government extension programmes in developing countries are not oriented towards addressing the needs of poor households. Further, although there are a large number of NGOs that are much closer to the people, development of household poultry enterprise does not appear to be on the agenda of many of these organizations. Similarly, some private-sector organizations (such as Keggfarms in India) have invested significantly in the development of fast-growing and more productive birds that do not require significant additional inputs, and have also made sufficient investment in developing the distribution network for birds. However, extension and public health support systems continue to be a weak point, increasing vulnerability to exogenous shocks.

In this context, significant investment in capacity-building and empowerment of village communities can promote change and technology adoption, and establish the foundation for village-based, farmer-to-farmer, livestock extension mechanisms. Many minor services like vaccination of day-old chicks and timely protection against poultry diseases are inaccessible to the poorest groups (especially in marginal areas); several rounds of vaccinations during the year are possible only if the relevant skills are available among farmers themselves. It would therefore be essential to impart skill training to farmers to promote self-help and

[9] At the time of writing this paper.

self-reliance for individual and community benefit. Thus, the real challenge appears to be to develop functioning partnerships between community-based animal health workers, NGOs, private-sector enterprises and government animal health support systems.

The bigger question, of course, is how does one promote small-scale poultry, and what sort of policy and organizational support may be necessary to nurture these enterprises? In areas where there is already a good tradition of backyard poultry, the requirement may be to systematically identify constraints and facilitate provision of support services. This, in turn, requires study of the entire production system, market chain, profitability and suitability of resources. It is also important to focus research on the aspects of the market and institutional environment that are changing, and on how these changes are likely to affect the poor. Once some understanding is established in this respect, it will be necessary to initiate a dialogue with influential agencies to put in place the required support mechanisms while ensuring that the process is interactive and inclusive. It is important that small-scale poultry is seen as an integral item in the menu of livelihood options, both by practitioners and policy-makers.

Where there is no tradition of household poultry, it is perhaps better to start in areas where there is already some awareness of the activity. Organizational support for organizations that have local credibility and are already engaged in livelihood-support activities will also be critical. Once again, additional efforts may be required to introduce smallholder poultry as an additional option for livelihood support. What needs to be understood in this case, however, is that poultry may not be the only entry point for poverty alleviation. There are certainly other entry points available; it is important to establish a menu of entry points, and identify those that are most appropriate for the specific circumstances.

Role of the government and other stakeholders: There is poor awareness among governments of the potential of smallholder poultry in supporting poor peoples' livelihoods. That is one reason why government support for promotion of this activity is often poor. It is, therefore, necessary to raise awareness about this option while ensuring that the government does not overwhelm and crowd out others. In this context it is also necessary to identify organizations that have already established some trust and credibility with local communities, and use these organizations as a catalyst for promoting action. At the same time, it is necessary to nurture powerful alliances, including academia, which can discuss smallholder poultry activities and can influence the opinion of government and the political establishment. International agencies such as FAO, and the United Kingdom's Department for International Development (DFID), can aid in this process by providing credibility to activities such as those promoted by BRAC and Keggfarms.

Need for a common platform: There is a need to organize a series of meetings and workshops to sensitize decision-makers, politicians, bureaucrats, technocrats, policy-makers and planners of pro-poor programmes. This sensitization must be based on hard data. It is also necessary to involve people who write Poverty Reduction Strategy Papers, Human Development Reports, policy documents, etc. International organizations such as FAO with a mandate to promote global exchange of information, collection, analysis, interpretation and dissemination of data, and national and international technological, social and economic research, can play a significant role in this context.

Capacity-building: Organization of support services and input supply is a critical ele-

ment of any model that attempts to link smallholders with output markets. This requires support from people with strong organizational skills. Thus, appropriate capacity-building measures must become an integral part of interventions that design and implement livelihood-support options such as backyard poultry. Successful projects such as those implemented by BRAC and Keggfarms can be a resource for this training. Similarly, government and NGOs can provide technical training.

Linking with microcredit: Microfinance organizations and self-help groups may help with credit to finance important expenditures. Establishment of strong linkages with microcredit organizations must, therefore, be seen as an integral component of all livelihood-support interventions, including household poultry. Besides facilitating access to credit, credible microcredit organizations and self-help groups can also help rationalize interest rates.

Data and analytics: Finally, the database pertaining to poultry production is extremely weak and seriously hampers the analytical work necessary to support decision-making. There are significant discrepancies even in the basic production and price data put out by the government, private agencies, and international organizations. Generation of accurate data is critical for informed policy decisions, and concerned agencies should seriously deliberate the possibility of creating a common information system for livestock products, including poultry.

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Village chicken production systems in Thailand

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SUMMARY

This paper reviews information on village chickens or Thai indigenous chickens (TIC) in Thailand, describing their production systems, management, conservation and utilization. TIC have been part of Thai farmers' way of life for centuries. Throughout this time, TIC production systems have been sustainable and have given rise to few problems. Currently, about 6 million households, or 50 percent of Thais, keep TIC at home. Each family produces 30–50 birds of marketable size annually, which represents 100–120 million birds for the country as a whole. These chickens are from parent stocks consisting of one cockerel and three to five hens per household. Flock size varies through the year, as it depends on the hatching rate, the availability of natural feed, the effects of endemic diseases, and the amount of time that the farmers have available to take care of their birds. Periods of seasonal change are critical times of high mortality; about 30–70 percent of birds in a flock die annually.

Although TIC productivity is very low compared to commercial breeds, attempts to increase production by using new techniques have not been successful. This is a lesson that has been learned in the past decades. However, introduction of high-performance TIC cockerels may be possible. About 50–70 percent of TIC raised in the villages are for home consumption; the rest are for sale to provide cash income. Few are used for cultural and religious activities.

Demand for TIC meat is generally higher than supply, as people regard TIC meat is tastier and healthier than broiler meat. Other good characteristics of TIC, including disease resistance, tolerance of heat stress, and good maternal ability, are heritable and need to be conserved. Appearance and plumage colours are major criteria for TIC classification. Out of 17 groups of TIC, four have, since 2001, been targeted and established for village-level and commercial-scale utilization. A cross-breed known as Kai Baan Thai (Thai village chicken), sired by TIC with exotic breed hens, and raised on a commercial scale, is a new product with good potential for high-end niche markets.

Since the avian influenza (AI) outbreaks of 2004, some 20 million TIC have been destroyed, as they were blamed for carrying the disease. Six measures for the prevention and control of AI outbreaks were launched immediately by the government, with positive effect. Education of the farmers regarding AI has continued; this is not only to reduce the

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risk of AI, but also to prevent other endemic diseases and parasites.

Key words: Thai, indigenous, chickens, Kai Baan Thai, production systems, Thailand

1 INTRODUCTION

Thailand is situated in the mainland Southeast Asia, lying between 5° to 20° North and 97° to 105° East. The country's area is 514 000 km^2; about 70 percent of which is used for agriculture. The climate is tropical with relatively high temperatures (24–36 °C) and high humidity (66–83 percent). The population is 65 million; with on average 5 people per household. Nearly 6 million households, mostly smallholders, are in the rural areas. Most of them traditionally possess indigenous chickens (Choprakarn, 2007).

Village chickens or Thai indigenous chickens (TIC) *(Gallus gallus domesticus)* have been Thai people's way of life at least since the time of the Ayutthaya Kingdom some 400 years ago (Choprakarn, 1976). This can easily be seen throughout the country. TIC are a source of food protein and quick cash income; they are used in leisure pursuits and as offerings in various rituals and ceremonies. They also play an important role as consumers or yard cleaners in the rural area ecosystem by converting leftovers and agricultural by-produce into meat. These roles make TIC a unique part of the everyday lives of the Thai people. Nonetheless, TIC are still at the bottom of the list of farmers' economic priorities (Choprakarn, 1988; Haitook *et al*., 2003; Klinhom *et al*., 2005; Laopaiboon *et al*., 1999; Namdaeng, 1991; Phalarask, 1985; Simaraks *et al*., 2007).

Most Thai farmers prefer TIC to imported exotic breeds, even though TIC have comparatively inferior egg and meat productivity. This is because TIC can survive under very harsh conditions and still reproduce regularly even with minimum care and management (Choprakarn *et al*., 1998a; Klinhom *et al*., 2005; Laopaiboon, 1990; Laopaiboon and Jitpraneechai, 1999).

About 100–120 million TIC of marketable size are produced annually. This comprised 10 percent of chicken-meat production in Thailand before the avian influenza (AI) outbreak of 2004 (Choprakarn *et al*., 1998a). It is reported that since this outbreak, AI has led to the death or slaughter of almost 20 million TIC (Department of Livestock Development, 2005). The loss of genetic resources is a major concern, and there is urgent need to find ways to save these resources from subsequent AI outbreaks. Many measures and ideas have been tried and proposed, with wide acceptance from other countries and World Organisation for Animal Health (OIE) (Lekchareonsuk *et al*., 2006).

This paper draws on both published and unpublished papers to review village TIC production systems, along with research and developmental work, and the conservation and utilization of these genetic resources. It also discusses prospects for the future.

2 MANAGEMENT SYSTEMS

Throughout the country, TIC are generally raised under free-range conditions. However, in the case of fighting cocks, production is much more intensive. Most smallholders employ a "low input/low output" system which is appropriate to their local conditions, while a few farmers (less than 10 percent) keep their chickens semi-intensively to supplement their incomes. Only a very small number of commercial farms exist, serving niche markets. For clarity, this paper focuses mainly on TIC production for meat and at the village level.

Most Thai farmers, generally, keep their TIC in the backyard. But some farmers may take their birds to the fields when endemic diseases break out in the villages and/or during crop growing and harvesting seasons. Chickens are penned to protect them from predators and/or thieves at night. A pen is usually located under a rice storage for ease of construction; if it stands alone it will still be close to the house. TIC are fed twice daily, in the morning and evening, mostly by women. Chickens can move freely with their flock scavenging around for edible insects, seeds and fresh plant parts. In most cases, there are no vaccination and de-worming for TIC; but some farmers may have local herbs for prevention and/or curing (Choprakarn *et al*., 1983; Klinhom *et al*., 2005; Laopaiboon, 1990). This practice tends to satisfy the farmers involved.

A family generally keeps one rooster with three to five hens to form a flock, annually. This helps to maintain pecking order and reduce fighting in the flock. In a year, such flocks can produce up to 90–150 day-old chicks, equivalent to 30–75 marketable birds of 1.0-1.5 kg body weight at four to five months of age (Choprakarn *et al*., 1983; Choprakarn *et al*., 1998a; Laopaiboon and Jitpraneechai, 1999; Namdaeng, 1991).

The number of chickens per household varies greatly depending on time of the year and capacity of the farmers. From October to February (cool and dry), the number of day-old chicks running around is at its greatest, and the chicks' growth rate is also high. This is because of the higher hatching rate, and the availability of plenty of natural feeds and of crop by-products. However, the numbers tend to decline from March to September (hot and humid) due to low hatching rate, shortage of natural feeds, endemic diseases, and internal and external parasites (Choprakarn *et al*., 1998a; Klinhom *et al*., 2005; Laopaiboon; Jitpraneechai, 1999).

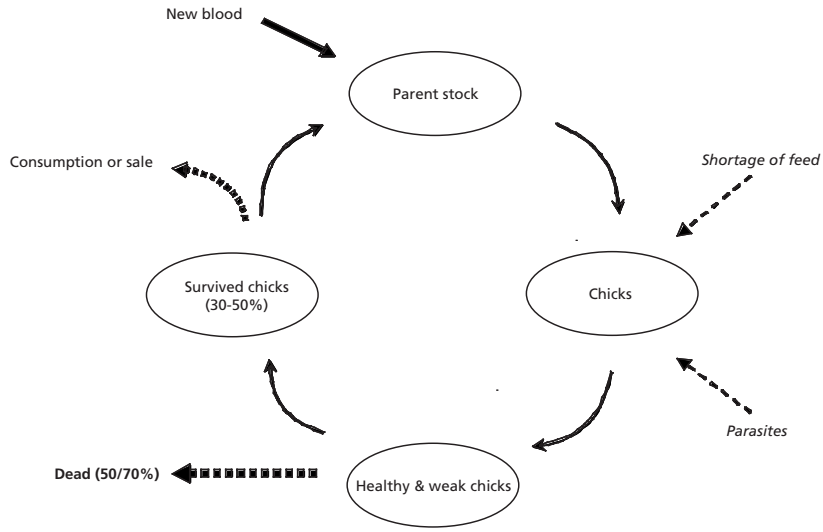
Demand for TIC is high during May to June and November to January; market-sized chickens are needed as food for farmers working in the fields during the crop cultivation and during harvesting seasons, respectively (Choprakarn *et al*., 1983; Choprakarn *et al*., 1984; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999; Namdaeng, 1991).

TIC parent stocks are used up to 2–3 years old depending on their performance. The next generation of chickens may descend from the same flock or be introduced from within or outside the village. Recommendations for parent-stock selection are, for males, high body weight and long legs, and for females, good maternal ability, i.e. producing at least 9 eggs/clutch, good behaviour during incubation and when taking good care of her broods. Another important criterion for parent stock is no cannibalism of their own chicks (Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999; Namdaeng, 1991).

The survival rate of TIC, from one-day old to marketable size, is 30-50 percent. Therefore, a typical hen can produce 10–15 market-sized birds annually (Choprakarn *et al*., 1983; Choprakarn *et al*., 1984; Namdaeng, 1991).

The general picture of the TIC production system is summarized in Figure 1.

FIGURE 1
Raising indigenous chickens by Thai farmers under traditional system



Source: Choprakarn *et al.* (1983).

3 POULTRY GENETIC RESOURCES

It is accepted by Thai researchers that Cochin Chinese and Burmese Red Jungle Fowl are the ancestors of TIC. The former is generally found in the east and the northeast of Thailand, while the latter are common in the east and the north (Royal Institute, 1995).

TIC are widely used as parent stocks throughout the country. They are primarily classified by appearances, especially their plumage. Male chickens are more colourful and also grow faster than females. Male plumage is mainly black, but the dorsal plumage on their necks, hackles, backs, saddles, and wings are in different colours such as yellow, green, dark brown, reddish brown, and/or white. Female feathers are basically black, dark brown, and/or brown; except for the Kai Chee (literally means "nun chicken") with all white feathers. Combs are usually pea, single, and/or rose. Shank colours are white, yellow, and/or black in both males and females. Currently, 17 groups of TIC have been categorized according to their feather colours (Reodecha and Choprakarn, 2005). More detailed information on their genetic make up relating to disease tolerance, maternal ability and economic traits is needed.

The behaviour of both sexes of the TIC is almost the same as that of wild fowls. Aggression is common, in order to protect themselves or their broods from predators and enemies. Maternal ability of the females is high during nesting, egg laying and brooding. Although these behaviours are not desired for commercial-scale production, and are culled out, they must be conserved in the TIC kept under rural conditions (Choprakarn *et al*., 1998a).

Under good management (high inputs), TIC productivity is very low compared to exotic breeds. However, under rural area conditions (low inputs), TIC perform much better (Laopaiboon, 1990; Phalarask, 1985).

Female and male chickens enter maturity at 6–8 and 8–12 months of age, and with 1.4–1.8 and 1.8–2.3 kg body weight, respectively (Choprakarn, 1988; Laopaiboon, 1990). Mating occurs at any time of the day, but is most frequent during early morning and evening (Choprakarn *et al*., 1998b; Klinhom *et al*., 2005; Phalarask, 1985).

A female TIC lays 3-4 clutches of eggs yearly. It takes 2 weeks for laying, 3 weeks for hatching, and 6–10 weeks for taking care of her broods. Thus, a hen spends 10–15 weeks for each reproductive cycle (Choprakarn, 1988; Choprakarn *et al*., 1998b; Katawatin *et al*. 1996; Phalarask, 1985). The time period of a hen's reproductive cycle depends on two main factors; feed and body weight. A hen needs good quantity and quality feed; and should reach at least the previous body weight before entering the next reproductive cycle (Boonlear, 1989; Choprakarn, 1988).

A hen lays 10–12 eggs/clutch. The hatching rate is 80–85 percent, higher in the cool season and lower in the hot and rainy season. Consequently, a typical hen produces 25–40 day-old chicks annually (Boonlear, 1989; Choprakarn, 1988; Klinhom *et al*., 2005; Phalarask, 1985).

Egg weight and body weight of day-old chicks are in the range of 45–55 and 33–35 grams, respectively. Growth rate of a chick is 7–10 grams/bird/day – highest between 12 and 14 weeks of age, then it tends to decline. A TIC takes about 4–5 months to reach marketable size with a 80–85 percent carcass (Choprakarn, 1988; Phalarask, 1985).

Local consumers consider TIC meat to be fine in texture and to have more flavour and less fat than the exotic breeds (Itarapichet *et al*., 2003; Jaturasitha *et al*., 2002; Wattanachant *et al*., 2004). This makes TIC a tasty and healthy chicken. TIC are more heat tolerant (Aengwanich, 2003; Tirawattanawanich *et al*., 2005) and are more resistant to common diseases such as Newcastle disease, fowl cholera and fowl pox than are exotic breeds and cross-breeds between TIC and exotics (Ratanasethakul and Laopaiboon, 1982; Ratanasethakul *et al*. 1983; Ratanasethakul and Boon-eg, 1989; Ratanasethakul *et al*., 1984a). To conserve and utilize these traits, research is being carried out on frozen semen (Vongpralab *et al*., 2007a and Vongpralab *et al*., 2007b) and genetic markers (Mekchay *et al*., 2005; Mekchay *et al*., 2006; Singhapol, 2003; Siriphonvat, 1995).

4 FEED AND FEEDING SYSTEMS

There are two styles of feeding for TIC; chickens may be fed by the farmers and/or scavenging around on their own. In the first method, chickens are given broken rice, rice bran, ground corn kernels, and/or cassava chips, depending on crops available, usually in the morning and evening. The amount of feed given is generally not enough for the birds' energy requirements, especially during the crop growing and harvesting seasons, as the farmers go to the fields early in the morning and return late in the evening. It is, therefore, suggested that, where there is plenty of natural feed, it might be better to feed TIC only once, in the evening. Doing this would force the chickens to scavenge extensively and save some inputs (Choprakarn *et al*., 1983; Choprakarn *et al*., 1984; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999; Phalarask, 1985).

Some farmers provide extra protein sources for their chickens by using termites and house-fly larva, but this is not convenient. A more practical method is by putting up light bulbs at night in the backyard to attract insects. This not only brings in a lot of insects as

chicken feed, but for human food as well. Moreover, insect pests attracted to the light can be destroyed, saving crops from damages (Choprakarn *et al*., 1983; Klinhom *et al*., 2005).

Another feeding method for TIC is to use household waste products, together with natural feed available around the homestead. Most natural feeds are composed of high levels of protein, vitamins and minerals. The quantity and quality of these feeds depend on location and season; there are plenty in the wet seasons but they are very scarce during dry seasons (Choprakarn *et al*., 1983; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999).

The most common natural feeds are earthworms, worms, termites, insects and plant leaves. Cattle ticks and manure are also sources of high-quality protein for chickens; the more scavenging by the chickens, the fewer ticks and less dry manure left on the ground (Choprakarn *et al*., 1983; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999). This not only helps cattle to stay healthy, but also reduces odour in the vicinity. It should be noted that termites are rarely found on the ground around farmers' houses, this is because the TIC are good predators of termites.

Scavenging also affects the chickens' health and survival rates, as waste products are the main sources of the bacteria and parasites that affect the birds all year round. Unexpectedly, young chicks tend to eat rubber bands, and once inside their gizzards, these rubber bands severely affect the digestion system (Kunjara and Sangvaranonda, 1993; Kunjara and Sangvaraononda, 1997; Ratanasethakul and Laupaiboon, 1986; Ratanasethakul *et al*., 1984b; Sukprasert *et al*., 2006).

At present, the scavenging area for TIC is tending to become more limited as houses take up previously available land. This, therefore, affects the quantity and quality of natural feeds available to the chickens. Consequently, numbers of free-range TIC are expected to be lower in the future.

5 MARKETING SYSTEMS

TIC are consumed mostly by their owners, relatives, and friends. It is estimated that 50–70 percent of TIC are eaten at home during times of food shortage, when guests are visiting, and at crop planting and harvesting times. Eggs are usually saved and hatched to produce new chicks. Non-fertile or un-hatched eggs are considered a specialty in some areas (Choprakarn, 1983; Haitook *et al*., 2003; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999).

Marketing systems for TIC can be divided into three levels; there are person-to-person purchase in the villages, wet (fresh) market in towns, and seasonal markets elsewhere (Choprakarn *et al*., 1998a).

Person-to-person purchases in the villages involve a direct contact between buyers and TIC farmers. These purchases occur when some villagers have guests visiting or a food shortage. This marketing system is occasional or seasonal, but significant. Chickens are sold live and the bird size varies from young, 1 kg body weight, birds up to old parent stocks (Choprakarn, 1983; Klinhom *et al*., 2005).

In the case of wet (fresh) markets in towns, the farmers carry their TIC to the markets very early in the morning. The number of chickens brought by a farmer ranges from three

to ten birds. The desired weight is 1.0–1.5 kg/bird; if heavier, the price tends to go down due to the inferior, tougher, meat texture. In general, prices of female chickens are higher than those of males due to better meat texture and flavour. Some farmers sell live birds directly to the consumers, while others sell slaughtered-cum-dressed birds, with or without viscera. A number of farmers may sell their chickens to the local slaughterers. Supply of TIC to these markets is not regular, and depends on the farmers' circumstances. Most farmers often sell their birds when they need cash or get sick and/or the flock is too crowded. Otherwise, they will keep their birds in the flock. Thus, TIC can be viewed as the farmers' "piggy bank" (Choprakarn, 1983; Choprakarn *et al*., 1998a).

Seasonal markets happen at special occasions, such as a few days before Chinese New Year's Day. There is a very high demand of TIC throughout the country at this time of the year. A few weeks earlier, intermediaries will collect mostly black-plumage female chickens of about 1 kg body weight. Birds are dewormed and fed full feed so that they reach marketable size. The chickens can then be sold for a price that is at least twice that obtained at normal times of the year. However, this seasonal market is facing uncertainty following the major AI outbreaks. The activity is limited by the government's AI prevention measures introduced in order to reduce the outbreak area (Choprakarn *et al*., 1998a).

TIC is one of a very few agricultural products that never face price problems. This is because of its high meat quality which results in high demand, while the supply is always low. In general, the price of TIC is about 1.5 times higher than that of broilers. However, most smallholders do not increase their production, as the practices do not fit well into their way of life and local conditions.

6 POULTRY HEALTH AND HEALTH CONTROL SYSTEMS

Newcastle disease, fowl cholera and fowl pox account for 30-100 percent of the mortality rate of TIC annually. Occurrence of these endemic diseases depends on the time of the year. Newcastle disease, the most serious for all ages of chickens, occurs during seasonal changes from cold to dry and from dry to wet seasons. Fowl cholera, the second most important disease, affecting mostly 3 month old chicks, occurs only in the dry season. Fowl pox can be found all year round in young birds. Another disease of young birds, infectious coryza, is common in both wet and cold seasons. Although fowl pox and infectious coryza do not cause immediate death, they weaken the chickens. This, subsequently, makes the chickens vulnerable to other diseases, and death often follows (Ratanasethakul and Laopaiboon, 1982; Ratanasethakul *et al*., 1983; Ratanasethakul and Laopaiboon, 1986; Ratanasethakul and Boon-eg, 1989; Ratanasethakul *et al*., 1984a).

When endemic diseases occur, some farmers move their chickens to the crop fields far from the villages. This reduces the chicken mortality rate to some extent. In some areas, villagers are encouraged not to bring commercial broiler meat in. They are afraid that the meat brought in may carry diseases (Choprakarn *et al*., 1983; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999; Namdaeng, 1991).

External and internal parasites are common in TIC. Although they do not cause death directly, they affect the hatching and growth rates of the birds. When a hen gets external parasites, mostly in the summer, she will spend less time in the nest. Thus, nest temperatures are lowered. The majority of external parasites are *Menopon gallinae, Megninia* spp.,

and *Echidnophaga gallinacea* which affect the hatching rate and young chicks (Ratanasethakul and Laopaiboon, 1986; Sangvaraononda, 1993). Young chicks will be weakened and vulnerable to other diseases and death often follows. In the case of internal parasites, chicks can easily be infected within a few weeks of scavenging on the ground, especially in the rainy season. These parasites include *Ascaridia galli, Raillietina echinobothridia*, and *Oxyspirura mansoni* (Kunjara and Sangvaraonononda, 1993; Kunjara and Sangvaraonononda, 1997; Ratanasethakul *et al*., 1984b; Sukprasert *et al*., 2006).

Traditionally, vaccination is not practised in the TIC production system, except in a limited number of villages where there is research work and/or extension programmes implemented by various agencies (Kwaengsopha, 1989; Simarak *et al*., 2007). However, most farmers can identify the differences between Newcastle disease and fowl cholera, and also point to the time of outbreaks. Some farmers, especially those close to town, use human medical supplies for their chickens' health programmes. These include antibiotics to treat respiratory diseases and insecticides for external parasites. Herbs available locally such as *Andrographis paniculata, Curcuma longa, Stemona tuberose, Tinospora crispa, Cymbopogon citratus, Nicotiana tabacum, Ocimum tenuiflorum, Psidium guajava* and *Areca catechu* are very popular among farmers to keep their birds healthy. These herbs are used quite satisfactorily for disease prevention and/or internal/external parasite eradication (Klinhom *et al*., 2005; Sukprasert *et al*., 2006).

A few decades ago, some farmers in the remote areas might have cooked dead chickens for food, as they did not have any idea about the detrimental effects. However, nowadays, birds that die of disease are well disposed of (Choprakarn *et al*., 1998a; Klinhom *et al*., 2005).

Even though a large number of TIC throughout the country were destroyed in 2004 as a result of the AI outbreaks, farmers take only about six months to restock chickens in their backyards. It is very easy to obtain parent stock from the neighbourhood or from other villages. This population elasticity is another advantage of TIC (Simarak *et al*., 2007).

During early AI outbreaks, farmers did not understand clearly about the virulent nature of the disease, and could not identify the differences between fowl cholera and AI. The Thai government immediately issued six major standard measures to control AI outbreaks. These included surveillance, movement control, stamping-out and pre-emptive culling, and disinfection and carcass disposal. Ongoing measures to educate the farmers via public media, and by local staff at farm level, are very effective. This education makes farmers take more care of their TIC, especially when they observe sick birds in the flocks. The measures not only benefit AI control, but also enhance the control of other common diseases (Lekchareonsuk *et al*., 2006).

7 CULTURAL ISSUES

Thai people in rural areas are predominantly farmers or their occupations are related one way or another to agriculture. However, most young people from these areas prefer to seek work in towns or cities. Some of them may come back home as farm labourers during crop growing and harvesting times, but most of them need to visit home during important festivals like the traditional Thai New Year's Day in April. These seasonal economics and social activities result in an extra demand for food, and the most convenient source is TIC

in the backyard. This encourages more than 90 percent of farmers to have TIC of their own (Choprakarn *et al*., 1983; Haitook *et al*., 2003; Klinhom *et al*., 2005; Laopaiboon; Jitpraneechai, 1999).

TIC – like rice – are part of the Thai farmers' way of life; both have been with the farmers for a very long time. The farmers' attitude towards their chickens is similar to that of people who keep dogs or cats. In terms of economics, TIC are much more beneficial. They are food for the farmers, a piggy bank at home, and can be used for cultural and religious activities (Klinhom *et al*., 2005).

Eggs, precursors of birth and symbols of life, are an essential part or ingredient of many Thai offerings and sweets used in many rituals and ceremonies. Boiled eggs are an important part of decorative flower baskets used in many ceremonies, ranging from welcoming the birth of a child to weddings. In some instances, a boiled egg is shelled and then cut into halves; the outer egg white and then the inside texture is examined carefully. Then the future is told, to satisfy or warn those involved. In some places, people may make a wish together with putting an egg upright on its end; when this is done, a wish is likely to be accomplished. In some remote areas, a raw egg is used to indicate the burial site for the dead (Klinhom *et al*., 2005).

Cock-crow early in the morning is still used as alarm call for the villagers. In some areas, it is said that when chickens stretch out their wings to dry feathers, this is a sign that rain will soon fall. In a wedding ceremony in some villages, a cock and a pullet are presented together, representing a bridegroom and a bride, respectively. Most farmers are very proud to serve their own chickens to distinguished guests. For some traditional customs, a slaughtered, plucked and boiled whole chicken is often used as an offering for ancestor veneration and worship of village deities. In some instances, a cartilage under mandible is examined to indicate soil fertility and availability of natural food (Klinhom *et al*., 2005)

Cock fighting is still a popular pastime for many Thai men. This is an important cultural heritage from the Ayutthaya Era when King Naresuan's cock won a fight against the Burmese King's cock (Choprakarn, 1976). People have both negative and positive attitudes to this social activity. Some regard the activity as a form of animal cruelty and as a source of family problems associated with gambling. Some argue that cock fighting maintains a good source of TIC genetics through both natural and human selection. A lot of local wisdom involving TIC has been developed and passed down the generations as a result of this activity. Most herbs used for TIC originate from cock fighting. Farmers still prefer to introduce the loser cocks to their flocks, as these birds are cheaper, bigger in size, and stronger than general cockerels.

With very deep ties between the farmers and their chickens, parent stocks are the last choice to be used for food or sold. Due to the familiarities between the farmers and their favourite chickens for a long period of time, some owners even have a special ceremony for their beloved chickens when they die (Choprakarn *et al*., 1983; Klinhom *et al*., 2005; Laopaiboon and Jitpraneechai, 1999; Simarak *et al*., 2007).

8 DEVELOPMENT OF TIC: PAST, PRESENT, AND FUTURE

Research and development of TIC can be categorized into two levels; one for smallholders and another for commercial-scale production. In the past, smallholders were the main tar-

get for research and developmental work. The importance of TIC had been recognized and this issue was added to the Fifth National Development Plan of Thailand during 1982 to 1986. Researchers and extension workers from various institutions were involved in many projects. The main objectives were to increase food-protein sources and cash income for the farmers; and also to increase the number of day-old chicks per hen per year, and to decrease the mortality rate of the chickens (Choprakarn *et al*., 1998a).

The number of hatchlings can be increased up to two times by increasing the number of clutches from three to five or six per hen per year, while the number of hatchlings in each clutch remains the same. The number of clutches can be increased by early separation of the hen from her broods. This stimulates the hen to enter the next reproductive cycle within one month of hatching, instead of the more usual two to three months. In this way, it takes only nine to ten weeks instead of 15 to 17 weeks for each reproductive cycle. In this case, day-old chicks are completely separated from the hen and are fed with concentrate for one month before they are let out to run with the flock. This is a critical period because chicks take at least two to three weeks to learn how to scavenge and survive. Weak chicks and high mortality are common during this growth stage (Boonlear, 1989; Choprakarn *et al*., 1998b; Katawatin *et al*., 1996).

Crossing TIC with exotic breeds in order to increase the number of day-old chicks is not practical. About 30 percent of the hens do not brood and do not take care of their broods. Cross-breeds do not like to scavenge around and can not cope as well as the TIC with the harsh environment in rural areas (Laopaiboon, 1990; Phalarask, 1985).

A good vaccination programme (Newcastle disease, fowl cholera and fowl pox), associated with internal and external parasitic control, can satisfactorily lower the mortality rate of the flock from 50–70 percent to 30-40 percent (Ratanasethakul and Laopaiboon, 1982; Ratanasethakul *et al*., 1983; Ratanasethakul and Laopaiboon, 1986; Ratanasethakul *et al*., 1984a; Ratanasethakul and Boon-eg. 1989; Ratanasethakul *et al*., 1984b; Sangvaraonon-da, 1993; Sukprasert *et al*., 2006). However, this is practised sporadically due to intermittent vaccine supplies, and it does not fit well to the farmers' way of life.

Early chick separation and vaccination can increase the number of chickens at marketable size from 10–12 to 30–35 birds per hen per year. Even though there is extra cost for feed and vaccines, it is covered by the additional returns. Most farmers agree with this approach, but this technique is not generally practised, as it takes more time and does not fit well to their production system. Moreover, high chick mortality tends to occur due to overcrowding in the flock and an imbalanced ecosystem (Boonlear, 1989; Choprakarn *et al*., 1998a; Choprakarn *et al*., 1998b).

It is concluded that the traditional TIC production system with low inputs is still suitable for Thai farmers. This has been proved by many researchers (Choprakarn *et al*., 1983; Choprakarn *et al*., 1998a; Laopaiboon and Jitpraneechai, 1999; Klinhom *et al*., 2005; Phalarask, 1985); it was reported that, for example, all 19 groups of farmers who had participated in various TIC extension projects ceased to do so after project terminations (Simarak *et al*., 2007). It is strongly recommended that there is no need to increase TIC production for smallholders by any other methods affecting their management systems.

Currently, Kai Baan Thai (Thai Village Chicken), a new product derived from a cross-breed sired by TIC with an exotic breed, is being produced commercially in standard farms

to supply high-end niche markets. These meat-type chickens grow faster than TIC and reach the marketable weight of 1.3–1.5 kg within a shorter time of 13–15 weeks. They have the same meat quality as TIC, in terms of both flavour and texture, but with less fat than broilers. At present, the annual production is about 10 million birds and it tends to increase (Intarapichet *et al*., 2003; Jaturasitha *et al*.; 2002; Wattanachant *et al*., 2004).

In 2001, a conservation programme for TIC was formally started, based on collaboration between the Thailand Research Fund and the Department of Livestock Development. The main objective has been to prepare uniformity of TIC breeding stock for smallholders and for industrial–scale production. Four out of 17 groups, namely Pradu Hangdum (Black-tailed Pradu), Luang Hangkhao (White-tailed Yellow), Kai Dang (Red Chicken), and Kai Chee (Nun Chicken) have been selected according to their plumage colours. These distinct feather groups have now been established (Reodecha and Choprakarn, 2005) and are available to the farmers. Moreover, some of these four groups are being selected for pure male lines to be used in the commercial farms. However, local populations of TIC are still important as parent stocks for smallholders throughout the country.

9 CONCLUSIONS

Raising TIC by the traditional method (low inputs/low outputs) has proved suitable for Thai farmers' production objectives and the conditions in rural areas.

Cross-bred TIC meat is tastier and better for health compared to broiler meat, making it a very interesting choice, not only in Thailand but also for other countries.

TIC genetic resources have to be conserved. TIC behaviours such as maternal ability and survival ability under harsh conditions are very important for smallholders. The meat quality of TIC is now used for marketing campaigns on an industrial scale. More studies of their genetic make-up relating to maternal ability and economic traits are needed.

It is important to regularly educate farmers on AI prevention measures and management of their flocks.

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Formal and informal contract farming in poultry in Bangladesh

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SUMMARY

Since the early 1990s, contract farming as a market institution in the poultry industry in Bangladesh has evolved along with the expansion of commercial poultry farming. Apart from classical contract farming within vertically integrated enterprises, there are also formal and informal contract arrangements in input marketing and output marketing. In this paper, the characteristics of these forms of contract arrangements and their implications for the poultry industry in Bangladesh are discussed. A high drop-out rate among commercial poultry producers is observed. Results of a survey conducted among farmers who dropped out of the poultry business in recent years are presented, highlighting the causes of dropping out and the possible role of contract farming in addressing them.

Key words: poultry, market, institutions, contract

1 INTRODUCTION

In Bangladesh, commercial poultry production using improved genetics, feeds and management has grown rapidly since the early 1990s in response to increased market demand for livestock products including poultry. The total poultry population in the country increased from 91 million in 1990 to 101 million in 1992, 123 million in 1995 and 153 million in 1997. This increase occurred almost entirely in the commercial poultry sector. In 1998, there was a sharp decline in the population to 138 million due to a severe flood. The population then stabilized at around 140 million until 2006 (figures from FAOSTAT – http://faostat.fao.org/default.aspx). Contract farming in the poultry sector has also evolved to some extent, along with the expansion of commercial production.

This paper begins by briefly presenting the background to the emergence of contract farming as a market institution in the developing world (Section 2). It then discusses the evolving forms of poultry contract farming, along with their pros and cons, and their implications for the future role of contract farming in the sector. In Section 3, the types of contract farming arrangements prevailing in the poultry sector in Bangladesh and the profiles of practitioners of various contract types are described. In Section 4, the implications of the current contract arrangements in the sector are summarized. In Section 5, major reasons for dropping out of the poultry business, as reported by a sample of farmers who dropped out, are discussed along with implications for contract farming.

This paper is partly derived from a longer study (see Jabbar *et al.*, 2007).

2 BACKGROUND TO THE EMERGENCE OF CONTRACT FARMING AS A MARKET INSTITUTION

In recent decades, the demand for livestock products in developing countries including Bangladesh has increased rapidly, propelled by rising levels of income, population and urbanization. Demand has principally been met by large-scale urban/peri-urban production. Although growth in demand for livestock products should, in principle, bring opportunities for the large numbers of livestock-dependent poor who have traditionally dominated developing-country markets, such producers have generally faced severe competition as markets have expanded. Small-scale or poor producers have captured only a tiny share of these expanding markets because of their inability to produce high quality products at competitive costs and to reach urban markets. This is a result of a lack of access to information, skills, technologies and other infrastructure, which increases transaction costs. Further, the absence, in most rural areas, of adequate preservation and marketing infrastructure means that the individual market-entry investments needed to fulfil production and sanitary standards are prohibitively high given, the quantities of marketable products produced. Lack of access to market information further reduces the negotiating position of small production units. Government policies have often supported and subsidized industrial livestock production, promoting economies of scale, but usually overlooking equity, environment and health consequences (Delgado *et al.*, 1999).

To overcome the above-mentioned constraints, a variety of organizational arrangements that allow small production units to benefit from various forms of collective action, such as producer groups, input- and output-marketing cooperatives, and product collection schemes, have been supported by government and non-government organizations in a number of countries, with varying degrees of success. Contract farming is one such institutional arrangement that is considered to be useful in facilitating market access for smallholders in high-value supply chains that require specialized production inputs, and sales to markets for specialized outputs. Contracting has long been used in various fields of economic activity as a means to strengthen supply chains, with varying degrees of success (Glover, 1987; Farrelly, 1996; Runsten and Key, 1996; Eaton and Shepherd, in FAO, 2001).

Contract farming promotes the linkage of smallholders to the market in circumstances where the transaction costs of direct engagement with the market are high for producers and/or traders. Contract farming has also been successful in enabling the transfer of improved technology and the integration of smallholders into an economy that embraces modernization and globalization. In addition to enhancing the incomes of smallholder producers per se, contract farming may also be beneficial for overall employment and for infrastructure or market development for the wider community. Particularly when multinational agribusiness firms are involved, contract farming may also increase access to lucrative export markets (ERS, 1997; Eaton and Shepherd, in FAO, 2001; Delgado *et al.*, 2003). Given current concerns about diseases such as avian influenza, quality assurance is becoming an even more challenging task, and the involvement of smallholders in any supply chain is likely to make the management of those chains even more difficult and costly. Under such conditions, contract farming may provide one avenue to keep smallholders engaged in the sector. Production and price risks are important features of poultry farming. Risk sharing is one of the widely cited reasons for contracting. Numerous studies of contract

farming put emphasis on risk reduction as a principal incentive for producers to enter into contracts (Covey and Stennis, 1985).

Conversely, contract farming has been blamed for breaking up existing farming activities, involving farmers in inflexible production arrangements, and potentially jeopardizing food security and subsistence production. Moreover, where the contracted product requires substantial investment in equipment or infrastructure, the debt burden of contract farmers may increase along with dependency on the large integrators or agribusiness companies which may show characteristics of monopoly firms (Shivramkrishna and Jyotishi, 2007). Depending on whether participation in contract farming is restricted to males and/or larger-scale farmers, and the rights and treatment of locally-hired labour by such farmers, contract farming arrangements may result in a negative effect on overall equity and gender relationships (Glover, 1987). Women and child workers, in particular, may be disadvantaged because of unfavourable contract terms (Singh, 2003).

3 TYPES OF CONTRACT FARMING IN POULTRY IN BANGLADESH

Contract farming is usually defined as farming which is a part of a vertically integrated enterprise within which actors are linked through contracts defining roles, responsibilities, rights and obligations. However, contract arrangements may also prevail outside vertically integrated enterprises. Forms of contract farming may be defined on the basis of a set of criteria (e.g. types of partners involved, how risks, benefits and obligations are shared, how contract agreements are made, enforced and monitored, and how disputes are settled). The prevailing legal and regulatory frameworks in a country or society determine how these factors are incorporated in contracts and are actually practised. Some of the above-mentioned elements of contract farming are common in other forms of collective action such as cooperatives and production and marketing groups; a distinction, therefore, needs be made between contract farming and other organizational forms.

Considering these elements and analysing the firms and enterprises involved in various contract arrangements in the poultry sector in Bangladesh, the following three types of contract arrangement can be identified:

(a) Production–marketing contracts – relevant actors are involved in contracts within a vertically integrated enterprise for supply of inputs and services, disposal of outputs, and sharing of risks and benefits. The agreement is documented in writing and signed by the parties.

(b) Input-marketing contracts – relevant actors are involved in contracts for supply of one or more inputs and services, generally to market agents who directly deal with producers. The agreement is documented in writing and signed by the parties.

(c) Output-marketing contracts – primarily a forward-purchase contract in which contractors purchase output from existing producers. The agreement is basically verbal or in a form that may not be considered acceptable in a formal court for dispute settlement.

The evolution, profiles and characteristics of the various enterprises operating under different contract types are discussed in more detail below.

3.1 Production–marketing contracts

The principal actors in this arrangement are Aftab Bahumukhi Farms Ltd operating in Kishoreganj District, Biman Poultry Complex operating in Savar near Dhaka District, and BRAC's poultry operations in a number of districts. The main characteristics of these three enterprises are summarized in Table 1. A more detailed description of the individual enterprises is given below.

Broiler farming by Aftab Bahumukhi Farms Ltd

The Aftab Bahumukhi Farms Ltd (ABFL) is one of the subsidiary companies of the Islam Group of Companies, Dhaka, a multi-enterprise company that also has the largest private-sector commercial operations in the agricultural sector. The ABFL established a broiler farm in 1991 in Bhagalpur Thana (subdistrict) in the District of Kishoreganj, about 110 km northeast of Dhaka city. The ABFL started contract farming as an experimental programme with a group of 20 farmers. Based on the initial experience, the ABFL took up in, 1994, an elaborate vertically integrated contract growing programme for poultry, involving rural people in poultry farming as an income-generating activity by providing technical and professional support. As the ABFL started as an agro-based firm, it included farms of all sizes in its poultry and other farm programmes. There was perhaps no special consideration given to small farms, but they were included so long as other requirements for engaging in poultry production were met. Unlike vertically integrated farms in developed countries, where big trading companies usually prefer contracts with large-scale farms and farmers to minimize transaction costs, the ABFL has tried to be inclusive. One of the objectives of the ABFL was to increase the income and welfare of farmers in the areas around the firm's headquarters. This motivation may partly lie in the fact that the owner of the Islam Group, of which the

TABLE 1
Summary of characteristics of enterprises practising production–marketing contracts

	Aftab Ltd	Biman	BRAC
Year established	1992	1997	2002
Products covered	Broiler and breeder stock	Broiler	Broiler
Vertical integration	Yes	Partial	Partial
Input supply	On credit till 2003, then cash	On credit	On credit
Output purchase	Market price plus margin	Fixed price	Fixed price
Production risk	100% producer with insurance	100% producer	100% producer
Price risk	Shared	Producer	Producer
Number of producers	350 and 122	25	215
Batch size	1 500–2 500 Average 1 800	1 000–5 000 Average 2 500	500–2 000 Average 800

Source: Jabbar *et al.* (2007).

ABFL is a component, comes from the locality; so contributing to the welfare of local people through his business ventures may serve both business and a welfare objectives.

The ABFL has developed into a vertically integrated firm over time and has established its own feed mill and hatchery. The firm consists of a modern hatchery that produces 60 000 broiler and layer parent birds and supplies 100 000 day-old chicks per week to the fast-growing poultry industry. The firm has also established retail sales centres in Dhaka city to supply eggs and poultry meat to consumers. The Poultry Complex of the ABFL is already one of the largest in the country. The ABFL's poultry feed mill was first established primarily to provide balanced feed for the ABFL contract poultry farms. It was later expanded to meet the wider demand for poultry feed in the country. At present, ABFL has three feed mills with a capacity of 10 000 tonnes of feed per month. It distributes balanced feed to farms throughout the country using its own distribution channel.

The agreement between the ABFL and a contract farmer is very simple. Any farmer located in the company's operating area is eligible to enter into a contractual agreement. From 1994 to 2003, the ABFL provided day-old-chicks, feeds and veterinary supplies on credit, and ensured purchase of the output. All the credit liability of the contract farmer was adjusted against the value of their delivered products. After the bird flu rumour which followed outbreaks in Southeast Asia in 2003, the ABFL changed the arrangement from input supply on credit to cash. Although there was no bird flu in the country in 2003, there was suspicion among producers and consumers, and this affected the industry. The price of broilers and day-old chicks decreased drastically within a few days. Many farmers went out of business as they incurred unsustainable losses. The ABFL reportedly incurred a loss of nearly taka (Tk) 150 million as a result of the incident (in mid 2006, US$1=Tk 65.31). As a consequence of the scare, the number of the ABFL's contract farms fell from 650 to 200 in 2004. However, numbers increased to 315 in 2005.

The distribution of responsibilities between the contract farmer and the ABFL within the vertically integrated farming system is summarized in Table 2. The contract farmer typically provides land, housing, equipment and labour. According to the agreement, a farmer builds a covered shed at his/her own cost under the direct supervision of the ABFL extension staff, to ensure a congenial and healthy environment for proper growth of the birds. The average duration of the grow-out cycle is roughly five to seven weeks for an average sized (1.5 kg) broiler. Until 2003, the ABFL used to buy the mature live broilers from the contract farmer by paying a fixed price per kg and then marketed these through the ABFL sales centres in Dhaka. After 2003, when the price of poultry fell drastically, the ABFL also changed its contract arrangement and stipulated that farmers would be paid a price that is a given amount lower than the prevailing market price. For example, in 2003, farmers were paid Tk 53 per kg when market price was Tk 60 per kg live weight, in order to cover the procurement and distribution costs of ABFL.

Risk reduction is an important cited reason for entering into a contractual agreement. Risk is an important feature of poultry farming. There are two types of risk: production risk and price risk. Price risk is an important contributor to revenue variability. The biological nature of broiler production and the unsuitability of the product for long-term storage is an important cause of price instability. Production risk is mainly a result of the death or loss of birds. Outbreaks of diseases may also cause considerable economic losses and erode

TABLE 2
Sharing of responsibilities between the contract farmer and the contractor (ABFL) in broiler production

Particulars	1994–2003		2003 onwards	
	Contractor	Farmer	Contractor	Farmer
Land, buildings and equipment		X		X
Manure handling, storage and disposal capacity		X		X
Day-old chicks	X*		X**	
Feed ingredients, processing and delivery	X*	X	X**	X
Fuel, electricity and telephone		X		X
Facility repairs		X		X
Veterinary services and medicine	X*		X**	
Transportation cost of all input and output		X		X
Labour: production and maintenance		X		X
Labour: supervisory and specialists	X		X	

Note: * = on credit and ** = in cash.
Source: Jabbar *et al.* (2007).

confidence in poultry farming. The major poultry diseases that farmers face in the study areas included fowl cholera, gumboro disease, fowl pox, Newcastle disease. Gumboro and Newcastle disease are epidemic diseases, which cause huge losses.

The vast majority of farmers are generally risk averse, i.e. they normally choose the less revenue-risky business. As poultry is a risky enterprise and farmers are not able individually to deal with distant urban markets, the ABFL initially tried to reduce price risk through a forward contract and purchase arrangement. Later, the mechanism was changed in favour of a risk-sharing arrangement between the ABFL and the contract farmer, which operated by assuring a certain share of the prevailing market price. In order to reduce production risk, an insurance scheme linking compensation to mortality rate was introduced.

There is no poultry insurance system for independent farmers in Bangladesh. The ABFL is the only organization that has introduced an internal insurance scheme to cover the risk of loss and safeguard the interest of its contract farmers in the case of death of immature chicks resulting from diseases or other causes. According to this scheme, the ABFL operates a contributory security fund. Farmers contribute Tk 1.50 per chick to the fund when they purchase day-old chicks. For chick mortality within a given range, a portion of the initial contribution or risk premium is refunded. For example, if chick mortality is less than 3 percent, 4–6 percent, 7–10 percent or 11–15 percent, then 80, 40, 20, and 10 percent of the contribution, respectively, is refunded to the farmer. If the mortality rate is above 15 percent, the farmer can claim full insurance compensation. In this case, for birds up to 20, days old Tk 20 per bird is paid after deducting 15 percent from the total number of birds

lost. For birds older than 20 days, Tk 30 is paid per bird after calculating the benefits from birds up to 20 days of age. Because of this measure, farmers feel secure and encouraged to take up the venture.

Overcoming marketing problems is a major motivation for joining a contract system. In Bangladesh, poultry farms located far from major urban markets face a number of problems in marketing, including inability to sell birds at desired times due to lack of buyers, inadequate transport facilities to carry birds to markets, uncertain prices and low bargaining power. By entering into a contractual agreement, farmers have an assured market outlet.

Access to technical knowledge and management skills is another advantage of contract farming. Most poultry farmers in Bangladesh start business without acquiring proper technical knowledge and management skills. Facilities to train poultry farmers on various aspects of poultry farming and management are inadequate in the country. There is a major deficiency in knowledge about feeding regimes and management, both of which heavily affect production efficiency. Most of the independent broiler farm owners reported that they did not have sufficient knowledge about poultry diets and optimal rations. In broiler production, the ratio of feed varies for starter, grower and finisher stages, and managing these properly is a precondition for profit efficiency. The ABFL provides initial training in the management of the contract farming package and also provides continuous supervision throughout the growing period.

The main feature of the ABFL broiler-farming system is that it is a partnership between the ABFL and the contract farmer, whereby the contract farmer provides land, housing, equipment and labour, and the ABFL provides inputs (initially on credit but later on a cash basis), technical knowledge and supervision which reduces yield uncertainty, and an assured market for products at pre-agreed prices or a pricing mechanism that reduces price uncertainty – all of which are likely to contribute to a remunerative business.

Breeder-stock farming contracts by ABFL

The ABFL started contract breeder-stock farming more recently. The ABFL's hatchery production systems depend totally on import of grandparent stock from abroad, usually from France, the United States of America and the Netherlands. The ABFL rears the imported birds under its own supervision. The eggs obtained from the grandparent stock are hatched and the day-old chicks are distributed to the selected contract-grower farmers as breeder-stock birds. After 25 weeks of rearing, the parent stock birds start producing hatchable eggs, which the ABFL buys back. After hatching, they distribute the day-old chicks to contract and independent broiler farmers for rearing as broilers.

A written agreement is made between the ABFL and the contract breeder-stock farmer, usually for a ten-year period which can be renewed on mutual agreement. Unlike broiler contract farming, only solvent or relatively wealthy farmers in the operation areas of the ABFL are eligible to participate in the scheme, because of larger investment requirement. According to the agreement, the ABFL provides day-old-chicks, feeds, veterinary supplies in kind on credit, and intensive supervision. It also ensures purchase of the output. All the credit liability of the contract farmer is adjusted against the value of their products. Unlike broiler contract farming, input credit was not discontinued in breeder-stock contracts (Table 3).

The contract farmer typically provides land, housing, equipment and labour, and builds

TABLE 3
Sharing of responsibility between the contract farms and contractor (ABFL) in breeder-stock farming

Particulars	Breeder-stock contract farmer	
	Contractor	Farmer
Land, buildings and equipment		X
Manure handling, storage and disposal capacity		X
Day-old chicks	X*	
Feed ingredients, processing and delivery	X*	X
Fuel, electricity and telephone		X
Facility repairs		X
Veterinary services and medicine	X*	
Transportation cost of all inputs and outputs		X
Labour: production and maintenance		X
Labour: supervisory and specialists	X	

Note: * on credit
Source: Jabbar *et al.* (2007).

a covered poultry shed under the direct supervision of the ABFL experts to ensure a healthy environment for proper growth of the birds. Building the shed is a relatively costly investment, which few rural households can afford. In case of need, the ABFL helps farmers to access a bank loan of Tk 800 000 from Uttara Bank to build the shed. If any additional funds are required, ABFL provides 50 percent on credit; the remaining 50 percent has to be borne by the farmer.

The ABFL's internal insurance scheme, mentioned above, also covers the breeder-stock farms, but the premium and compensation rates are different. Farmers contribute 4 percent of the day-old chick price to the fund as a premium, and get refunds based on the rate of mortality. If the mortality is less than 10 percent, 11–25 percent or 26–50 percent, then 70, 60, 50 percent, respectively, of the contribution made by the farmer is refunded. If the mortality rate is above 50 percent, then the farmer can claim for the full insured sum. In this case, Tk 60 per bird is paid if the bird dies at the laying stage. In the event of a bird dying during the growing stage, Tk 100 per bird is paid to the farmer. Because of this measure, farmers feel secure and are encouraged to subscribe to the scheme.

Broiler-farming contracts by Biman Poultry Complex

The Biman Poultry Complex (BPC) is a sister concern of Biman Bangladesh Air Lines Corporation, which deals with dressed broilers under contractual arrangement. The complex started its operation in 1997. With 25 contract growers located in Dhaka, Tangail, Manikgonj and Gazipur Districts, within about 60 km of the Poultry Complex at Savar, the system ensures a supply of dressed chicken to the Biman Catering Centre and two sales centres in Dhaka. The Biman Catering Centre supplies chicken-based foods to different airlines operating out of Dhaka International Airport.

The BPC has entered into agreement with 25 farmers who have built good poultry sheds and have experience in broiler farming. Batch size varies from 1 000 to 5 000 birds, with an average of 2 500 birds. The BPC provides day-old chicks on credit and supplies technical services including veterinary treatment to the enlisted farmers and buys back live chickens from the contractee at a pre-determined price. In 2006, the prices were Tk 100/kg from February to July and Tk 95/kg from August to January. The price is reviewed periodically based on market conditions, so that any price risk is shared between the BPC and the contract farmers. However, production risk is fully borne by the farmers. There are rare cases of dispute between the contractor and the contractee. These disputes are settled through mutual negotiation and understanding.

Broiler farming contracts by the Bangladesh Rural Advancement Committee

The Bangladesh Rural Advancement Committee (BRAC) is the largest national NGO operating in the country as well as abroad. The BRAC's involvement in contract poultry farming has evolved over time. The BRAC is committed to poverty reduction and empowerment of the poor through providing credit, training and technical assistance. According to Saleque (2000), BRAC considered poultry to be a potential candidate activity for income generation among the landless and small farmers, particularly destitute women, many of whom owned a few chickens. In Bangladesh, poultry is kept by 70–90 percent of households, while fewer households keep goats and cattle. Households owning no land or less than 0.5 acre of land own more than 50 percent of the total poultry population. Poultry is sometimes used as the first investment in a "livestock ladder" (in the sense that one can move from poultry to goats/sheep to cattle, etc) to increase income and get out of poverty. During the 1970s and early 1980s, there were almost no job opportunities in the country for the landless, disadvantaged women who were BRAC's targets for relief and development work following the independence of Bangladesh in 1972. Relief could not be a mechanism for creating sustainable livelihoods for poor people. There was a need to provide relief beneficiaries with opportunities to earn an income. It was realiszed that poultry rearing, in which women in relief-beneficiary families were already engaged on a very small scale, could be an income earning activity for a large number of poor women. The belief that, starting with a few chickens, relief-dependent ultra-poor people, especially women, could gradually move away from relief and towards self-sustained livelihood activities was the basic foundation of the poultry model developed by BRAC jointly with the Department of Livestock Services (thus called the BRAC-DLS model) which eventually became a major development innovation (Islam and Jabbar, 2005).

Through trial and error, over the period 1978 to 1985, BRAC developed a smallholder poultry model in collaboration with the DLS, targeting landless and poor households, especially women. Initially there was no model or specific design, but over time several activities were linked together in a network involving nine inter-related actors, each performing a specific task such as hatching eggs, rearing day-old chicks to a certain age, rearing them to mature birds, supplying feeds and vaccination services, and selling eggs and broilers. The DLS used to supply day-old chicks from its hatcheries as foundation material for the network groups. After the model proved to be a success at a pilot scale, it was replicated in wider areas during 1985–1992, when the concept was taken up by major donors such as

the International Fund for Agricultural Development (IFAD), the World Bank and the Asian Development Bank (ADB), and the Government of Bangladesh for replication through development projects over the period 1992–2003. BRAC and the DLS remained involved in the implementation of this large project – providing of some services, along with several other NGOs. The DLS continued to provide day-old chicks for the project participants. However, the DLS's limited capacity to supply day-old chicks became, at some stage, a constraint to expansion of the model. Partly as a response to this problem, BRAC started to produce day-old chicks in order to serve the requirements of the poultry model (Dolberg, 2001). However, in addition to addressing the shortage of day-old chicks for the project participants, BRAC also saw a business opportunity. It used the experience of the poultry model to develop a contract-growing system, whereby it started supplying day-old chicks and other inputs on credit to smallholder producers, and initially bought back eggs and broilers at pre-determined prices. The difference between this system and commercial contract growing is that, as in the poultry model, BRAC kept the focus on poverty alleviation by targeting smallholders and the poor (Islam and Jabbar, 2005).

After the expiry of the smallholder poultry development project in 2004, many of its poultry network groups became non-functional, and in many places the supply chains collapsed. However, BRAC continued to support more efficient and functional groups by supplying day-old chicks through its own rural livelihood programme, while developing alternative mechanisms to promote contract poultry farming as an income-generating activity among smallholders.

Apart from the poverty-focused collaborative poultry development programmes, BRAC has gradually moved to unilateral programmes under varying arrangements. BRAC generally sells day-old chicks and feed to the poultry farmers through dealers. It also provides support for training, vaccines and medicine and helps with the marketing of products, through agents, at the existing market price. At the field level, dealers make an informal contract arrangement with farmers by making credit sale of inputs and often buying output on credit.

During 2002–2004 BRAC tried contract farming in Sherpur District by providing key inputs such as day-old chicks, feed and medicine on credit and buying back broilers at pre-determined prices. The arrangement did not work because of violation of contracts by farmers, particularly during periods of higher market prices when they sold products in the local market instead of selling to BRAC.

Recently, BRAC has entered into an arrangement with "Mexicana Chicken", a fast-food retailing enterprise of the Nasir Group of Industries. Under the arrangement, BRAC supplies "Mexicana Chicken" with hygienic broilers raised through contract growing by 215 farmers in seven districts, namely Gazipur, Manikganj, Norshingdi, Kishoreganj, Tangail, Mymensingh and Brahmanbaria. Batch size varies from 500–2 000 birds, with an average of 800 birds. BRAC supplies day-old chicks and other inputs to the farmers through agents. It also provides technical supervision to the farmers. Quality of the product is ensured through strict scrutiny by BRAC personnel according to specifications suggested by "Mexicana Chicken". BRAC usually enters into a written contract with the producers to buy products at the prevailing market price. The contract includes the provision that if, under certain unavoidable circumstances, the specified quantity and quality of products cannot be

supplied or bought, it must be informed at least three days before the delivery date. Price risk is shared by both contractor and contractee, because the contract price depends on market price fluctuation. The production risk is fully borne by the farmer. The contracting arrangement ensures access to quality inputs for farmers and also ensures a stable market for the inputs supplied by the integrator.

3.2 Input-marketing contracts

There are 130 hatcheries in the country, of which 68 are fully functional, others are partially functional or closed for one reason or another. There are also 52 feed mills. Among these, only three large companies – Kazi Farm Ltd, Paragon Poultry and Nourish Feed Ltd – practise formal input-marketing contracts. A brief description of their operations follows.

Kazi Farm Ltd is the largest producer of parent stock as well as day-old chicks for broiler and layer poultry in Bangladesh. The farm was established in 1996. In 2006, the company also established the largest poultry feed mill in Bangladesh. Kazi Farm Ltd has begun exporting poultry products to the Middle East and Nepal, and is managing the operations of a broiler-breeding farm in the Sultanate of Oman.

To achieve the full potential of the farm, Kazi provides countrywide sales and services. It employs over 100 sales staff, who are stationed in different poultry-producing areas. The day-old chicks and feeds are distributed through 600 feed and chick distributors all over the country. A person who, according to the judgment of the company, is financially solvent and has personal integrity is selected as a distributor or agent for a particular geographical area comprising one or two thanas (subdistricts).

Kazi Farm Ltd enters into a written contract with the distributors, under which the latter have to abide by a set of conditions including fulfilment of a target volume for the purchase of day-old chicks and feed from the company. The distributors are also required to deposit some security money with the company, normally equivalent to the price of 1 000 chicks. The distributors have to purchase day-old chicks and feed through advance payment in cash or as a bank draft. There is no provision of credit sale to the distributors. Under the informal contractual arrangement with the farmers, the company has set up a service network of veterinarians and animal husbandry graduates to help farmers to deal with disease problems. These technical personnel regularly visit the client farmers and offer veterinary services free of cost. This is an investment by the company to ensure chick survival and that the poultry business operates on a sustained basis – thus ensuring that its own feed and day-old chick business can be sustained and expanded.

In this system of contract, both production and price risks are borne by the farmers. However, farmers benefit from the supply of healthy day-old chicks and feed through the dealers both in peak and lean periods.

Paragon Poultry Ltd is one of the largest producers of day-old chicks in Bangladesh. It has developed a special type of contractual arrangement through which it supplies day-old chicks and feeds to poultry raisers through its 205 dealers scattered all over the country. It supplies 400 000 day-old chicks per week and 140 tonnes of feed per day. The company claims more than a 10 percent market share of the day-old chicks produced in the country. The company does not directly participate in purchasing the farmers' products, but some of the dealers help farmers with selling the products. All production and price risks are, obviously, borne by the farmers.

Nourish Feed Ltd is one of the largest poultry-feed producers in the country. It also produces day-old chicks as a supplementary venture. It supplies day-old chicks and feed to the farmers through its 160 dealers operating across the country. The company supplies 300 000 day-old chicks per week and 330 tonnes of feed per day. The company captures a substantial market share for poultry feed and more than 2 percent of the country's day-old chick production. The company considers Kazi, Aftab and Paragon to be the major competitors in the feed market. The company does not directly participate in the purchase of farmers' products, but occasionally helps farmers in the marketing of products through the dealers. As the company does not participate in the purchase of products at any predetermined price, both production and price risks are fully borne by the farmers.

3.3 Output-marketing contracts

Other than the producers, aratdars, wholesalers and output retailers are the three main actors in the output marketing chain.[2] The aratdars and wholesalers of eggs in Dhaka city sometimes make forward purchase contracts with layer farmers in Gazipur District. They also sometimes make contracts with agents who then buy eggs from producers with or without prior contract to supply the aratdars. The difference between this arrangement and formal contract is that these forward contracts are made with existing farms rather than for the establishment of new farms. In this arrangement the aratdars make a lump-sum advance payment, which is adjusted according to the value of products at the time of delivery. The main benefit for the producers is that this cash advance can be considered as a form of credit with which to buy inputs in situations where going to a formal credit agency may be time consuming or problematic. The price of eggs is generally fixed unilaterally by the aratdars. Although these prices remain close to the prevailing market prices, they are sometimes lower than the prices that prevailed during the immediate past, and are therefore unexpected from the point of view of producers. The basis on which prices are set is not made clear by the aratdars. The producers supply eggs without knowing the price beforehand. The aratdars in Dhaka, through their syndicate, set prices on a day-to-day basis, and the producers just have to accept it. It is often alleged that the aratdars extract an unduly high margin/commission through these practices.

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[2] Aratdars are large traders and one of the basic institutions in the traditional market system. They buy and store products for varying periods of time for temporal arbitrage. In the case of broilers and eggs, the storage period is relatively short, as live birds can't be stored for more than a day without incurring extra feed costs and risking loss of weight, and eggs can't be stored for long without risk of spoilage.
Wholesalers are large traders (but smaller than aratdars) dealing with one or more inputs (feeds, drugs, equipment) and/or products (broilers, table eggs). They are licensed full-time traders having fixed business premises in the wholesale market, and they handle a large volume of transactions mainly in bulk. They purchase products from producers and small traders and sell to the retailers.
Output retailers are the smallest traders, having permanent stalls in the section of the markets for broiler and table eggs. Input retailers are similar enterprises dealing with one or more inputs; they operate in local markets or convenient places close to producers. They mostly buy products from the wholesalers and sell to the ultimate consumers or users.

4 IMPLICATIONS OF THE VARIOUS CONTRACT ARRANGEMENTS FOR THE POULTRY INDUSTRY

4.1 Production–marketing contracts

About 600 farm households are involved in production–marketing contracts or the classical type of contract farming under the three enterprises operating such schemes; this accounts for a tiny share of the country's total broiler output market. From the point of view of producers, there is no opportunity to choose among the three operators as they operate in different geographical areas. Thus, there is no competition, as such, with regard to the terms that they offer to prospective participants. There are some differences between the operators in terms of the potential for smallholder farming families or small-scale poultry producers to participate in poultry contract farming as a mechanism to diversify income generation and to achieve some escape from poverty. BRAC is relatively more involved in serving smallholders – the average size of the land and poultry flock of its contractees is the smallest among the three operators – while Aftab's breeder-stock farmers are relatively rich.

The main advantage to the producers is an assured outlet for products; other conditions, such as production- and price-risk sharing and mode of payment for inputs, are variable among the three current operators of this type of contract. However, Aftab's internally generated insurance scheme has something to recommend it for adaptation by other enterprises – not only in the poultry sector, but also in other commercial agricultural operations. There is no similar example of an insurance scheme in the agricultural sector providing service to smallholders, though there is much talk about insurance to cover risks in crop and livestock production. Potential risk of avian influenza may limit expansion of this type of contract arrangement in poultry, and may also lead to the emergence of terms more favourable to integrators. An insurance scheme of the type being operated by Aftab may be modified to accommodate such high-risk events and allow small producers to remain engaged in the poultry sector alongside large operators.

4.2 Input-marketing contracts

A dual structure is emerging in both the hatchery and feed industries: a few large operators are deriving economies of scale and controlling large market shares; they may push smaller operators out of business if policy distortions (cheaper credit, import subsidy on raw materials, tax relief) continue to favour large operators. Continued competition in the industry will be beneficial for suppliers of inputs, input traders and producers, as it will keep prices low and improve the quality of products and services. There is underinvestment in the hatchery industry, so production of day-old chicks is lower than demand. Consequently, to maintain the production cycle, producers are required to make advance orders and advance payments at higher prices. Advance payment requirements may also result from the perishable nature of the product, which means that hatchery owners may want to schedule production based on orders and concomitant delivery schedules. Contract farming is supposed to address this imbalance and uncertainty, but it appears that input-marketing contracts alone, with input sellers and agents having secondary contracts with producers, are not a satisfactory solution to the problem of uncertainty. The feed industry and the commercial feed market is operating slightly better than the hatchery industry in this respect, perhaps because of the less perishable nature of the product; yet there is room for expansion of

investment in this industry. Dependence on imported raw materials and uncertain electric supply are, however, major bottlenecks constraining expansion.

4.3 Output-marketing contracts

Forward-purchase contractors are basically informal money lenders who provide a service in a situation where access to formal credit for small-scale poultry producers is either limited or costly. Asymmetric information on supply, demand and prices, and the market power of buyers derived from this asymmetry, are the main problems for producers under this type of contract. Easier access to formal credit at interest rates and terms comparable to larger operators will increase the bargaining power of small-scale producers becoming involved in forward-sale contracts. Entry of more formal contract farming operators into the industry, easier access to formal credit, feeds and day-old chicks, and better provision of market information on supply, demand and prices to producers and traders will increase opportunities for producers to choose between input-purchase and output-marketing options, and also increase the bargaining power of producers even when they have to be involved in informal forward-purchase contracts.

5 PROBLEMS LEADING TO BUSINESS FAILURE AND THE ROLE OF CONTRACT FARMING IN SOLVING THEM

A survey among commercial poultry producers conducted by Jabbar *et al*. (2005) indicated two fairly common features of the poultry industry: some farms changed from broiler to layer farming or vice versa, while others dropped out of the poultry business altogether. A similar pattern was observed during a more recent survey (Jabbar *et al*., 2007). Change from one type of poultry farming to another indicates that producers respond to anticipated market opportunities and are able to adapt their fixed infrastructure easily or quickly. Many reasons may contribute to the business failures that cause producers to drop out of the business altogether.

In order to understand the causes of business failure and dropping out of poultry farming, a survey was conducted during July–September 2007 among 140 poultry farms in five districts namely – Gazipur, Kishorganj, Jamalpur, Bogra and Rangpur – which have concentrations of commercial poultry farming. As there was no list of the farms that had dropped out of business, purposive sampling was used to select farms for interview. The thanas or subdistricts within each of the selected districts were visited and "drop-out" farms were identified by talking to feed and output traders, DLS staff and other key informants. The interviewees were asked a direct question about the reason(s) for dropping out of the business. The survey also included some additional information to elucidate the nature of the business and its management – including flock size, duration of the business, sources of input supply and veterinary services, training in poultry farming, quality of the poultry houses, feeding and management practices, and the types and skills of the labour employed. This information was used to assess possible links between the stated reason(s) for dropping out and the technical and financial management of the business.

Eighty-four percent of the sample farms raised broilers, while the remainder raised layers. These farms were in business for an average of 3.6±2.6 years: 3.1±1.9 years for broilers and 6.3±4.0 years for layers. Forty-six percent of the layer farms operated for more than

seven years before dropping out, while 61 percent of broiler farms dropped out within three years of establishment (Table 4).

A summary of the interviewees' reported reasons for dropping out of business is presented in Table 5. Most respondents gave multiple answers, so the percentages do not add up to 100. It appears that inconsistency between input and output prices, several problems related to the supply and price of day-old chicks (the basic material for the broiler industry), shortage of capital, high mortality and low productivity, low local demand for products, and difficulty in accessing distant markets are the major reasons that led to business failure and eventual dropping out of the business. All the stated reasons for dropping out of business were found to be enterprise neutral (i.e. there was a similar pattern among broiler and layer farms). They were also scale-neutral: for each stated reason or combination of reasons for dropping out, there was no significant difference between terms of the scale of operation (measured by installed capacity and actual number of birds raised or flock size) between those respondents giving the reason and those not giving the reason (but who might have given another reason). No systematic technical and management problems could be associated with the stated reason(s) for dropping out, except that some associations between high mortality and low productivity could be discerned, which had implications for contract farming type market institutions.

Sixty-six (47 percent) of the sample of 140 drop-out farms gave high mortality leading to unsustainable losses as the main reason for dropping out of business. Among these 66 respondents, 61 percent had had no formal prior training in poultry farming, compared to 81 percent among those who did not give high mortality as a reason for dropping out. Among those who gave high mortality as a reason for dropping out, 42 percent derived their technical knowledge about poultry farming from observing and talking to neighbours, 21 percent from traders of day-old chicks and feeds, 17 percent from drug suppliers or agents of pharmaceutical companies, and 20 percent through trial and error or other means. The corresponding percentages for those who did not give high mortality

TABLE 4
Duration of operation of sample broiler and layer farms before dropping out

Duration of business (years)	Enterprise type		Both
	Percentage of broiler farms	Percentage of layer farms	Percentage of all farms
1	23.7	9.1	21.4
2	19.5	13.6	18.6
3	18.6	9.1	17.1
4	16.1	4.5	14.3
5	11.9	13.6	12.1
6	6.8	4.5	6.4
7+	3.4	45.6	10.1
All	100.0	100.0	100.0

Source: Field survey 2007.

TABLE 5
Causes of dropping out of poultry farming as reported by a sample of farms

Perceived main reason(s) for dropping out	Percentage of the sample
Input price higher than output price/lower price of output/ output price not remunerative	81
Problems related to day-old chicks:	
High prices	63
Desired quality not available	51
Timely supply not available	34
Adequate quantity not available	31
Shortage of capital	60
High mortality of birds	47
Low productivity of birds	43
Low demand for products in local market	33
Moved into other business	29
Disagreement among family members/partners	26
Difficult to sell in distant markets	17

Source: Field survey 2007.

as a reason (but might have given another reason) were 31, 42, 16 and 11 percent. Thus, it appears that lack of proper knowledge of commercial poultry farming, and derivation of such knowledge from amateur or unprofessional sources, was a major reason for high mortality and consequent business failure.

Sixty (43 percent) out of 140 drop-out farms gave losses arising from low productivity of birds as the main reason for dropping out. Of these 60, 75 percent said they did not obtain supplies of day-old chicks on time, 70 percent said they did not get the desired number of day-old chicks, 97 percent said the quality of day-old chicks was low to average, and 89 percent said they had low/average satisfaction with the quality of purchased veterinary drugs. The corresponding percentages for those who did not give low productivity as reason for dropping out (but might have given another reason) were 60, 50, 75 and 63 percent. Thus, problems with the supply of day-old chicks and of quality drugs appeared to be a major reason for low productivity leading to losses and failure of the business, although other reasons could also have played some role.

These are the types of problems (especially those related to reduction of input and output price uncertainty and assurance of a remunerative return for all parties through timely and adequate supply of good quality inputs to produce quality output and reduce mortality) that are ideally addressed by contract farming-type market institutions. In the Bangladesh context, contract farming currently covers a tiny share of the industry, so there is wide scope to expand this type of market organization for the mutual benefit of producers, hatchery owners, feed manufacturers and integrators, and to promote the stable growth of the industry.

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Getting the poultry private sector involved in the development for Africa

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SUMMARY

Africa has the largest number of least-developed countries globally. Aid and debt relief, the traditional remedies offered to overcome the continent's dependency and underdevelopment have not been very effective. To achieve Africa's goal of sustainable development, the development of its private sector is essential. With the change in the role of state, and the increased competitiveness caused by globalization, African countries are increasingly relying on the private sector for economic growth. The private poultry sector in Africa is growing fast, and has the capability not only to influence its economic development, but to serve as a tool for poverty alleviation.

Key words: Africa, poultry, private, sector

1 INTRODUCTION

The agricultural sector is the backbone of the economies of most sub-Saharan African countries, providing food for the populations. Livestock production currently accounts for about 30 percent of the gross value of agricultural production in Africa. Seventy percent of the rural poor in Africa own livestock (Seré, 2004), and as mentioned in the poverty reduction strategy papers prepared by many African governments in the past years, livestock and especially poultry can play a big role in improving nutrition and poverty alleviation.

Food policies have been mostly concerned with promoting increased production of staples. While this is important for good nutrition, food and agriculture policies have done too little to improve dietary diversity and increase consumption. Even though liberalization of the economy means that the private sector is playing a greater role than previously, there is increasing evidence that the reform has not led to the anticipated broad-based sustained growth in farm productivity and incomes, particularly among the small-scale farmers and traders who continue to dominate the region's agricultural systems.

2 THE PRIVATE SECTOR

In recent years, many African countries have undertaken economic reform programmes, and the private sector is now one of the most important actors. It is widely recognized that the private sector institutions in most countries are weak, partly due to the dominance of the state in the past. Enterprises need a wide array of support services, from representation before government, to consulting and technical services, to financing (Kennedy and

Hobohm, 1999). The need for a strong private sector is further evidenced by the poor record of African countries in attracting foreign direct investment.

3 THE INFORMAL SECTOR

Challenges are many, as the formal small private sector faces competition from an informal sector that grows day by day. The informal sector in Africa could account for a significant portion of the GDP and employment. As Muwonge *et al*. (2007) note "There is an ongoing debate in the literature [as to] whether the informalization of African economies is a result of bottlenecks and red tape that hinder smooth operation in the informal sector, and hence compete with the formal sector, or whether the sector is complementing the inadequacy of the formal sector". The International Labour Organization (Xaba *et al*., 2002) illustrates how important the informal sector is to sub-Saharan Africa. In Cameroon, 80 percent of all jobs created in 1992 were in the informal sector. In Ghana, 89 percent of the labour force is employed in the informal economy, and in Nigeria, the informal sector employs one-third of the urban labour force (Muwonge *et al*., 2007).

Relevant studies in the region and casual observation across the continent show that African economies are becoming increasingly engulfed by problems related to the harmful impact of this unregulated sector on the economy in general and revenue performance of the government in particular (ibid.). The 2001/2002 Uganda Business Register reported that the informal sector constituted 150 138 businesses, which is 87 percent of the total 160 883 business establishments in the country (ibid.).

The private sector cannot act alone, it needs to work together with the public sector, and it is often realized that weakness in the capacity of the public sector also needs to be overcome. The role of the state has changed; while public institutions are no longer as directly involved in the provision of goods and services, they still have an important role to play in the development of the private sector, especially in regulating and promoting its development.

Partnerships between the private and public sectors are very important. The governments need to put in place sound and stable "rules of the game" that create a fair, attractive and level playing field, and give the private sector the confidence to get on, and compete, in what it does best: business and creation of wealth.

4 THE POULTRY INDUSTRY IN UGANDA

Livestock production constitutes an important subsector of agricultural production in Uganda. Most livestock production, including poultry, takes place on small farms. It is estimated that commercial flocks for egg and meat production represent only around 14 percent of the total number of birds in the country. Table 1, below, shows the estimated evolution in the number of commercial birds over a period of 11 years. Both production of broilers and layers have increased significantly.

The industry is relatively new in the country, with the first hybrid chickens arriving in the 1950s. In 1965, the first private company started producing animal feed. During the 1970s and 1980s the industry decreased tremendously; chicks, drugs and feeds were allocated by the Government due to shortage in the market. During the 1990s, the animal feed industry, drugs, and veterinary and extension services were liberalized, leading to the emergence of

TABLE 1
Evolution in the number of commercial birds in Uganda (1 000)

Poultry	1993	1994	1995	2000	2004
Commercial layers	597	657	722	1 163	1 658
Commercial broilers	1 274	1 402	1 542	2 483	3 573
Total	1 871	2 059	2 264	3 646	5 231

many feed mills and private practitioners. The private sector invested heavily in breeders and hatcheries.

The poultry sector in Uganda can be classified into three levels of production: indigenous flocks, parent-stock flocks producing hatching eggs for day-old broilers and day-old layers; and commercial flocks of broilers for meat and layers for production of table eggs. Supporting the industry are the feed mills, which provide feed for the whole industry. It is estimated that feed mills in Uganda produce a total of 80 000 tonnes of compound feed per year, sourcing 97 percent of their raw material locally (maize, fishmeal, cassava, cottonseed cake, etc.). Considering that 90 percent of total feed production is directed to the poultry industry, it could easily be said that poultry production is the driving force of agricultural development in Uganda.

Despite the importance of indigenous flocks for the rural population of Uganda, production of eggs and meat is very low compared to commercial flocks. Disease challenges and lack of proper vaccination programmes can in any year reduce the number of indigenous flocks.

The informal poultry sector dominates the scene in the country. While no more than ten feed mills are formalized, hundreds of small mixers have invaded the whole country. Therefore, an organized industry that can sustain the nutritional needs of the people and contribute to the growth of the economy and to the overall development of Uganda is of utmost importance.

4.1 The Poultry Association of Uganda

On 3 September 2004, the Minister of Agriculture officially launched the newly established Poultry Association of Uganda (PAU). For many years, all stakeholders had felt that without an organized association it would be impossible to solve many of the problems affecting the poultry industry.

The association is made up of poultry farmers, hatchers, feed millers, veterinary and animal husbandry service providers, animal and human nutritionists, health workers, economists, policy-makers, educationalists, drug manufactures and dealers – all united in the common cause of fighting malnutrition and poverty, right from the grass roots. The major objective is to transform poultry production in Uganda into a broad-based commercial activity for sustained food security, malnutrition reduction, poverty alleviation and income generation through integrated production, utilization, marketing and trade.

4.2 Challenges and initiatives

Today, poultry is playing a big role in the urban and rural economy in Uganda, acknowledging that there are many challenges to be solved. The emergence of highly pathogenic avian influenza (HPAI) worldwide has brought the poultry industry in Uganda into the picture as never before. Government has discovered a small but organized formal sector with a lot of potential to develop. But, it becomes evident that the sector, formal and informal, needs to be organized, monitored and regulated in order to promote development.

Implementing policy

This requires that the private sector sets itself high standards in terms of the way it behaves, its corporate governance, its approach and attitude toward the evils of corruption, and its approach to environment sustainability. All of that is part of the deal that has to be struck if profit is to be maximized, if growth is to be sustainable and if Africa is to develop (Boateng, 2005). It requires that the public sector equips itself with policy-makers that understand the industry, its dynamism, and its local and its regional context. It requires total commitment of key players and involvement of a multiplicity of disciplines to put policy formulation in context and take into consideration the peculiarities which exist in society, and to ensure that policies are acceptable to all. Polices can be useless if public regulating bodies capable of ensuring minimum standards in the informal poultry sector are not present.

The Animal Feed Bill

The Animal Feed Bill can serve as an example. The draft presented and proposed by the government to the formal sector in 2000 has not been effective, as 50 percent of the total output of animal feeds in Uganda is produced by the informal sector. Feed millers from the formal sector have suggested a pilot test of the bill involving the informal sector. A sensitization workshop involving more than 150 participants was held, and for a period of one year, samples of compounded feeds and raw materials were collected and analysed; the results were published in the newspapers with the names of the company and the standards attained by their respective products. This initiative has demonstrated the urgent need to improve the informal sector by registering premises and setting quality-control standards for the producers in order to create a fair market for all and sustain good production countrywide.

Egg awareness campaign

The egg awareness campaign promoted by the PAU focuses on enhancing consumption of eggs across the whole country by using existing resources: thereby generating a real revolution in the agricultural sector in Uganda. While one egg a day is good advice, per capita consumption of eggs in Uganda is below 20 eggs per year; a marketing campaign will address this issue by sensitizing the population as to the importance and benefits of including an egg in the their daily diet. Research has shown that the content of animal protein tends to be very low in the average African diet (Neumann, 1998). Therefore, raising awareness about the positive contribution that eggs, as a cheap animal protein source, can make to the diet of the Ugandan population, especially children at primary school level, is of utmost importance. It is assumed that an egg awareness campaign will increase egg consumption, and hence the poultry sector as a whole will be promoted.

Harmonizing players

Players in the sector need to be organized, and it has taken five years to form an association. Today, under the umbrella of the PAU, breeders, hatchers, feed millers, processors, commercial farmers and poultry product dealers, are united for a common goal. This is the main reason for having an association that has the objective of promoting the development of the sector and contributing to the development of the whole country. The members feel they are no longer single individuals, but one body looking forward to a better future.

Partnerships

Partnerships in our days are not only fashionable, but a necessity. Companies and particularly those in the poultry sector cannot work in isolation: public–private partnership is the only way to go. The recent HPAI crisis has highlighted the necessity of adapting not only the public veterinary services, which over the years have not been up to the dynamic changes in the sector, but also the necessity of having the private sector setting priorities, harmonizing players and, finally, formalizing the partnership with the public sector as a way of driving towards sustainable development.

5 CONCLUSION

The obstacles to private sector development in Africa are clearly many and varied. This is partly related to former dependency on the public sector as a provider and to the fact that the private sector is young and inexperienced, but above all it is related to the absence of the national or regional policies needed to develop an organized and harmonious sector. In Uganda, as in many African countries, there is an enormous room for expansion in the production; processing and marketing of poultry – see the budget speech for the financial year 2007/2008 (Suruma, 2007). Successful experiences with the private sector fostering growth and development will be realized if good governance, a sound economic environment and well-functioning physical and social infrastructure is in place. With improved policies and upgraded governmental institutions that promote and efficiently regulate the private sector, we foresee that the African poultry sector can contribute to reversing the increasing marginalization of African economies, and finally to changing the focus of the world's eyes towards this continent that is awaiting to be discovered as having the highest potential on our globe.

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Poultry as a development tool

SUMMARY OF DISCUSSION

There was a general consensus that, unfortunately, poverty would persist for the foreseeable future and that poultry keeping would continue to be a widespread livelihood activity among the poor. It was also noted that a problem in Sector 4 (backyard poultry) can be a problem for everyone. It was therefore recognized that this sector requires attention. However, there was some disagreement as to the potential of small-scale poultry keeping as a development tool. According to one point of view it is merely a safety net for the poor, with little potential for development. Others, however, stressed that poultry development is a means to empower and give options to the poor, thus enabling them to participate in the development process and take the first steps on a pathway out of poverty. Further, it was argued that although keeping a small flock of chickens is not in itself a solution to poverty, it can serve as an entry point for discussion of nutrition and other health issues with the owners. It was also argued that there is no clear distinction between the "safety net" and the "development" aspects of poultry keeping as the former is an important function for people who have no access to other forms of savings.

The point was also made that poultry production will inevitably change as society changes, and that there is a need to ensure that development policies do not restrict the opportunities for the poor to move beyond small-scale systems. Conversely, it was argued that there is a need to take into account the possibility that development efforts could expose poorer poultry keepers to greater levels of risk.

There was also some debate as to whether the main need is for poultry specialists or for generalists who can understand village systems, an argument for the latter being that the bottom line is to improve the health and nutrition of the villagers rather than only to promote poultry production; other options for livelihood development need to be considered. It was noted that projects can bring in specialist services as and when needed.

Another question related to the transfer of existing poultry development models to other countries. It was, for example, noted that attempts to introduce the Bangladesh BRAC model into Malawi – a country with a less dense population and fewer NGOs – were not successful. It was argued that approaches need to be adapted to the particular circumstances, starting with local priorities and developing according to the needs of local people.

Several speakers emphasized the importance of partnerships, including the need to work through local institutions and to ensure backing from governments. It was argued that links between private vets and community animal health workers offer an opportunity to overcome the weaknesses that often characterize public-sector delivery of livestock services to the poor. Links between the animal health services and the poultry keepers were also seen as important from the perspective of surveillance for highly pathogenic avian influenza and for other disease threats that may emerge in the future. The need for platforms for debate was noted, with FAO being described as one such platform.

Links to the market and mechanisms for the provision of credit were noted as important elements of poultry development programmes for the poor. Training and capacity-building were also emphasized. It was argued that health and food safety issues need to be better addressed, particularly where more trade in poultry products is seen as an objective. The genetic diversity of local poultry populations was described as a resource that to some extent underpins future sustainability and productivity; opportunities to exploit niche markets of various kinds (tastier or healthier meat) were noted.

Annexes

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Featherless broilers may facilitate industrial production of quality meat under hot conditions

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Genetic enhancement in the growth rate of industrial broilers has increased their sensitivity to heat. The rapid growth is driven by higher rates of feed intake and metabolism, and is therefore associated with increased production of internal heat. Efficiency of heat dissipation is reduced by high ambient temperatures. Thus, under hot conditions modern broilers cannot dissipate all the heat they generate. Heat stress is further exacerbated by increased stocking densities, which result in higher litter temperatures and reduced air movement.

The negative effects of heat can be countered by cooling and ventilation systems, but they are associated with high costs for equipment, maintenance and electricity. Without effective cooling, modern commercial broilers acclimatize to hot conditions by reducing feed intake to minimize the excess production of internal heat. This leads to a significantly lower growth rate and body weight, poorer feed conversion, and specific reduction in breast-meat yield. Moreover, heat stress also reduces the quality of breast meat and may lead to PSE syndrome (the letters stand for three negative meat characteristics: pale, soft and exudative).

Heat dissipation from the body is hindered by feathers. Although advantageous in slow-growing chickens or in broilers that are reared under cooler conditions, under hot conditions feather coverage has a negative effect on thermoregulation. Accordingly, we hypothesized that genetic elimination of the feathers may provide fast-growing broilers with an inherent heat tolerance.

Our featherless broilers were developed by backcrossing scaleless mutants (homozygous sc/sc) to contemporary fast-growing broilers. The featherless broilers, their feathered sibs, and commercial broilers were reared at stocking densities ranging from 7 to 22 birds/m^2, under medium-hot conditions (about 30–32 °C) without cooling or forced ventilation. These conditions are less stressed than, or similar to, actual environmental conditions in simple broiler houses in tropical and subtropical regions.

As expected, the growth of the feathered broilers was depressed by heat, and this effect increased with stocking density and with the age of the birds; their mean body weight (BW) at 44 days ranged from 2.3 kg (7 birds/m^2) to 1.8 kg (17 birds/m^2). In contrast, growth of the featherless broilers was minimally affected by density, with mean BW ranging from 2.4

kg (12 birds/m^2) to 2.2 kg (17 birds/m^2) and 2.1 kg (22 birds/m^2), with the latter resulting in overall live weight production per unit floor area of 46 kg/m^2. The stress of heat and high stocking densities reduced breast yield in the feathered broilers to 15–16 percent, whereas in featherless broilers, breast meat yield was in the range of 19–20 percent under all stocking densities, with superior industrial meat quality: not pale, not soft, and having better water holding capacity. These features, along with the ease of processing (because feather plucking is not needed) and minimal skin fat, make the featherless broilers especially suited for industrial processing, deboning and further processing.

In summary, standard (feathered) broilers suffer under hot conditions, as evidenced by depressed appetite, elevated body temperatures, and higher incidence of heat-related and disease-related mortality. These effects are rare in fast-growing featherless broilers reared under hot conditions. Moreover, featherless broilers can contribute to sustainable production in hot regions, in two ways:

1. There is no need to use costly energy (and equipment) for climate control in the broiler houses. In addition to saving scarce global resources, independence from costly cooling and ventilation facilitates efficient broiler production also in developing countries, especially in regions (or by farmers) lacking a reliable supply of electricity for climatic control in broiler houses.
2. About 15 percent of broiler feed nutrients, mainly the amino acids, are used to build the feathers that are later discarded as waste at the slaughterhouse. These nutrients are saved in featherless broilers, apparently contributing to their higher meat yield. Moreover, a 10 percent reduction in dietary nutrients was shown to have no negative effect on growth rate, feed conversion ratio or meat yield in featherless broilers.

Poverty reduction in Bangladesh through microfinance and poultry development

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1 INTRODUCTION: MICROFINANCE IN BANGLADESH

Bangladesh is a global centre of excellence in microfinance. Its microfinance programmes have been acclaimed worldwide for their success in providing poor people with access to credit. It has been shown that a series of successive micro-loans can not only lift a household out of poverty, but with over 90 percent of the loans being to women, also lead to considerable empowerment and improvement in the position of women at the household level. In 2006, Dr. Muhammad Yunus and the Grameen Bank, the pioneers of microfinance in Bangladesh, were awarded the Nobel Peace Prize for their work.

2 THE ROLE OF PALLI KARMA-SAHAYAK FOUNDATION IN MICROFINANCE

Palli Karma-Sahayak Foundation (PKSF) is the world's largest apex lending and capacity-building institution in the field of microfinance. It presently services about 200 microfinance institutions, many of them NGOs. The loan portfolio is US$ 275 million and the total number of members is 7 million. On the assumption of five members per household, this indicates an outreach to 35 million people. In microfinance programmes the borrowers' repayment rates are typically high – at 98 percent or even higher. PKSF's repayment rate to the government is 100 percent.

3 PKSF AS A PARTNER IN THE USE OF POULTRY AS A DEVELOPMENT TOOL

PKSF has worked with donor and development organizations such as the International Fund for Agricultural Development (IFAD), Danida and the Asian Development Bank (ADB) in projects that use, or have used, poultry as a tool in human development. The background to this is that poultry production adds more value than any other industry accessable to poor women and their families. The following points are also important:

- that the government has declared poultry as a thrust sector and classified it as an agro-based industry;
- that the government has liberalized its policies by introducing easier loan procedures, lower interest rates, and tax holidays; and
- that poultry production contributes to poverty reduction, to the generation of new employment, and to people's nutritional status.

4 FACTORS CONSTRAINING POULTRY DEVELOPMENT IN BANGLADESH

Factors that constrain poultry development in Bangladesh include: (i) inadequate and inappropriate training of the various livestock cadres; (ii) lack of technical staff within the Micro Finance Institutes (MFIs), and poor linkages between the government veterinary services and the MFIs; (iii) immobility of the government staff; and (vi) lack of clear understanding of the modalities of the poultry model among MFIs and at government level.

5 SMALLHOLDER POULTRY – AN EXCELLENT TOOL FOR POVERTY ALLEVIATION

Despite the above-mentioned constraints, smallholder poultry can be an excellent poverty alleviation tool (Dolberg, in FAO, 2003) because nearly all rural, poor and landless households own poultry, because poultry is mainly owned and managed by women and children, and because ten chickens under improved management are enough to create a positive impact. The following technical features of smallholder poultry development should be noted:

- it can be started with hardly any assets;
- the technology is simple and easy to adapt and apply;
- it is based on traditional poultry-rearing knowledge;
- the inputs required are locally available; and it has a built-in marketing mechanism.

6 IMPACT

The impact can best be illustrated through a case study.

Case study: Jhumi is no longer a burden on anybody

Abdul Mannan is a poor man, who is more than 50 years old. He lives in Lalkhatangi Village 10 kilometres from Sylhet town in the northeast of Bangladesh. He has three daughters and one son. Because of his age he cannot work as he once did. His family lives from hand to mouth.

Jhumi is Abdul Mannan's eldest daughter. She had to give up her studies for tenth class examination, as her father was unable to continue to support her education. Instead, she became the only family member earning an income. She sacrificed her education and devoted herself to housekeeping, together with her mother. After some time she became frustrated with her inactive life. She heard from her neighbours about the Micro Finance and Technical Support Program (MFTSP) of VARD (a partner organization of PKSF which is working in eastern Bangladesh).

She joined VARD as a member of the Lalkhatangi Group on 19 June, 2004, and because she was able to read and write she became cashier of her group. The first training she received was on social development. She learned about the savings and credit programme, human nutrition, cleanliness, vitamins and minerals, child care, child education, women's rights, homestead gardening and integrated farming. The loan she took was a small one – taka 5 000 (US$ 70). With this she started a very small grocery shop. Her parents helped her to run it. After seven to eight months she heard from VARD's Field Worker and the Livestock Technical Assistant (LTA) that with less labour, time and investment it would be possible to earn more profit by keeping poultry, provided she had the right knowledge – and

this she could get through the project's training programme. The LTA told her that there are many opportunities in the poultry business, especially by becoming a Parent Breeder. Jhumi thought that she could run this business in her house.

In the meantime, the Project Coordination Unit of the MFTSP arranged training on Model and Parent Breeder management at TMSS (a partner organization of PKSF) in Bogra District. Here Jhumi attended a seven day training programme on keeping and managing a flock of poultry that produces hatching eggs. In the project's terminology this is called a Parent Breeder. After she returned from the training she took her second loan, which was US$ 3 000. Her first loan was repaid by profit she earned from running the grocery shop. From the US$ 3 000 she made a house for her chickens – 46 hens of the Fayoumi breed and six cocks of the Rhode Island Red breed. After five months, she was getting 35 fertile eggs on average per day. The LTA helped her to establish a link with the hatchery that used her eggs. This hatchery – called the Rice Husk Hatchery – is another enterprise under the project (Nahar *et al*., 2006). By now, Jhumi sells fertile eggs to Mira's Mini Hatchery for taka 6 per egg. Mira (the lady who runs the mini-hatchery) is another participant in the MFTSP.

After meeting all her expenditures, Jhumi is now earning US$ 50 per month from her Parent Breeder Farm alone. Her future plans are to establish a larger Parent Breeder Farm. She has not only become self-dependent, she ensures food for all her family and has become a role model for the young ladies of her village. Another three young ladies have started poultry farms. The villagers are taking advice from her as a specialist. She is proud of her profession and the villagers are also proud of knowing their own specialist.

7 LESSONS LEARNED

- Demand-driven microfinance approaches with appropriate technical support provided to savings and credit groups work very well, and produce significant impact among beneficiaries.
- The livelihood of rural poor (especially women) can be improved significantly by providing training in activities pertaining to natural resources, such as poultry production.
- Poultry rearing is highly successful in reaching the poor, particularly women, and has generated significant benefits in terms of poverty reduction.
- Poultry is one of the few enterprises in which a large number of landless and poor women can participate.
- Intensive supervision and monitoring is needed for the success of the programme.
- Commitment on the part of the NGOs, and the establishment of linkages with service and input providers, are extremely important.
- Continued NGO support (microfinance and technical) beyond project closure is essential for the sustainability of the programme.

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Continuing education in the prevention and control of highly pathogenic avian influenza: a case study on Indonesia

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1 INTRODUCTION

Highly pathogenic avian influenza (HPAI) subtype H5N1 is now endemic across much of Indonesia. This situation has revealed a lack of human-resource capacity in many institutions especially in terms of understanding of, and experience in, the control of poultry diseases. An example of this situation is the endemicity of Newcastle disease and very virulent infectious bursal disease; outbreaks of these diseases, particularly in smallholder and village flocks, are not actively reported or controlled.

2 PREREQUISITES FOR EFFECTIVE HPAI PREVENTION AND CONTROL

The effective control of HPAI requires:

- understanding the behaviour and ecology of influenza viruses generally and of this subtype in particular;
- understanding the perspectives and decision-making processes of key stakeholders (e.g. poultry producers from all production systems, workers, traders, disease control officers) with regard to poultry health and disease control;
- understanding the different local poultry production and marketing systems, in themselves and within the wider system (e.g. within the local farming system for sectors 3 and 4);
- understanding how the characteristics of the local poultry production and marketing systems affect the evolution of HPAI;
- mobilizing all stakeholders to engage in the preparation of HPAI responses and to actively practise adequate measures in all three phases of an HPAI outbreak – pre-outbreak (prevention), occurrence and post-outbreak (Bagnol, in FAO, 2007);
- ensuring that donors, national governments, media and civil society collaborate and are involved in the development of the strategy; and

FIGURE 1
A PDSR Officer shares information about the prevention and control of HPAI with a community in Yogyakarta, Indonesia

- adapting the communication process to the anatomy of outbreaks and the needs of the different stakeholders (Alders and Bagnol, 2007).

3 IMPLEMENTING HPAI PREVENTION AND CONTROL

Cost-efficient prevention and control of HPAI are built on a sustainable poultry health programme that incorporates collaborative research and development activities involving the public and private sectors. The programme must provide appropriate education, communication and services to: all poultry producers, workers and traders; community animal health workers; field veterinarians including Participatory Disease Surveillance and Response (PDSR) Officers, livestock officers and extension workers; and senior decision-makers at national, provincial and district levels.

4 CONCLUSION

Education and communication materials developed in collaboration with field veterinarians (both public and private) and small-scale and village poultry producers involved in HPAI prevention and control communicate more effectively and provide information appropriate to the local context.

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Promotion of HIV/AIDS mitigation and wildlife conservation through improved village poultry production in Southern Africa

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1 INTRODUCTION

Many poor rural households in developing countries rely on village chickens (FAO, 2004a). In rural households affected by HIV/AIDS and areas surrounding protected wildlife populations, they play a particularly important role (Alders *et al.*, 2007; McDonald, 2006). In farming households, the illness or death of family members due to HIV/AIDS leads to loss of valuable labour resources (FAO/UNEP, 2002). Consequently, the focus of household activity turns to maintaining family food security. In affected households, food security is maintained through revising the complex division of labour in accordance with the possibilities presented by the local farming system. Throughout Africa, expanding human populations have created situations in which large numbers of poor people live close to protected wildlife populations. Inevitably, the needs of people and wildlife come into conflict. One approach to ensure that meat intake is maintained while reducing bushmeat hunting is to improve the ability of people to subsist on alternative sources of protein and income.

Village chickens provide a scarce resource – animal protein – in the form of meat and eggs, and can be sold or bartered to meet essential family needs such as medicine, clothes and school fees. Village chickens are active in pest control, provide manure, are required for special festivals and are essential for many traditional ceremonies. The output of village chickens is lower than that of intensively raised birds, but it is obtained with minimum input in terms of housing, disease control, management and supplementary feeding. The chickens are generally owned and managed by women and children (Guèye, 2000) and are often essential elements of female-headed households (Bagnol, 2001). As women are the main carers of sick people, chickens can play an important role as they provide the women with additional resources to carry out their important task of supporting people living with HIV/AIDS.

The components of village poultry production include indigenous poultry breeds, feed, shelter, disease control, and community collaboration and group formation (FAO, 2004b).

2 PROJECT: HIV/AIDS MITIGATION IN MOZAMBIQUE

The main activities of this project include: baseline studies and annual participatory rural appraisals; training local NGOs volunteers as community vaccinators against Newcastle disease (ND) (Alders *et al.*, 2003); training NGO technical staff and local government agricultural staff in ND control; implementing ND vaccination campaigns; training farmers to experiment with low-cost improvements to village poultry husbandry; working with volunteers and NGO staff, local health posts and primary schools to promote village poultry production and consumption of poultry meat and eggs; and technical backstopping, and monitoring and evaluation. The project has demonstrated the potential to deliver triple benefits: direct support to people affected or infected by HIV/AIDS (FAO, 2005); income generation for carers and community-based organizations; and an increase in the capacity of communities to support welfare activities.

3 PROJECT: WILDLIFE CONSERVATION IN ZAMBIA

This project focuses on the sustainable control of ND in village poultry (Alders *et al.*, 1994; Songolo and Katongo, 2001); improved village poultry husbandry and management strategies including marketing (Alders, 2007; McDonald, 2006); and improved household

FIGURE 1
Sra (Mrs) Celestina Zimbawe, a widow in Manica Province, Mozambique

Celestina received one rooster and three hens. Six months later, she had 21 birds. She was delighted with the results and so were her children. Celestina also helps with the training sessions for child-headed households and continues to provide advice to four households in her local area

welfare, including improved nutrition and food security as a means of reducing the need for communities surrounding South Luangwa National Park to hunt, eat and sell bushmeat (Faiela *et al.*, 2007).

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Structural changes in the Brazilian poultry sector 1995 to 2005[1]

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SUMMARY

Between 1995 and 2005, Brazil became a world agricultural powerhouse. Agriculture was no longer viewed as something of the past, but as a segment in which Brazil could excel due to its natural conditions. Meats are among the leading "new" agricultural products that have contributed to this change, and in this period the country consolidated a position as one of the major poultry producing and exporting countries in the world.

The interdependence of international markets requires that producers for export adapt to demands that differ from those prevailing in their immediate markets (e.g. 100 percent vegetable feeds; GMO-free feeds; traceability to grandparents; constant audits of quality assurance, food safety, ethics, environment, animal welfare, etc; and slaughtering according to different religious precepts), thus forcing the sector to develop the production flexibility that in the long run enhances its competitiveness.

The paper discusses the importance of the poultry sector for the economy of Brazil, and how it has evolved in a country where bovine meat has been historically dominant. Supported by abundant statistics, it shows the growing importance of poultry to the country at both the national and international levels.

It describes the factors that have contributed to this evolution, points out the contribution of the sector's concept of hunting and defending "in a pack" as one of key factors accounting for Brazil's leading position, regardless of the fierce competition among the leading local companies. As occurs in most major producing countries, the poultry business is moving towards concentration. There is an incipient presence of foreign capital attracted by the unique competitiveness of the segment – a presence that is expected to expand in the coming decade.

It establishes the origins of the poultry industry and its march towards the Centre-West Region, describes the production systems and presents the future perspectives for this industry in the a country rich in grains, water and which has immense reserves of agricultural land. It counterpoints this positive scenario with concerns regarding the insufficiency of public investments in infrastructure, education and budgetary limitations affecting the public agricultural research and organization that are not in line with the sector's progress.

[1] This report was prepared as background information for the international conference *"Poultry in the 21st century – avian influenza and beyond"*, but was not part of the originally published proceedings.

Rich in detailed statistics, the paper contributes to an understanding of how Brazil became a world poultry leader. Without advocating a Brazilian model, it presents the author's views regarding factors that have permitted a developing country to face subsidized competitors from developed countries, some which might be emulated by other developing countries.

1 THE CHANGING POULTRY SECTOR

1.1 The relative importance of the sector

In 2005, Brazil was the third largest agricultural and food exporter in the world, behind only the United States of America and European Union (EU) (25 countries). Described as an "agricultural powerhouse", the country has the potential for continued growth. In addition to its current 62 million hectares (153 million acres) of arable land, Brazil has an estimated 90 to 107 million hectares of potential arable land. The country also has one of the world's largest reserves of water. A document published by Brazil's Ministry of Agriculture and Livestock[2] states that the country is using one-third of its potential arable land (Table1).

TABLE 1
Brazil Use of the Land in 2005

	In million of hectares	% over total area	% used in agriculture
Brazil total area	**851**		
Protected areas	55	6.46%	
Cities, lakes, roads	20	2.35%	
Other uses	38	4.47%	
subtotal	738	86.72%	
Amazon Forest	345	40.54%	
Pastures	220	25.85%	33.73%
Annual Cultures	47	5.52%	
Permanent Cultures	15	1.76%	
Cultivated Forests	5	0.59%	
Available area for agriculture w/out Amazon Forest	106	12.46%	

Source: MAPA (2007a)

[2] MAPA (2007a).

Agribusiness was responsible for 23.2 percent (R$540.1 billion)[3] of Brazil's gross national product (GNP) (R$2 332.936 billion)[4] in 2006; this figure is estimated to reach R$564.36 billion or 23.3 percent in 2007.[5] Brazil is a significant world exporter of soybeans, sugar, coffee, orange juice, tobacco, and bovine and poultry meats. It figures among the ten largest world producers of 40 different agricultural products.

TABLE 2
Brazil - Country Rank in the World Production of Agricultural Commodities - 2005

Commodity	World Rank	Commodity	World Rank
Beans, Dry	1	Persimmons	4
Coffee, Green	1	Pineapples	4
Mate	1	Avocados	5
Oranges	1	Cocoa Beans	5
Papayas	1	Eggs, excluding Hen	5
Sugar Cane	1	Lemons and Limes	5
Bananas	2	Indigenous Turkey Meat	6
Cassava	2	Jute-Like Fibres	6
Indigenous Cattle Meat	2	Cow Milk, Whole, Fresh	7
Indigenous Chicken Meat	2	Hen Eggs	7
Soybeans	2	Buckwheat	8
Tobacco Leaves	2	Fruit Tropical Fresh nes	8
Cashew Nuts	3	Indigenous Horse Meat	8
Castor Beans	3	Mangoes	8
Maize	3	Rice, Paddy	9
Pepper,White/Long/Black	3	Tomatoes	9
Tang.Mand.Clement.Satsma	3	Figs	10
Coconuts	4	Natural Rubber	10
Cocoons, Reelable	4	Onions, Dry	10
Indigenous Pigmeat	4	Sorghum	10

Source: FAO, Economic and Social Department, The Statistics Division, Major food and Agricultural Commodities and Producers http://www.fao.org/es/ess/top/topproduction.html?lang=en&country=21&year=2005

[3] MAPA (2007b).

[4] IPEA – Instituto de Pesquisa Econômica Aplicada (Research Institute of Applied Economics), (http://www.ipea.gov.br/default.jsp) IPEADATA, Sinopse macroeconômica (Macroeconomic synopsis).

[5] MAPA (2007a).

Agribusiness exports in 2006 (US$49.428 billion) represented 36 percent of all Brazilian exports. In 2006, agriculture contributed US$42.7 billion to the country's US$46.1 billion balance of trade surplus.

TABLE 3
BRAZIL - AGRIBUSINESS TRADE[6] *US$ millions*

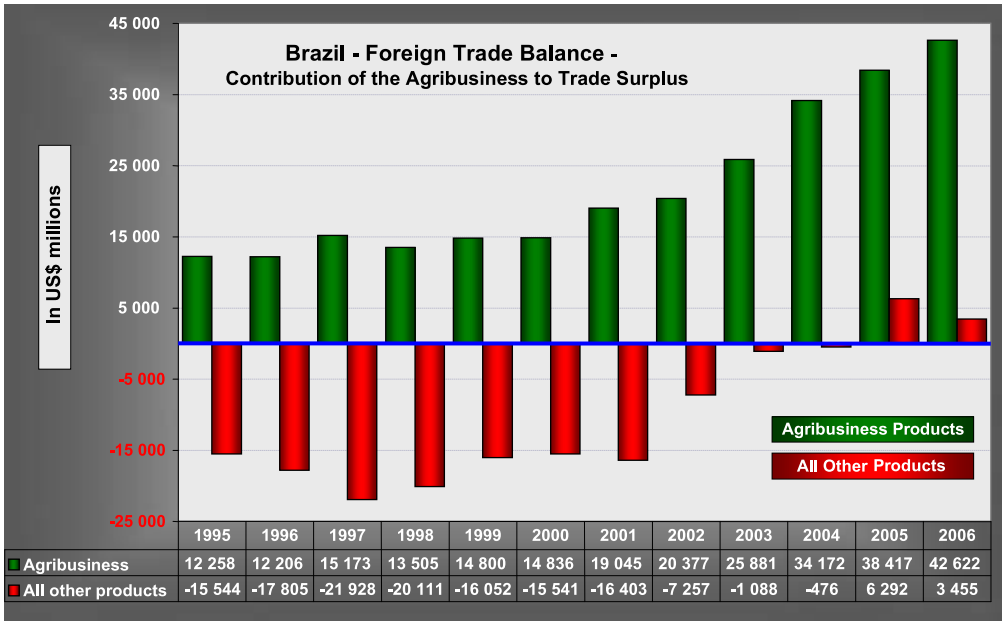
TRADE	2005			2006			Change	
	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS
Total trade	118 308	73 599	44 709	137 471	91 394	46 077	16.2%	24.2%
All other products	74 707	68 415	6 292	88 043	84 588	3 455	17.9%	23.6%
Agrobusiness	43 601	5 184	38 417	49 428	6 806	42 622	13.4%	31.3%
Share (%)	36.85	7.04		35.95	7.45		-2.4%	5.7%

It is not an overstatement to say that agribusiness exports allowed Brazil to accumulate its foreign currency reserves (US$177 060 million in November 2007)[7] and that it has been decisive in enabling the country to reduce its international debt to levels acceptable to the international finance community. Meat is presently the third most important of Brazil's agribusiness exports and is one of the main sources of foreign trade surplus.

[6] Source: data from ALICE-WEB (or simply ALICE) – Análise das Informações de Comércio Exterior (Foreign Trade Information Analysis), a database available via the Internet developed by the Secretaria de Comércio Exterior - SECEX (Secretary of Foreign Trade), from the Ministério do Desenvolvimento, Indústria e Comércio Exterior – MDIC (Brazilian Ministry of Economic Development, Industry and Foreign Trade). ALICE-Web is updated on a monthly basis with statistics on Brazilian exports and imports obtained from the Sistema Integrado de Comércio Exterior - SISCOMEX – (Foreign Trade Integrated System), governmental management system of the Brazilian foreign trade. (http://aliceweb.desenvolvimento.gov.br/default.asp).
This table was elaborated by MAPA/SRI/DPIA (Agribusiness International Relations Secretariat, Agribusiness International Promotion Department, General Coordination of Export Organization – CGOE). Data are available on their Web site, under "Indicadores e Estatísticas, Balança Comercial, Balança Comercial do Agronegócio" (Indicators and Statistics, Balance of Trade, Agribusiness Balance of Trade), 2005/2006 (http://www.agricultura.gov.br:80/portal/page?_pageid=33,5020270&_dad=portal&_schema=PORTAL).

[7] Source: Banco Central do Brasil BACEN (Brazil's Central Bank) (http://www.bcb.gov.br/?INDICATORS).

FIGURE 1
Contribution of agribusiness to Brazil's trade surplus, 1995–2006



Source: elaborated with data from ALICE (Análise das Informações de Comércio Exterior) (http://aliceweb.desenvolvimento.gov.br/default.asp).

TABLE 4
Brazil – Agribusiness Exports – Meats – 2005-2006

Brazil exports of main agribusiness products	2005		2006	
Total agribusiness exports	USD 43 600 934,00		USD 49 427 574,00	
	US$ 000	**% total exports**	**US$ 000**	**% total exports**
MEATS	**7 976 561**	**18.3%**	**8 346 452**	**16.9%**
		% meat exports		**% meat exports**
Bovine meat	2 419 103	21.6%	3 134 436	37.6%
Bovine meat processed	613 718	5.6%	724 493	8.7%
Chicken meat	3 324 209	54.9%	2 922 633	35.0%
Chicken meat processed	184 339	1.7%	280 781	3.4%
Turkey	168 251	2.2%	112 104	1.3%
Pork	1 123 151	11.5%	990 118	11.9%
Other meats	143 790	2.5%	181 887	2.2%

Source: elaborated with data from ALICE (http://aliceweb.desenvolvimento.gov.br/default.asp).

Poultry meat exports represented 58.8 percent of the country's meat exports in 2005, a percentage that dropped to 39.7 percent in 2006 – Brazil suffered severely as a result of drops in demand caused by highly pathogenic avian influenza (HPAI) in some of its main export markets, such as Europe, the Middle East and the Far East. In 2006, beef exports represented 46.3 percent of Brazil's total meat exports. Preliminary figures for 2007 indicate that poultry and beef will each represent 40 percent of total meat exports.

This fundamental change that took place during the period between 1995 and 2005 has provided the Brazilian agribusiness entrepreneur with more stable economic conditions under which to operate. It may be hard for a foreign entrepreneur, above all those from developed countries, to appreciate the importance of stability to their Brazilian counterparts. Nonetheless, it is a major change and will certainly contribute to enhancing, if not their competitiveness, then at least the rules of engagement.

It would perhaps help to understand the importance of economic stability if we consider that from 1975 to 1995 the Brazilian entrepreneur had to cope with an economy in which inflation reached as high as 84 percent a month, and in which eighteen zeros were cut from the national currency (which changed name six times).

The new stability is most certainly among the top structural differences between the Brazil of 1995 and that of the present day. Agribusiness is at the root of this structural change, and meats are among the leading "new" agricultural products that have contributed to this shift. The poultry-meat sector was the first to show how international markets could leverage the growth of an entire sector and positively influence internal consumption through constant innovation, high quality standards and product differentiation. Brazilian meat exports followed the road opened by the poultry sector, and soared by 506 percent in terms of tonnes and 459 percent in terms of US$ FOB (free on board) value during the period between 1996 and 2006.

TABLE 5
Brazilian Meat Exports – 1996-2006

	All Meats		*Bovine*		*Pork*		*Poultry*	
	US$ FOB 000	**tonnes**	**US$ FOB 000**	**tonnes**	**US$ FOB 000**	**tonnes**	**US$ FOB 000**	**tonnes**
1996	1 493 879	811 368	430 628	134 306	128 821	59 751	890 978	571 578
2000	1 893 808	1 450 735	755 183	312 066	173 800	123 880	904 096	917 470
2005	7 976 561	5 029 646	3 032 821	1 366 775	1 123 151	579 413	3 676 799	2 957 783
2006	8 346 452	4 916 388	3 858 929	1 502 200	990 118	484 217	3 315 518	2 791 950
% Growth								
2006/1996	**458.7%**	**505.9%**	**796.1%**	**1018.5%**	**668.6%**	**710.4%**	**272.1%**	**388.4%**
1996			28.8%	16.6%	8.6%	7.4%	59.6%	70.5%
2000			39.9%	21.5%	9.2%	8.5%	47.7%	63.2%
2005			38.0%	27.2%	14.1%	11.5%	46.1%	58.8%
2006			46.2%	30.6%	11.9%	9.8%	39.7%	56.8%

Source: Alice.

There are other reasons to begin this paper by stressing the importance of poultry exports to the country's trade surplus. The various Brazilian authorities that interact with the poultry industry have recognized this importance, and relations are considerably better than they were in the past.

The poultry industry has always had close relations with the Ministry of Agriculture and with the Ministry of Foreign Relations. These relations were conducted through its main associations, União Brasileira de Avicultura (UBA) (Brazilian Poultry Union) and Associação Brasileiras do Produtores e Exportadores de Frango (ABEF) (Brazilian Chicken Producers and Exporters Association).

Until the early 1990s, state organizations or agencies were more active in inspection and control of the industry. This reflected the heavy intervention and involvement of the state in the economy during the military regimes that held power between 1964 and 1985. Private entrepreneurs were not regarded very positively by state organizations which in many instances had the power to control almost every aspect of the life of a company, including decisions regarding to whom and at what prices products could be marketed.

The state totally controlled exports and had the power to deny authorization for sales if the product in question was needed to assure internal supply or if they judged the export price to be insufficient. From 1978, the shortage of foreign currency became acute; import permits were extremely hard to obtain, and a parallel market of foreign currency boomed. Authorities would examine every single export operation to see whether exporters were keeping foreign money abroad.

Many key products had special state agencies which controlled every aspect of the activity; examples included the – Instituto Brasileiro do Café (IBC) (Brazilian Coffee Institute) and the Instituto do Açúcar e do Alcool (IAA) (Alcohol and Sugar Institute). Fortunately, there was no Brazilian Institute of Poultry or of Meat, probably because agriculture and livestock were perceived by the authorities to be less relevant "raw materials" or "basic products". The military regime saw industrialization as the top priority for the country's economy, and thus grains and meat were "things of the past". We had no Institute of Meat, but state-owned trading houses would compete with the private companies.

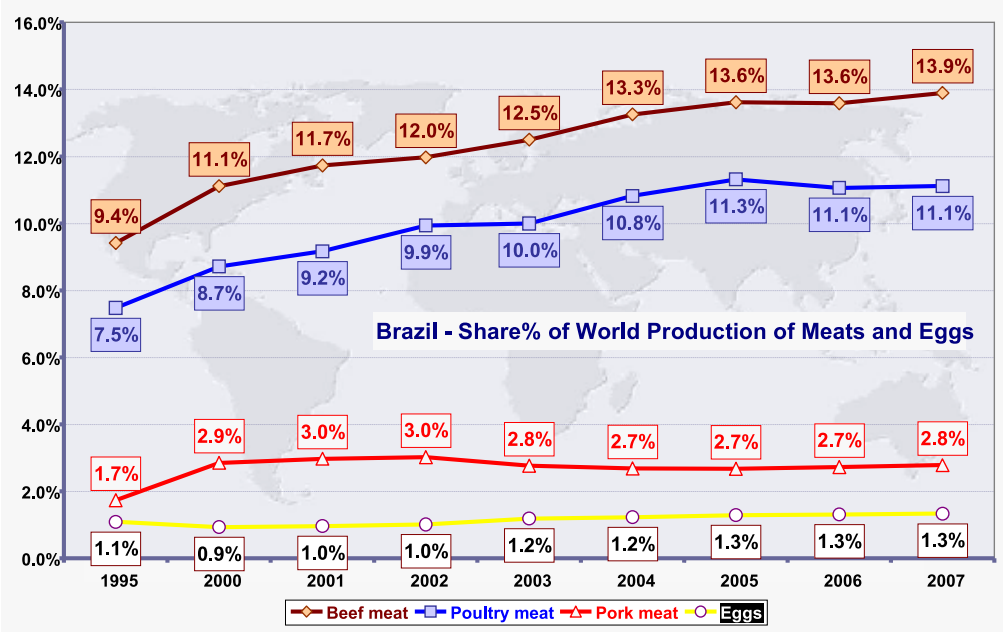
Professor Delfim Netto, Finance Minister (1967–1974) and Economic Planning Minister (1979–1985), pursued a policy of promoting exports as opposed to merely restricting imports. He granted fiscal and financial incentives to exporters, along with more flexibility in authorizing imports. For an industry which depended on essential micro-elements for feed production and which was eager to import modern equipment, this was particularly attractive.

The early 1990s brought changes – with the principles of the market economy starting to prevail, along with the extinction of fiscal and finance incentives to export. From 1995 onwards, a policy of reducing state intervention in the economy and of privatization of state-owned companies gave rise to a new era in relations between state agencies and the private sector. During the period 1995 to 2005, these relations evolved towards cooperation, establishment of joint action strategies and development of synergies. Several ministers with experience in the private sector helped to achieve this structural change – and results were obtained. Agriculture was no longer viewed as a thing of the past, but as a sector in which Brazil could excel thanks to its natural conditions.

1.2 Brazil and the world – selected animal products

One of the consequences of the new relations between the state agencies and the private sector, which prevailed after 1995, was that they helped Brazil to become one of the world's major meat producers. By 2005, Brazil represented 13.6 percent of world beef production and 11.3 percent of world poultry production.

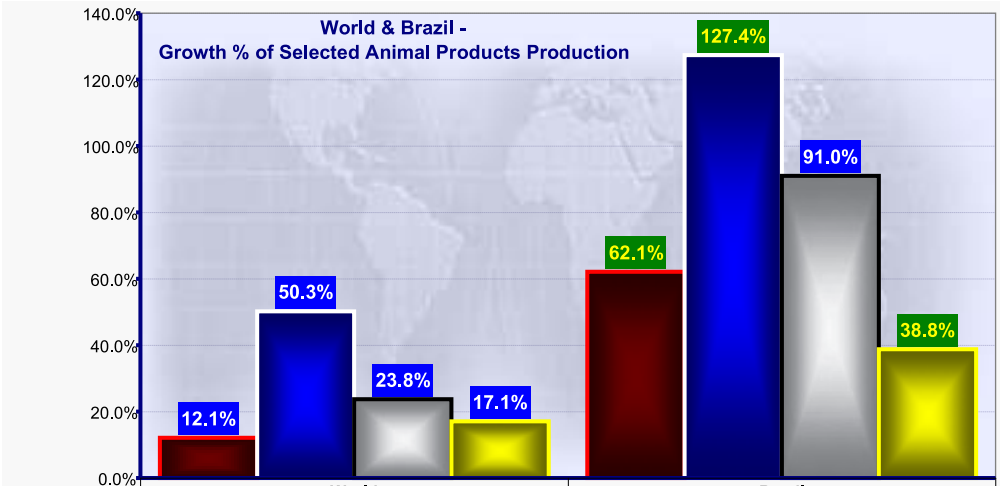
FIGURE 2
Brazil's share of world meat and egg production



Source: elaborated with data from OECD.Stat.

During the period 1995 to 2005, Brazilian beef production grew by 62.1 percent, as compared to 12.1 percent growth in world beef production. Poultry production grew by 127.4 percent, as compared to 50.3 percent for the world as a whole. Pork production grew by 91.0 percent as compared to 23.8 percent for the world as a whole. From 1995 to 2005, Brazilian beef, poultry meat and pork production grew, respectively, at 5.1, 2.5 and 3.8 times the world growth rate. Egg production grew at 2.3 times the world growth rate.

FIGURE 3
Meat production growth 1995 to 2005 – world and Brazil

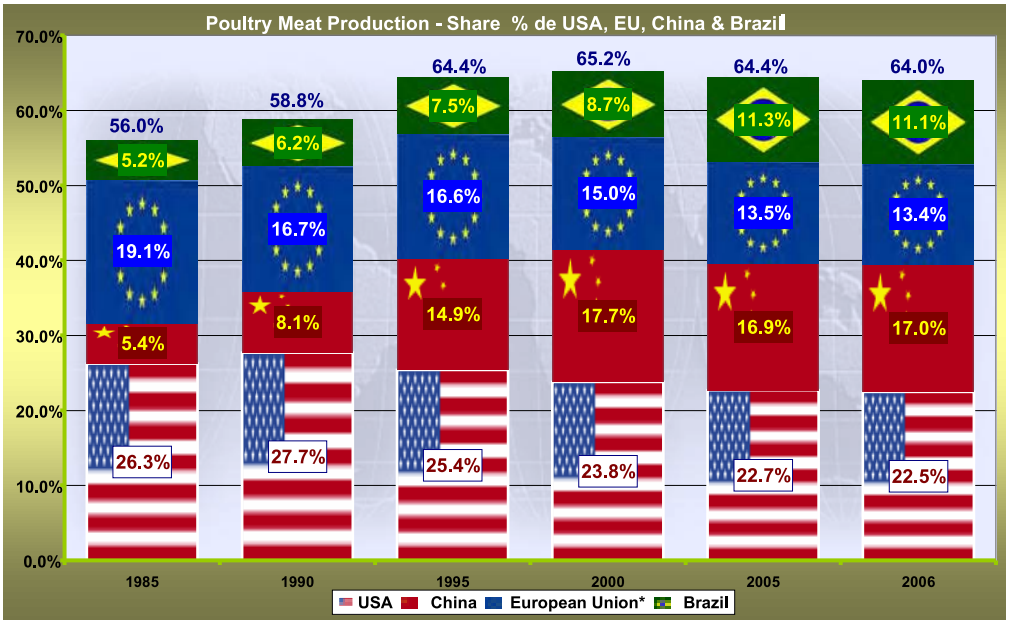


	World	Brazil
Beef meat	12.1%	62.1%
Poultry meat	50.3%	127.4%
Pork meat	23.8%	91.0%
Eggs	17.1%	38.8%

Source: elaborated with data from OECD.Stat.

Poultry-meat production is highly concentrated in a few countries. Until the early 1990s, the United States of America and the EU (15 countries) accounted for about 45 percent of production. During the 1990s, both China and Brazil acquired a significant share of world production. Almost two-thirds of world poultry production now comes from only four countries, among which Brazil and China had the highest accumulated growth in production during the period 1995 to 2005. The growing importance of Brazil and China has contributed to the migration of poultry-meat production from developed to developing countries – a process which is forecast to continue in the future.

FIGURE 4
Market share of poultry meat production – selected countries, 1985–2006



**European Union – 25 countries from 1995 onwards.*
Source: figures for the years 1985 and 1990 are from FAOSTAT. Figures for 1995 to 2006 are from OECD.Stat.

TABLE 6
Poultry production accumulated growth – world and selected countries, 1995–2005

World	50.3%
United States	34.1%
European Union-25	22.5%
Brazil	127.4%
China	70.9%
Other Countries	41.2%

Source: : OECD.Stat

Among the four leading countries, it is the United States of America and Brazil that have the natural conditions (arable land, photosynthesis and water) to maintain leading positions in the coming decades.

1.3 Brazilian meats and the international market

The expansion of Brazilian meat production during the period 1995 to 2005 surpassed both the country's population growth and the growth of internal consumption, which in 2005 reached 85.5 kg/per capita/year compared to a per capita availability of 114.4 kg/year.

TABLE 7
Meat production, trade and consumption balance, selected years, 1995 to 2007[8]

	Total Main Meats* in 000 tonnes	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	11 010	15 075	17 841	19 778	21 114	21 469	22 757
+	IMPORTS	271	106	103	55	51	33	103
-	EXPORTS	770	1 678	3 171	4 921	5 745	5 534	5 441
=	Apparent Consumption	10 512	13 503	14 773	14 912	15 420	15 967	16 418
	Population (million)	155.8	169.5	173.4	182.1	184.6	187.2	187.7
	Per capita kg/person/year	67.47	79.67	85.20	81.91	83.53	85.28	87.47
	Export/Production	7.0%	11.1%	17.8%	24.9%	27.1%	25.8%	28.3%
	Production per capita	70.67	88.94	102.89	108.64	114.38	114.67	121.24

** Beef + Pork + Chicken + Turkey*

Brazil has generated a meat production surplus that permitted the country to expand its meat exports by 646.3 percent between 1995 and 2005. The country has a tradition of exporting meat (mainly beef). Historical texts describe canned and dried beef being sold to foreign vessels and even shipped abroad during the nineteenth century. In contemporary trade history, Brazilian beef is present from 1961 onwards; the first chicken-meat operations date from 1975.

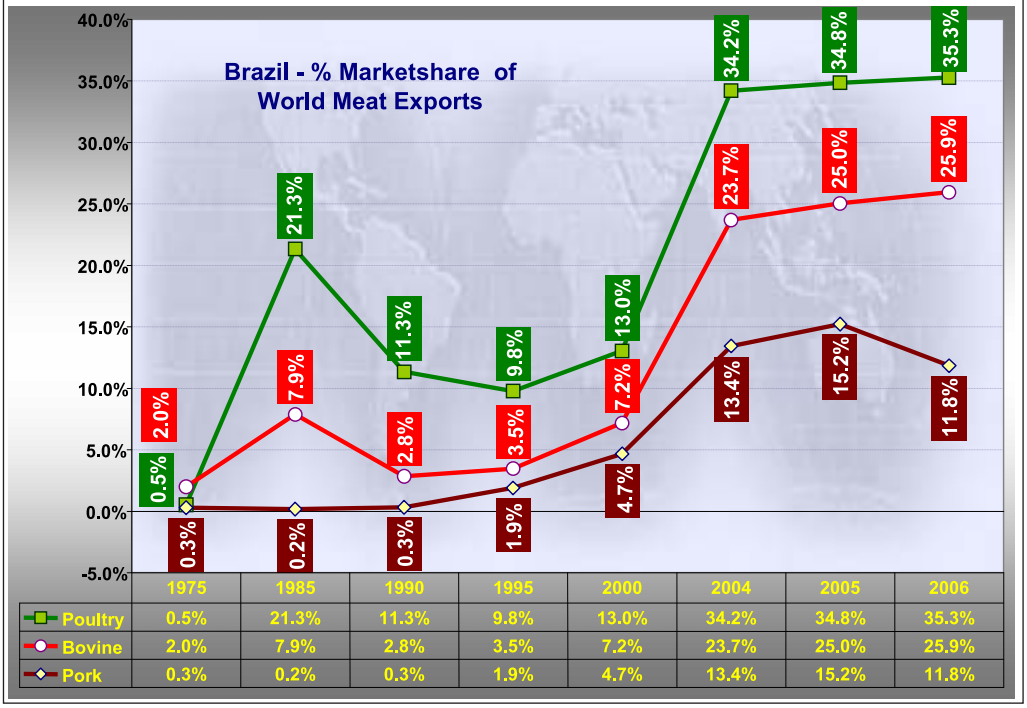
While the international presence of Brazilian beef has been constant since 1961, the country's market share has oscillated between 2 percent and 5 percent. The focus of the

[8] Source: elaborated by ODConsulting. Population data are from IBGE – Instituto Brasileiro de Geografia e Estatística (Brazilian Institue of Geography and Statistics). For 1995 and 2000 they are based on the Demographic Census 2000. In December 2007 IBGE announced some preliminary results of a national census conducted in cities under 100 000 inhabitants. According to the census, the Brazilian population has grown at a much lower rate and is estimated at 183 987 291 for 2007. As this figure is not yet definite and is being debated, for the purpose of this study we have used projections made by IBGE based on the 2000 census, including the figure for 2007. The years 2004 to 2006 are based on data available from the PNAD – Pesquisa Nacional por Amostra de Domicílios (National Survey by Home Samples), conducted by IBGE, which may be found on their Web site (http://www.ibge.gov.br/home/estatistica/populacao/trabalhoerendimento/pnad2005/tabsintese.shtm and http://www.ibge.gov.br/home/estatistica/populacao/trabalhoerendimento/pnad2006/tabsintese.shtm).

beef entrepreneur was the domestic market. In contrast, poultry (with a few exceptions normally caused by government interference) continuously expanded its market share. The classic example government interference was the "Cruzado Economic Plan" of 1986, when the government tried to curb inflation by freezing domestic prices and restricting exports to ensure supply. The plan had the lack of success predictable for an attempt to control inflation and promote income distribution by decree. Several heterodox economic plans followed, with similar degrees of success, but without the negative repercussions imposed by the official announcement in 1986 that Brazil would no longer be an exporter of food, but rather an importer. Indeed, Brazil imported unprecedented quantities of beef and pork in the years 1986 and 1987; our chicken importers took the official statement seriously and started to develop alternative sources of supply.

Disregarding this incident and others of minor consequence, poultry exports have shown constant annual growth and an ongoing quest for new markets. Poultry exports have been a success story and have shown that a model of growth based to a large extent on international marketing can serve as a lever for domestic production and consumption.

FIGURE 5
Brazil's share in world meat exports, 1975–2006[9]

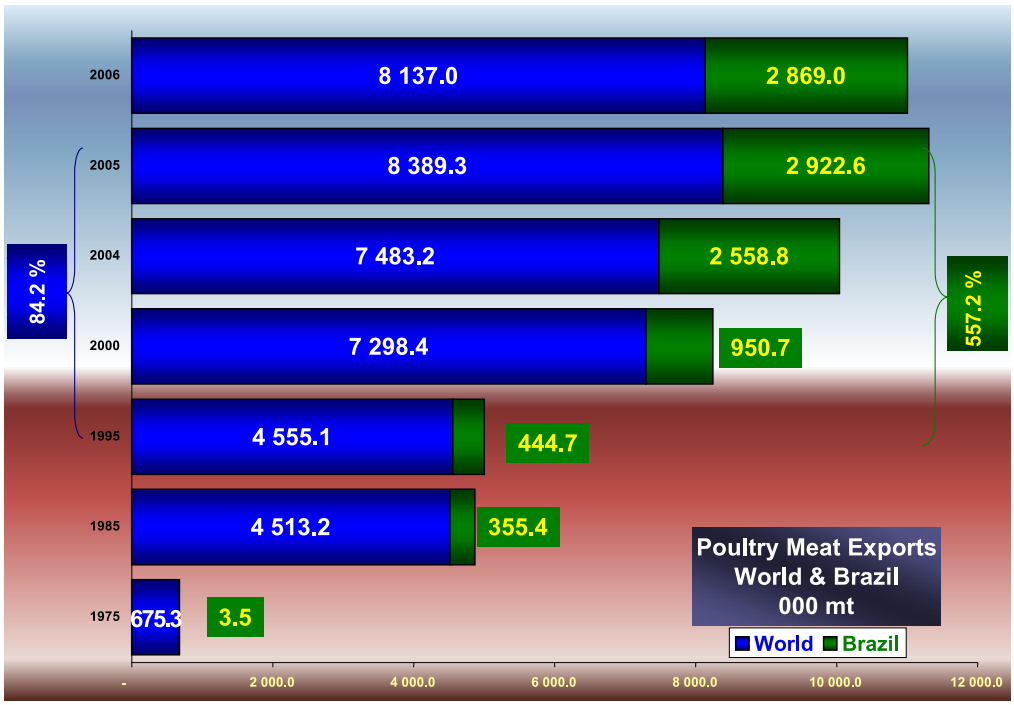


	1975	1985	1990	1995	2000	2004	2005	2006
Poultry	0.5%	21.3%	11.3%	9.8%	13.0%	34.2%	34.8%	35.3%
Bovine	2.0%	7.9%	2.8%	3.5%	7.2%	23.7%	25.0%	25.9%
Pork	0.3%	0.2%	0.3%	1.9%	4.7%	13.4%	15.2%	11.8%

[9] Elaborated from FAOSTAT data for 1965 to 1975. Data for 1985 to 2006 are from the Commodity Markets, Policy Analysis and Projections Service (ESTM), Trade and Markets Division, of FAO, May 2007. Data on Brazilian exports for the years 1995 to 2006 have been corrected according to those published by various Brazilian associations. We have used FAOSTAT and FAO ESTM figures because of their comprehensiveness as they cover 200 countries. The Prodution, Supply and Distribution (PSD) database of the Foreign Agriculture Service (FAS) of the Unites States Department of Agriculture (USDA) is of incredible quality, but in contrast to FAOSTAT it covers only selected countries, normally the main players. Using PSD database, the Brazilian share in world meat exports would be more prominent, but not in a realistic way. FAOSTAT may have its limitations in terms of updating data, a Herculean task considering the number of countries involved, but in our opinion is the most complete.

During the period 1995 to 2005, Brazilian poultry exports expanded 5.5 times, and the country moved to a leading position in poultry exports, particularly chicken meat.

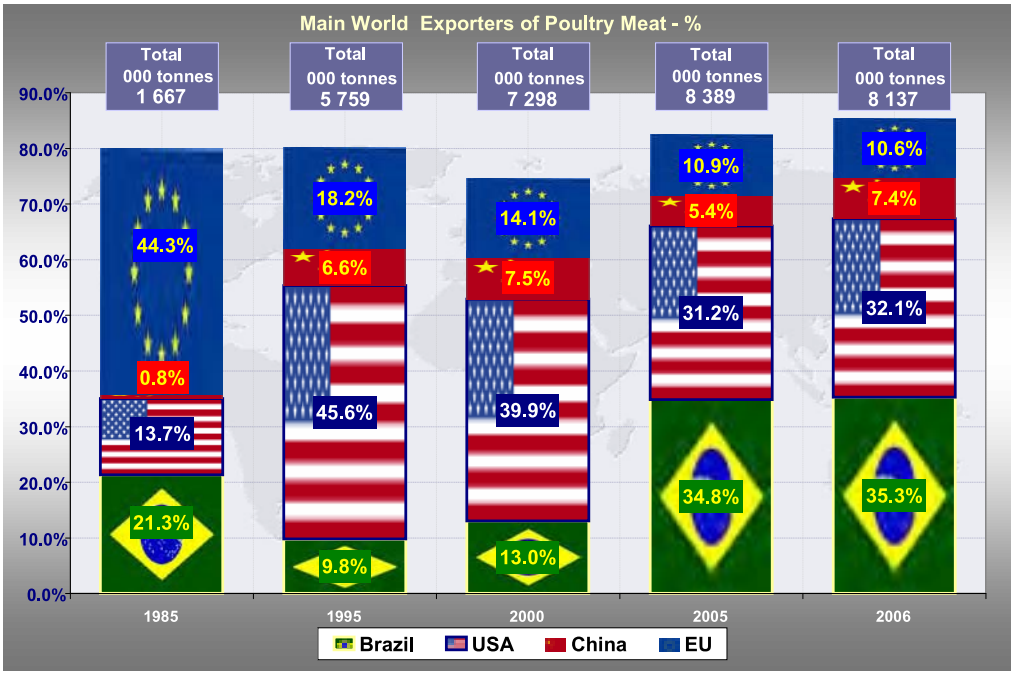
FIGURE 6
Brazilian and world poultry-meat exports, 1975 to 2006



Source: See footnote to Figure 5

Figure 7 shows the predominant role currently enjoyed by the United States of America and Brazil, which together represent more than two-thirds of world supply. As noted above, these two countries have the natural conditions to sustain poultry production and generate exportable surplus over the long term. This factor is of extreme importance given that future demand for poultry meat is likely to be concentrated primarily in the developing countries of Asia and Africa, which for the most part are situated in areas where there are shortages of water or arable land.

FIGURE 7
Market shares of the world's major poultry exporting countries



Source: figures for the years 1985 and 1990 are from FAOSTAT. Figures for 1995 to 2006 are from OECD.Stat.

Documented production and export data for beef, chicken, turkey, ducks and geese, pork and sheep indicate in 2005 respectively 115.6 kg and 84.31 kg for a population 184.6 million. *There are no reliable data available on meats of equines*, asinines, mules, buffalo, quail, guinea fowl and other commercially produced wild birds, ostrich, rabbit, game, caprine and other meats. Although FAO (2006), forecasts decelerating growth in world aggregate consumption of meat, an annual growth of 2.4 percent in poultry is still predicted for the period between1990/1991 and 2030. A shift in meat preference towards poultry (mainly chicken) meat will continue. Several factors contribute to this shift, including:

- the absence of major religious restrictions on eating poultry;
- poultry meat's reputation for being lower in fat, healthier and containing easy-to-digest protein;
- changing consumption patterns from economic vegetarianism to higher animal protein intake as income increases;
- poultry meat's enhanced availability, whether via the expansion of local production or via an increasingly dynamic international trade; and
- the fact that, of all meats, chicken meat is the most water efficient and requires the least time to be ready for consumption[10].

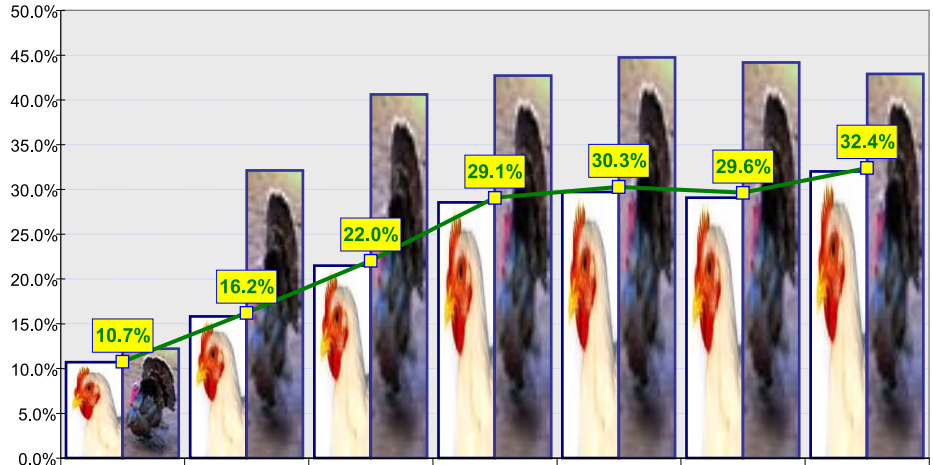
[10] Source: UNESCO (2006) – page 258, Chapter 7: "Water for food, agriculture and rural livelihoods" prepared by FAO and IFAD.

Although, as FAO (2006), notes, many low-income countries have not raised their incomes or their demand for poultry products, and recognizing that averages conceal as much as they reveal, projections by many international organizations (e.g. the World Bank) indicate rising incomes in most parts of the world and falls in the number of people living on less than US$2 per day.

Many researchers affirm that until people reach an income of US$8 per day, additional income is used to enhance the diet.[11] After passing this barrier, the additional income is used to improve clothing, housing, transport, education and leisure. More than one paper (e.g. Delgado et al., 1999) example, has established that increases in income are accompanied by higher intakes of animal protein, particularly meats.

We consider that the future perspectives for international demand for poultry meat are positive. Future demand for meat will depend on developing countries, where income increases will be used primarily to enhance the diet. A more equitable income distribution – needed in many Latin American countries, Brazil included – will also positively affect demand for meat. Brazil is currently witnessing that even minor efforts to diminish income disparities and to reduce the number of destitute individuals can have an effect on demand. International trade will be a driver of change, as it will enhance the availability of meats in areas that lack the natural conditions to produce them.

FIGURE 8
Share of exports in Brazil's poultry production[12]



	1995	2000	2002	2004	2005	2006	2007
Chicken	10.7%	15.8%	21.5%	28.5%	29.7%	29.1%	32.0%
Turkey	12.2%	32.1%	40.6%	42.7%	44.7%	44.2%	42.9%
Poultry	10.7%	16.2%	22.0%	29.1%	30.3%	29.6%	32.4%

[11] This statement was made by Professor Dr. Robert Thompson, during the World Agricultural Forum 2005 Congress, in his presentation "The Doha Round: making trade work for economic development and growth".

[12] Chicken data are based on UBA (http://www.uba.org.br/) and ABEF (http://www.abef.com.br/default.php). Figures for 2007 are projected.
Turkey-meat figures are based on UBA Annual Reports 2004/2005 (page 66), 2005/2006 (page 55) and 2006/2007 (page 61) for the years 2002 to 2006. Figures for the years 1995 and 2000 are from Supply and Distribution (PSD) online database of the United States Department of Agriculture's Foreign Agricultural Service's, (http://www.fas.usda.gov/psdonline/psdHome.aspx). Figures for 2007 are based on Foreign Agricultural Service, Official Estimates.

The fact that, in 2005, Brazil accounted for two-thirds of global poultry meat exports has major structural implications. This market position gives the Brazilian poultry industry an international dimension which, because of the country's lack of bargaining power, it would not otherwise have. Some 146 countries import Brazilian poultry meat. Brazil has become highly dependent on the international market. The country exported 10.7 percent of its poultry production in 1995; by 2005 this percentage had reached 30.3 percent.

From 1995 to 2005, Brazil evolved from being a significant supplier in the international poultry market to being one of the major suppliers. Presently, almost two-thirds of the country's poultry production depends on international trade. This is a considerable structural change. A number of points should be noted:

- The strength of the country's poultry sector in the international scene has been enhanced, compensating to some extent the country's lack of power in international commercial negotiations.
  The interdependency of international markets requires that producers for export adapt to demands that differ from those prevailing in their immediate markets (e.g. 100 percent vegetable feeds; GMO-free feeds; traceability to grandparents; constant audits of quality assurance, food safety, ethics, environment, animal welfare, etc; and slaughtering according to different religious precepts), thus forcing the sector to develop the production flexibility that in the long run enhances its competitiveness;
- Constant demand for product innovation determines investments in research and development, and almost constant updating or renovation of slaughterhouses and processing plants. This constant innovation attracts more clients both internationally and domestically and creates a virtuous circle.
- Developed-country consumers tend to concentrate their demand on some very specific cuts (e.g. Europeans just want white meat, preferably breast filets; Japanese consumers prefer dark meat, preferably boneless legs). The industry is forced to look for markets for the remaining cuts, and ends up targeting the Brazilian domestic market as Brazil is the fourth largest poultry market in the world.

1.4 Market demand

Brazil is historically a beef country and bovines constituted an important element of economic cycles in colonial days – as a source of food and leather and as a means of transport in the sugarcane plantations. Brazilians understand that "meat" (carne) means beef, and up to today are very surprised when they are served poultry or pork when invited for a "meat meal".

Brazil's meats balance – beef and pork

TABLE 8

Brazil's beef and pork production, trade and consumption balance – selected years, 1995 to 2007

	Beef in 000 tonnes	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	5 400	6 650	7 300	8 350	8 750	8 950	9 200
+	IMPORTS	261.5	99.9	100.7	53.3	49.2	30.0	100.0
-	EXPORTS	285.1	591.9	1 006.0	1 854.4	2 197.6	2 200.0	2 420.0
=	Apparent Consumption	5 376	6 158	6 395	6 549	6 602	6 780	6 880
	Population	155.8	169.5	173.4	182.1	184.6	187.2	187.7
	Per capita kg/person/year	34.51	36.33	36.88	35.97	35.76	36.21	36.65
	Export/Production	5.3%	8.9%	13.8%	22.2%	25.1%	24.6%	26.3%
	Production per capita	34.66	39.23	42.10	45.86	47.40	47.80	49.01

Source: 1996-2005 Abiec - Conselho Nacional da Pecuária de Corte - Per capita consumption . 2006 by USDA

	Pork in 000 tonnes	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	1 470	2 556	2 872	2 620	2 708	2 830	2 987
+	IMPORTS	9.0	5.0	2.0	1.0	1.0	2.0	2.0
-	EXPORTS	40.0	135	476	508	625	465	600
=	Apparent Consumption	1 439	2 426	2 398	2 113	2 084	2 366	2 389
	Per capita kg/person/year	34.51	14.31	13.83	11.61	11.29	12.64	12.73
	Export/Production	2.7%	5.3%	16.6%	19.4%	23.1%	16.4%	20.1%
	Production per capita	9.44	15.08	16.56	14.39	14.67	15.11	15.92

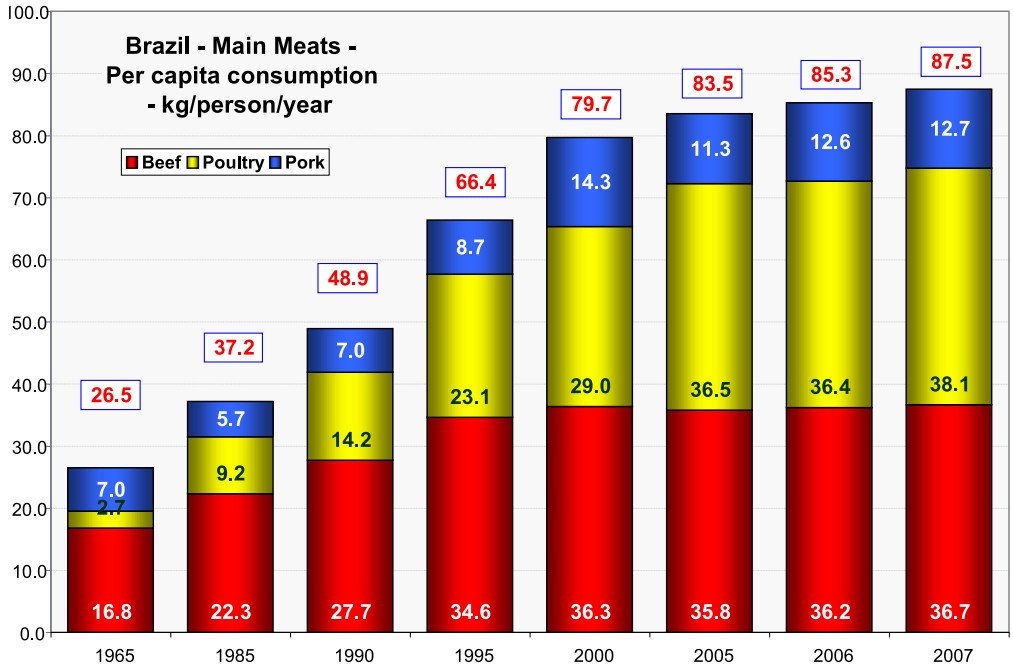
Source: Abipecs 1996-2006

Until the mid 1980s beef was less expensive than chicken to the extent that a popular Brazilian humorist used to say in the 1950s that "when a poor person eats chicken, it is because one of the two is ill". Actually, until the end of the 1960s, the access of the Brazilian consumer to poultry meat consisted of some discarded layers from the incipient egg industry and some backyard production. Data on chicken-meat prices for this period are consequently unavailable, but we can obtain an idea of the relative prices if we consider that in 1946 1 kg of beef was sold in the city of São Paulo at Cr$6.00[13] (average price of all cuts), while a dozen of eggs were sold for Cr$12.00. In 1956, the figures were, respectively, Cr$40.30 and Cr$ 33.00 (Arashiro, 1989, page 158).

[13] Cr$ = cruzeiro.

The situation has considerably changed since then. Figure 9 shows the evolution of per capita consumption of the three main meats from 1965 to preliminary data for 2007; it illustrates the progress of poultry in Brazilian meat consumption.

FIGURE 9
Brazil's meat consumption per capita, 1965 to 2007



Source: elaborated with data from ABEF (http://www.abef.com.br/default.php), UBA (http://www.uba.org.br/); ABIEC and ABIPECS.

TABLE 9
Evolution of per capita consumption in Brazil

	Δ% 1965/2005	Δ% 1995/2005
Beef	112.9%	3.4%
Poultry	1 251.0%	57.9%
Pork	61.3%	30.3%
Total	215.2%	25.9%

Source: elaborated with data from ABEF (http://www.abef.com.br/default.php), UBA (http://www.uba.org.br/); ABIEC and ABIPECS.

In a traditional beef country, poultry meat has achieved preponderance in meat intake. Between 1965 and 2005, per capita consumption of poultry meat in Brazil grew 5.8 times faster then total meat consumption and 11 times faster than beef consumption. Several factors have contributed to this change. Poultry-meat production has increased in scale and become increasingly more economical; complementarities to the export market have permitted a broad differentiation of products, stimulating people to consume poultry meat several times a week.

As Brazilian exports have diversified in terms of markets and products – mostly parts – they have helped to enhance the domestic market. Product variety and special cuts became available to the Brazilian consumer thanks to the fact that the industry found in the Brazilian market a channel to dispose of the non-exported parts of the chicken. Brazil is a cultural melting pot, and its cuisine has been subject to the influences of all the immigrants that have come to the country. This unified diversity values all parts of the bird, including feet, wing tips, backs, necks and offal.

Complementary between the Brazilian domestic market and the export market, and their interdependency, is among the pillars of the competitiveness and growth of Brazilian chicken production. This became particularly true when the country started to export to Europe, a market that today only values the chicken breast filet, which represents 9 percent of the weight of a live chicken.

The capacity of the industry to find value in all parts of the bird has been another pillar of Brazilian competitiveness in poultry-meat production. Non-edible offal is transformed into "poultry meal" – highly valued by the pet care industry. Feathers, thanks to their high protein content (more than 80 percent), are transformed into meals and exported to aquaculture feed manufacturers.

In an industry characterized by progressively lower margins, producers must obtain good value for the whole bird. More than once in our experience it is the by-products that render positive the monthly results of a poultry operation. As margins go down the poultry industry cannot afford to lose anything and should preferably find markets that would value even the noise that the flocks make.

One of the merits of the Brazilian poultry sector has been to realize that it is unsustainable to produce a whole bird and to use only part of it. It is not unusual for a meat packing business involved in exports to have some 300 different products, including both on-the-bone and boneless cuts. Many of these products are developed just to provide an economic use for a poultry part generated by the export of another part.

Between 1995 and 2005, several industrialized poultry-meat products became available to Brazilian consumers. The leading poultry companies in Brazil have a various poultry-meat products in their portfolios, ranging from very basic and traditional raw whole birds to ready-to-eat products. Chicken became abundant, low priced, easy to prepare and consume, and available in hundreds of forms – with options appealing to every segment of the consumer market.

Chicken meat moved from being the Sunday family lunch of 1960s and 1970s to being an everyday meal. During the period between 1995 and 2005 it consolidated its leadership as the meat most frequently consumed by Brazilians of every income level.

Poultry-meat balance

If meat for the Brazilian consumer means beef, then poultry means chicken – which represents 97 percent of the poultry consumed in Brazil.

TABLE 10
Brazil's chicken meat production, trade and consumption balance – selected years, 1995 to 2007

	Chicken in 000 tonnes	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	4 050	5 732	7 449	8 494	9 297	9 336	10 189
+	IMPORTS	0.6	0.6	0.6	0.3	0.6	0.6	0.8
-	EXPORTS	433.7	906.7	1 599.9	2 424.5	2 762.0	2 713.0	3 258.4
=	Apparent Consumption	3 617	4 826	5 850	6 069	6 535	6 623	6 932
	Population	155.8	169.5	173.4	182.1	184.6	187.2	187.7
	Per capita kg/person/year	23.22	28.47	33.74	33.34	35.40	35.37	36.93
	Export/Production	10.7%	15.8%	21.5%	28.5%	29.7%	29.1%	32.0%
	Production per capita	26.00	33.82	42.96	46.65	50.36	49.86	54.29

Source: Chicken data are based on UBA and ABEF. Figures for 2007 are projected.

TABLE 11
Brazil's turkey meat production, trade and consumption balance – selected years, 1995 to 2007

	Poultry in 000 tonnes	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	90	137	220	315	359	353	380
+	IMPORTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-	EXPORTS	11.0	44.0	89.2	134.3	160.7	156.1	163.0
=	Apparent Consumption	79	93	130	180	199	197	217
	Per capita kg/person/year	0.51	0.55	0.75	0.99	1.08	1.05	1.16
	Export/Production	12.2%	32.1%	40.6%	42.7%	44.7%	44.2%	42.9%
	Production per capita	0.58	0.81	1.27	1.73	1.95	1.89	2.02

Source: Turkey meat figures are based on UBA Annual Reports 2004/2005 (page 66), 2005/2006 (page 55) and 2006/2007 (page 61) for the years 2002–2006. Figures for the years 1995 and 2000 are from the Production, Supply and Distribution (PSD) online database of the United States Department of Agriculture's Foreign Agricultural Service' (http://www.fas.usda.gov/psdonline/psdHome.aspx). Figures for 2007 are based on Foreign Agricultural Service, Official Estimates.

Consumption of turkey is very limited, and is mostly concentrated around the Christmas period, although turkey hams and other industrialized products have been gaining popularity since the 1990s.

TABLE 12
Brazil's poultry meat production, trade and consumption balance – selected years, 1995 to 2007

	Poultry in 000 tonnes	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	4 140	5 869	7 669	8 808	9 656	9 689	10 569
+	IMPORTS	0.6	0.6	0.6	0.3	0.6	0.6	0.8
-	EXPORTS	445	951	1 689	2 559	2 923	2 869	3 421
=	Apparent Consumption	3 696	4 919	5 980	6 250	6 734	6 820	7 149
	Per capita kg/person/year	23.72	29.02	34.49	34.33	36.48	36.43	38.09
	Export/Production	10.7%	16.2%	22.0%	29.1%	30.3%	29.6%	32.4%
	Production per capita	26.58	34.63	44.23	48.38	52.31	51.75	56.31

Source: Poultry figures are the sum of chicken and turkey meats.

Consumption of ducks and geese is insignificant (annual total of 5.796 tonnes in 2006);[14] it is concentrated in restaurants and in some states of the South Region that are influenced by German immigrants. Quail are mostly used for producing eggs, which are quite popular among Brazilian consumers. Some barbecue restaurants offer quail meat. Selected restaurants serve guinea fowl, but all these meats represent something foreign to the average Brazilian consumer.

The progress of the poultry sector would not have been achieved if based only in exports. The existence of a potent domestic market, mainly for chicken/broiler meat, was fundamental.

In 2006, HPAI generated a food scare (in some instances, food panic would be a more appropriate expression) among consumers in many of the countries to which Brazil exports. Importers from these countries requested postponements of shipments or in some instances cancelled orders. Suddenly, the Brazilian domestic market was flooded with broiler meat produced for export.

The consequence was a depression of local prices to the level of total loss. The industry reacted by diminishing lodging of day-old chicks, reducing production by means of slaughter at an earlier age and finally by diminishing prices in the domestic market to avoid logistical and financial costs associated with the lots cancelled by importers.

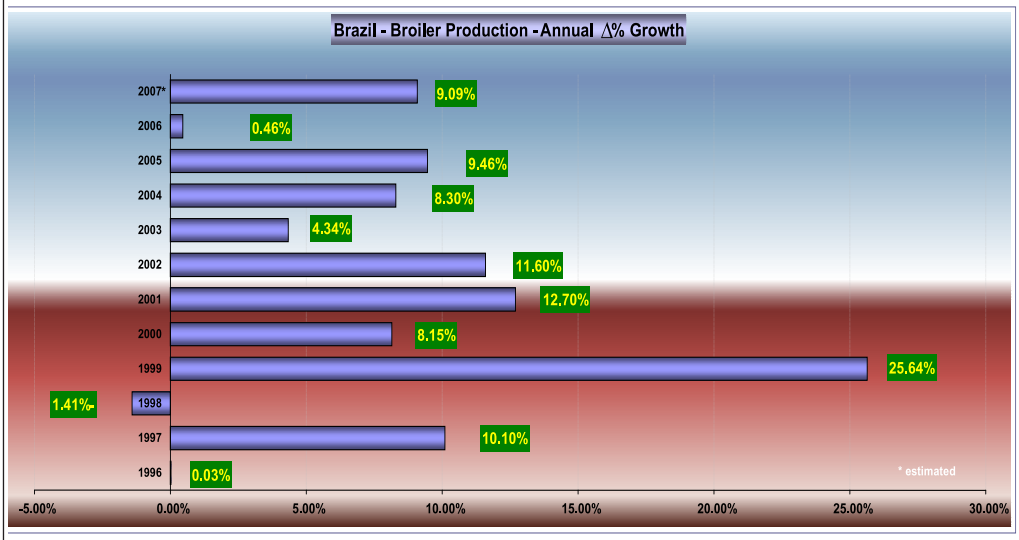
From November 2005 to March 2006, the Brazilian domestic market absorbed 15.6 percent more broiler meat than it did during the same period the in the previous year – not a small amount for a country that consumes 540 000 or 550 000 tonnes per month. Producers did not celebrate the prices that prevailed during that period, but they sold the their products in the domestic market until the measures taken to reduce output produced their effects.

[14] Data from UBA Annual Reports.

The end result was that broiler meat output had one of its lowest annual increases – 0.5 percent higher in 2006 than in 2005. However, the poultry sector survived this tough test and demonstrated the power of the Brazilian domestic market. During the last quarter of 2006, international demand accelerated and perspectives for a good year in 2007 were confirmed with a forecasted growth of 9.09 percent for broiler production, 19.9 percent for exports and 3.03 percent for the domestic market.

During the period from 1995 to 2005, Brazilian broiler exports averaged an annual growth rate of 18.13 percent while the domestic market averaged 7.91 percent – resulting in an average annual growth rate of 9.79 percent for total production.

FIGURE 10
Annual growth of Brazil's broiler production, 1996 to 2007



Source: UBA and ABEF.

Table 13 presents the average annual composition of Brazil's chicken-meat balance and per capita consumption from 1995 to preliminary figures for 2007. Data on per capita consumption may slightly differ from those obtainable from other sources, including poultry associations such as UBA, ABEF and APINCO (Association of Day-Old Chick Producers). Most poultry statistics do not consider that Brazil does import poultry meat, including chicken (although in small quantities). We have included imports of chicken parts – most commonly "chicken hearts", which are an extremely popular "churrasco" appetizer. Actually, Brazilian consumers will pay as much for chicken hearts as they do for chicken breast filets, if not more. The popularity of chicken hearts explains imports from neighbouring countries.

TABLE 13
Brazil's chicken/broiler meat production, trade and consumption balance, 1995 –2007

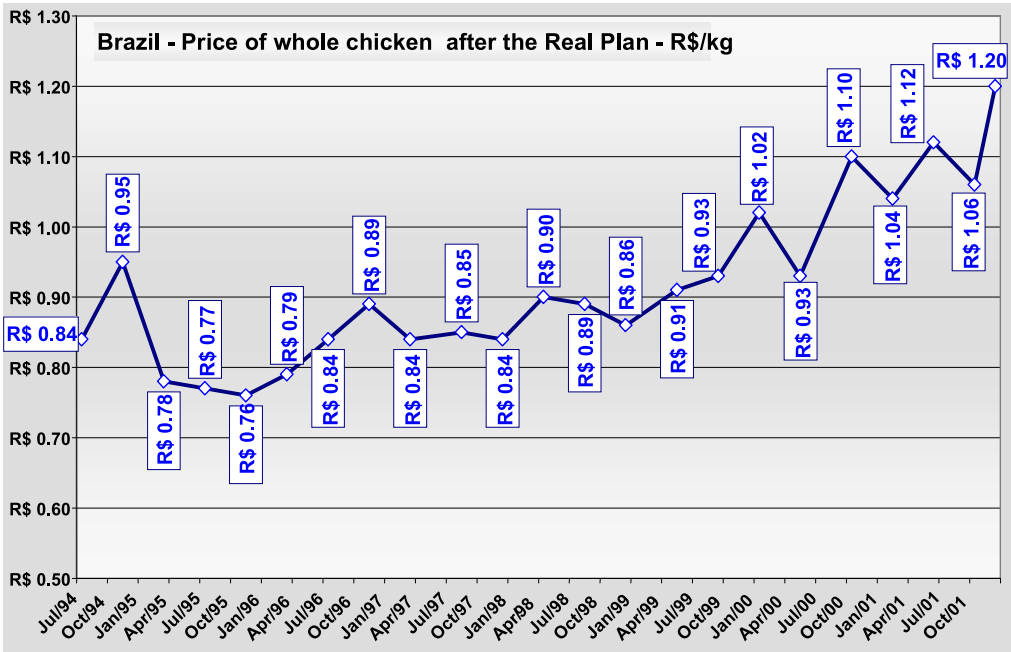
Annual Total	Per capita Consumption	Production (+)	Import (+)	Exports (-)	Domestic Availability =
	kg/inhabitant	tonnes	tonnes	tonnes	tonnes
1995	22.78	4 050 449	649.3	433 744	3 617 354
1996	21.61	4 051 561	695.1	568 794	3 483 462
1997	23.29	4 460 925	1 284.8	649 356	3 812 654
1998	22.79	4 398 186	1 190.0	610 6751	3 788 701
1999	28.19	5 526 044	243.0	770 552	4 755 735
2000	29.62	5 976 523	649.3	906 746	5 070 426
2001	31.58	6 735 696	139.4	1 249 288	5 486 567
2002	33.58	7 516 923	622.2	1 599 923	5 917 643
2003	33.11	7 842 950	266.8	1 922 043	5 921 175
2004	33.47	8 493 854	319.1	2 424 520	6 069 653
2005	35.53	9 381 130	550.0	2 845 945	6 535 735
2006	35.52	9 340 120	551.5	2 717 533	6 623 094
2007	36.54	10 246 267	767.2	3 286 774	6 960 260

Source: Data on production and exports are from UBA and ABEF. Import data from Aliceweb.

In Appendix 1, the data summarized in Table 13 are presented on a monthly basis for the years from 2005 to 2007. The tables in Appendix 1 also include the maximum, minimum and average price at the São Paulo wholesale market. Prices are in US$ per kg of whole chicken, including liver and gizzard, neck, feet and head.

Chicken meat is sold in all types of retail outlet, from major national supermarket chains to small individually owned and operated shops. Supermarkets frequently use chicken meat as a way to attract consumers to their shops through promotions and pricing. Chicken meat became a symbolic indicator of "consumer price stability" after the Real Plan of 1994/1995. Brazilians were used to almost daily corrections in prices of their foodstuffs and the fact that the price of chicken stood for years below R$1/kg helped to create confidence in the new currency.

FIGURE 11
Average whole-chicken prices received by producers



Source: elaborated with data from FGV – Fundação Getúlio Vargas (Getulio Vargas Foundation), IBRE – Instituto Brasileiro de Economia (Brazilian Institute of Economics) (http://www.fgvdados.fgv.br/).
Prices received by producers indicate the average for the whole country.

Brazil's eggs balance

Brazil is among the world's five largest markets for meat and is the seventh largest table-egg producer. Nonetheless, per capita consumption of eggs in Brazil ranks below sixtieth in the world, despite the fact that this is the lowest-priced animal protein on the local market.

Prejudices, misinformation and lack of a coordinated promotion effort are factors frequently invoked to explain the low levels of consumption. In a country where under nourishment is still present, fears and the desire to control cholesterol restrict the intake of eggs. However, per capita consumption is growing due to the affordability of eggs, good horizontal distribution and isolated promotional efforts on the part of some state-level associations.

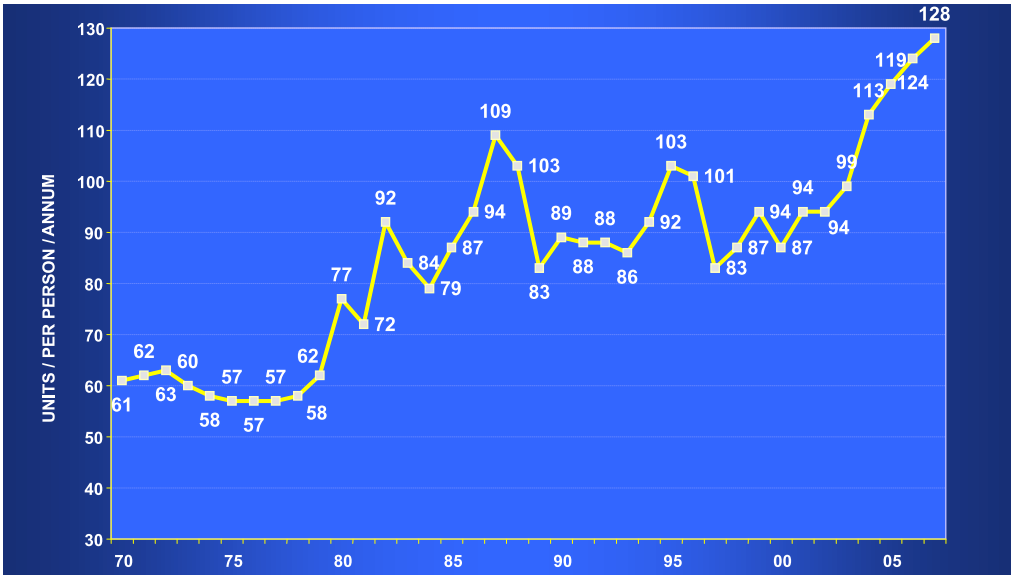
TABLE 14
Brazil's egg production, trade and consumption balance – selected years, 1995 to 2007

	Eggs in millions	1995	2000	2002	2004	2005	2006	2007
+	PRODUCTION	16 066	14 796	16 488	20 818	22 328	23 575	24 892
+	IMPORTS	0	4	7	4	3	5	5
-	EXPORTS	12	15	108	214	394	382	382
=	Apparent Consumption	16 054	14 686	16 388	20 609	21 937	23 199	24 516
	Population	155.8	169.5	173.4	182.1	184.6	187.2	187.7
	Per capita eggs/person/year	103	87	94	113	119	124	128
	Export/Production	0.1%	0.8%	0.7%	1.0%	1.8%	1.6%	1.5%
	Production per capita	103	87	95	114	121	126	133

Source: egg production, APA – Associação Paulista de Avicultura (São Paulo State Poultry Association) and UBA; export-import data from ALICE.

Brazil does not import table eggs – import figures thus represent only eggs for reproduction purposes (pure-line parent and grandparent stock, etc.) and for the production of vaccines and similar purposes. The export figures include eggs for consumption, fertile eggs and eggs used for medical purposes. Export figures also include, in egg equivalents, the export of manufactured products such as frozen liquid eggs, dried eggs and pasteurized eggs.

FIGURE 12
Brazil's per capita egg consumption, 1970–2007



Source: egg production, APA – Associação Paulista de Avicultura (São Paulo State Poultry Association) and UBA; Export-import data from ALICE. Figures elaborated by José Carlos Teixeira Consultoria Ltda

In Brazil, the market for brown eggs represents some 30 percent of total consumption, with white eggs having distinctly lower prices at retail level. Consumers usually buy eggs in packs of a dozen. Eighteen-unit packs are also available, as in recent years are packs of four and six units – a response to the declining number of persons per household, mainly in the big cities. Special eggs (enriched with vitamins, antibiotic free, mineral enriched, etc) can also be bought. Both the egg trade and industry adopt the "carton box with 30 dozens" as their unit for prices

Quail eggs are extremely popular. Statistics from the Brazilian Institute of Geography and Statistics (IBGE) indicate that 8 million quail layers are in production, with a monthly production of 8 million eggs. There is no specific association of quail-egg producers and UBA's reports do not cover this activity.[15]

Summary

- From 1995 to 2005, Brazilian agribusiness exports boomed and generated considerable trade surplus, permitting the country to balance its international debt and build up foreign currency reserves. Meats were the third most important agribusiness product exported and poultry was the leader in meat exports.
- Brazil's improved international financial standing and the control of inflation gave rise to unprecedented stability in the national economy. This stimulated production, exports and local demand. Poultry production expanded by 133.2 percent, exports by 557.2 percent and domestic demand by 82.2 percent over the period 1995 to 2005.
- Brazil consolidated a position as one of the world's major poultry-producing countries. Among the leading countries, the United States of America and Brazil have the natural conditions (arable land, photosynthesis and water) to retain this leading position during the coming decades.
- From 1995 to 2005, relations between the poultry industry and the agencies and organs of the state evolved towards cooperation, synergy and the establishment of joint action strategies – with very positive results.
- From 1995 to 2005, Brazil developed from being a significant supplier in the international poultry market to being one of the major suppliers. The country is responsible for one-third of world exports and almost one-third of the country's poultry production depends on the international market. This is a considerable structural change with consequences that affect all aspects of the poultry sector and have given the industry an international dimension.
- In a traditional beef-consuming country, poultry meat has achieved preponderance in meat intake. From 1965 to 2005, per capita consumption of poultry meat in Brazil grew 5.8 times more than total meat consumption and 11 times more than beef consumption; it has become the country's most consumed meat.
- Complementarity and interdependence between exports and the domestic market

[15] "Avicultura Industrial" Web site (http://www.aviculturaindustrial.com.br/site/dinamica.asp?id=27890&tipo_tabela=produtos&categoria=codorna) 5 July 2007

enhanced the country's competitiveness in poultry meat, creating a virtuous cycle.

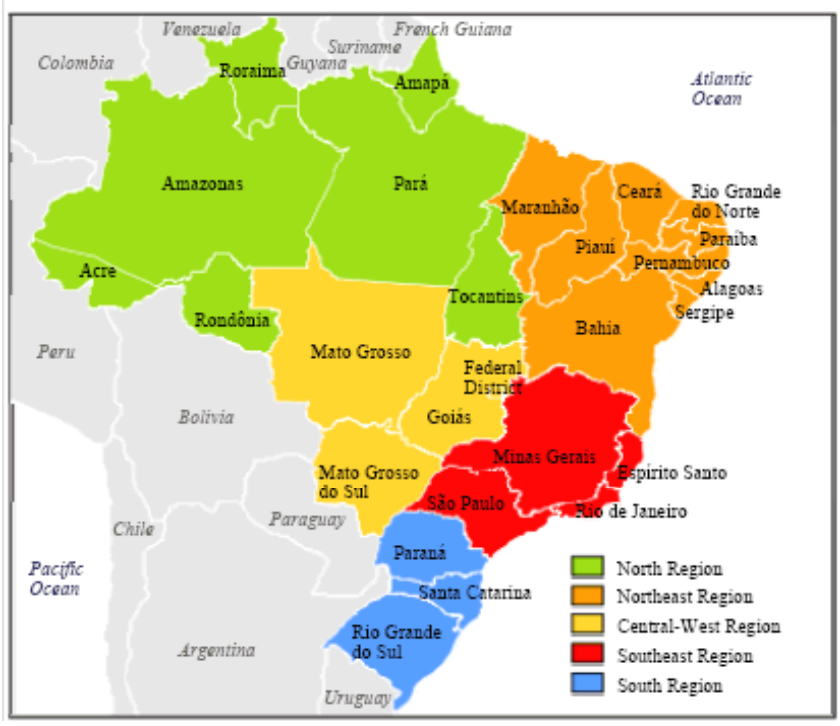
- Over the period 1995 to 2005, the Brazilian poultry industry maximized commercial uses of the bird's weight. In an industry that is faced with progressively declining margins this was essential for competitiveness and to sustain a position as one of the world's main poultry-meat producers and exporters.

1.5 Changes in the geographical location of commercial production

Brazil's regions and federated states

Brazil is a federal republic, comprising 26 states and the Federal District. The states are integrated into five regions. The borders of each region – North, Northeast, Southeast, South and Centre-West – coincide with the borders of the states that they comprise. Brazil's total official area is of 8 514 876.599 km².

FIGURE 13
Political map of Brazil – regions and federated states



Location of Brazil's livestock

In Section 1.4., we discussed the growing contribution of chicken/broiler meat to the animal-protein intake of Brazilians. These changes have, naturally, had an impact on Brazilian livestock populations. The "chicken for meat" flock grew by 50.1 percent between 1995 and 2005. At the end of the period it represented 63.1 percent of the Brazilian "herd" in terms of number of head, against 55.7 percent in 1995. The figures from the PPM (Pesquisa Pecuária Municipal – Municipal Livestock Research) 2006 show that this growth is continuing.

TABLE 15
The Brazilian herd – 1995, 2000 and 2005

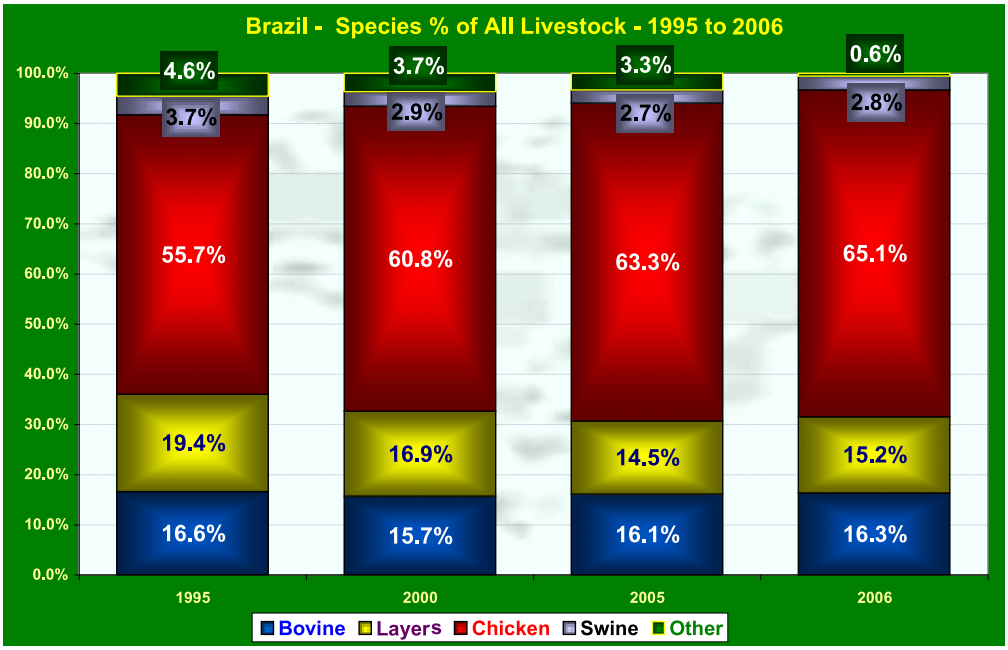
	Brazilian Herd in heads			Δ%
	1995	2000	2005	1995/2005
Total IBGE[1]	971 239 013	1 083 984 733	1 282 839 110	32.1%
Chicken for Meat	541 163 942	659 245 547	812 467 900	50.1%
Layers	188 367 357	183 494 626	186 573 334	-1.0%
Quail	2 939 376	5 775 181	6 837 767	132.6%%
Bovine	161 227 938	169 875 524	207 156 696	28.5%
Swine	36 062 103	31 562 111	34 063 934	-5.5%
Horses	6 394 145	5 831 817	5 787 249	-9.5%
Asses	1 344 155	1 242 177	1 191 533	-11.4%
Mules	1 990 108	1 347 855	1 388 665	-30.2%
Buffaloes	1 641 950	1 102 551	1 173 629	-28.5%
Rabbits	499 854	375 573	303 640	-39.2%
Ovine	18 336 432	14 784 958	15 588 041	-15.0%
Caprine	11 271 653	9 346 813	10 306 722	-8.6%

Source: data on the Brazilian livestock herd are from "Pesquisa Pecuária Municipal – PPM" (Municipal Livestock Research) 2005 and 2006 from IBGE – Brazilian Institute of Geography and Statistics. IBGE figures do not include geese, ducks, guinea fowl or turkeys and the total herd size corresponds to the listed species. Data are extracted from IBGE's databank SIDRA – Sistema IBGE de Recuperação Automática (IBGE Automatic Data Recuperation System).

IBGE conducted an Agricultural and Livestock Census in 2006 and very recently (December 2007); preliminary tables have been published. They scale up the figures for chickens and layers to 1 244 260 280, or 84.8 percent of a total herd of 1 467 915 832 head for all species. This census considerably reduces the estimate for the number of bovines and contradicts all estimates made by both official and private organizations and associations

connected to the cattle industry. It also registers reductions in the pig, ovine and caprine herds. In terms of pigs, the figures contradict a very recent work conducted by ABIPECS (Brazilian Association of the Pork Meat Producer and Exporter Industries).[16]

FIGURE 14
Size of the Brazilian herd – main species, 1995 to 2006



Source: IBGE-SIDRA.

Location of the "chickens for meat" flock

This section presents a discussion of the location of Brazil's "chickens for meat" flock (distribution by region) and how this changed over the period 1995 to 2005 (also including data for 2006).

Table 16 shows the evolution of the size of the "chickens for meat" flock according to IBGE's Agricultural and Livestock Censuses and Researches. It indicates that the South Region is the largest chicken producer and that the Centre-West Region is experiencing a true boom in chicken production.

[16] cf. Arashiro (1989).

TABLE 16
Size of Brazil's "chickens for meat" flock – by region

	Brazilian Chicken Herd Size (heads)				Δ%
	1995	2000	2005	2006	1995/2005
Brazil	541 163 942	659 245 547	812 467 900	821 541 630	50.1%
North	22 487 547	18 972 976	18 219 721	18 167 075	-19.0%
Northeast	71 128 493	76 503 803	84 818 301	82 099 458	19.2%
Southeast	145 545 294	186 288 544	223 620 923	229 072 756	53.6%
South	273 485 220	326 615 968	402 957 183	409 923 190	47.3%
Center-West	28 517 388	50 864 256	82 851 772	82 279 151	190.5%

	1995	2000	2005	2006
North	4.2%	2.9%	2.2%	2.2%
Northeast	13.1%	11.6%	10.4%	10.0%
Southeast	26.9%	28.3%	27.5%	27.9%
South	50.5%	49.5%	49.6%	49.9%
Center-West	5.3%	7.7%	10.2%	10.0%

Sources: "Pesquisa Pecuária Municipal – PPM" (Municipal Livestock Research) 2005 and 2006 from IBGE – Brazilian Institute of Geography and Statistics. Data for 2000 and 1995 are from IBGE's SIDRA Sistema IBGE de Recuperação Automática (IBGE Automatic Data Recuperation System) (http://www.sidra.ibge.gov.br/bda/acervo/acervo2.asp?e=v&p=PP&z=t&o=21). SIDRA data are based on Agricultural and Livestock Censuses and for the most recent years on data from PPM.

Data from IBGE may differ from those published by various poultry associations. The reason for this lies in the methodology, as IBGE bases its figures on Livestock Census and Researches from which it projects figures until it conducts the next census or research.

Censuses are not the best way to monitor livestock species that have short lifecycles, such as chickens for meat which are slaughtered at a maximum of 45 days old. A census or research will provide a snapshot of the population during period in which it is carried out, which is just fine for animals that have medium or long lifecycles, but is rather inadequate for chickens. Besides, hens can be used either as layers or for meat production; layers can be used either for egg production or for reproduction. It is difficult for statisticians to account for the peculiarities of each activity.

Associations collect figures from their member companies or farmers on a monthly basis, and members have a direct interest in supplying precise data as they will guide estimations of the feed requirements of the sector, the quantities of meat or eggs that will be available in the market, etc. – all factors that influence the economics of the poultry keeping. If members provide "cosmetic" figures, i.e. figures that are over or under the actual ones, they are likely to realize before long that lying to oneself can be a costly exercise.

Many associations are highly respected for the figures they keep and more and more official agencies and ministries use them or conduct joint studies – an example of the significant structural change referred to above.

To estimate long- and short-term chicken/broiler meat production data of parent stock and lodging of day-old chicks are required. To verify the accuracy of the estimations, it is necessary to have data on the numbers of birds slaughtered and the quantity of meat produced.

From 1995 to 2005, according to poultry association statistics, the lodging of parent stock for meat production in Brazil increased by 66.1 percent, led by the Centre-West Region with a growth of 179.6 percent, followed by the South Region with 83.1 percent growth. The South Region leads with 56.2 percent of the total number of lodged parents in 2005.

TABLE 17
Lodging of parent stock for meat production – by region, 1995–2006

Region	1995	2000	2005	2006	Δ% 1995/2005	% 1995	% 2005
North	69 927	107 880	32 400	49 369	-53.7%	0.3%	0.1%
Northeast	1 631 089	2 142 997	2 242 004	2 467 732	37.5%	7.4%	6.1%
Southeast	8 067 855	8 078 280	10 867 776	10 923 417	34.7%	36.6%	29.6%
South	11 262 550	15 205 005	20 621 154	21 379 958	83.1%	51.0%	56.2%
Center-West	1 037 191	2 001 393	2 900 173	3 577 762	179.6%	4.7%	7.9%
Brazil - Total	22 068 612	27 535 555	36 663 507	38 398 238	66.1%	100.0%	100.0%
Exports	887 717	934 206	1 124 036	1 122 940	26.6%	4.0%	3.1%

Source: UBA statistics and annual reports (www.uba.org.br).

In approximately the same period, the lodging of day-old chicks increased by 81.2 percent, again led by the Centre-West Region with a 264.8 percent increase from 1996[17] to 2005, followed by the South Region with 85.9 percent; the latter region accounted for 54.5 percent of the total in 2005.

[17] Statistics for lodging of one-day chicks per Region are only available at UBA databank from 1996 onwards.

TABLE 18
Day-old chicks lodged in Brazil – by Region, 1996-2006 (head)

Region	1996	2000	2005	2006	Δ% 1996/2005
North	36 294 546	39 878 004	60 705 453	65 312 980	67.3%
Northeast	239 709 124	278 468 361	353 018 748	374 339 278	47.3%
Southeast	806 174 721	893 400 868	1 239 082 545	1 205 195 105	53.7%
South	1 373 917 566	1 801 457 105	2 554 250 391	2 441 449 495	85.9%
Center-West	132 429 375	232 864 251	483 050 637	484 899 886	264.8%
Total Domestic	2 588 525 332	3 246 068 589	4 690 107 774	4 571 196 744	81.2%
Exports	4 600 350	8 099 950	5 771 200	5 354 900	25.5%
Total Brazil	2 593 125 682	3 254 168 539	4 695 878 974	4 576 551 644	81.1%

Region	1996	2000	2005	2006
North	1.4%	1.2%	1.3%	1.4%
Northeast	9.3%	8.6%	7.5%	8.2%
Southeast	31.1%	27.5%	26.4%	26.4%
South	53.1%	55.5%	54.5%	53.4%
Center-West	5.1%	7.2%	10.3%	10.6%

Sources: UBA and APINCO (Association of Day-Old Chick Producers). Published in UBA's Annual Reports and available in its data bank.

These tables demonstrate that most of the production is concentrated in the South Region, but they also show that the Centre-West Region is gaining strength. It is not an exaggeration to say that chicken production is moving to the Centre-West Region towards Brazil's new agricultural frontier following grain production.

A brief history of the geographical distribution of the Brazilian poultry industry

As briefly described above, until the late 1960s or early 1970s the Brazilian poultry industry focused on egg production and was concentrated around the major cities. For this reason, the main producing states at the time were São Paulo, Minas Gerais and Rio de Janeiro, all in the Southeast Region. Dr Haroldo Vasconcellos[18] recalls an article about the "industrial poultry industry in Brazil" in World's Poultry Science Journal, April–June 1957, which stated:

[18] Dr Haroldo Vasconcellos, MD during the week and poultry farmer at the weekends, one of the pioneers of the layer industry in Brazil, responsible for Project ETA 42 which in 1957 began technical cooperation with poultry professionals from the United States of America.

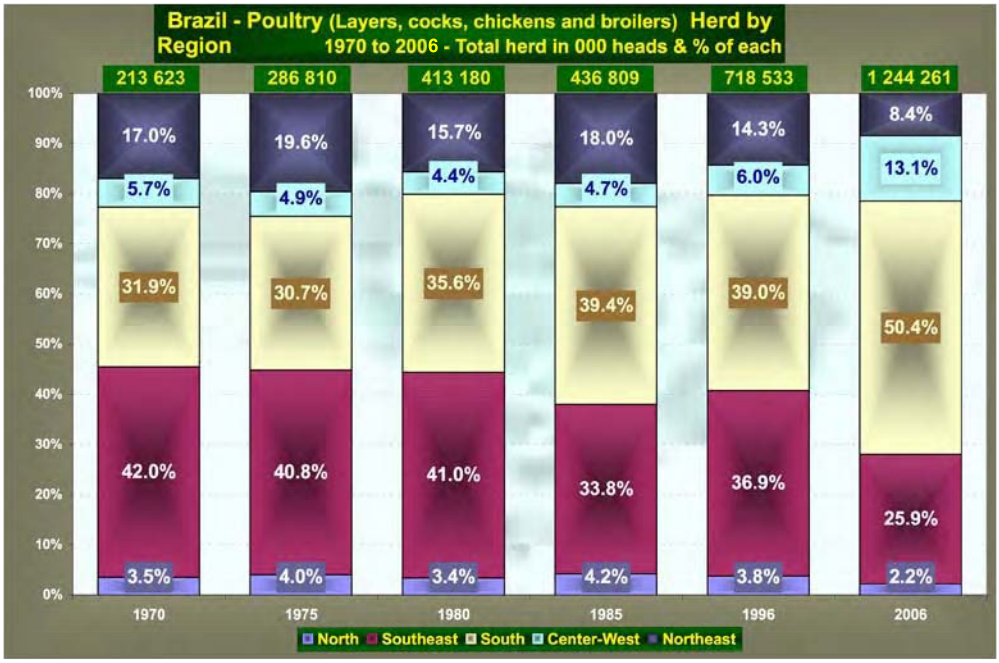
"The Brazilian poultry industry is mainly concentrated around the cities, such as Rio de Janeiro, Sao Paulo and Belo Horizonte, within a circle of 125 miles.

Within the geo-economic areas of these cities, there are hundreds of small poultry farms with capacities of 1 000 to 10 000 head and some big organizations with up to 100 000 head."[19]

The egg producers would sell the live layers directly to the consumer at the end of the birds' productive cycle. It was also a habit for those living in houses with backyards to raise their own chickens, even in the major cities. Later this practice ceased as cities grew larger and houses started to give way to apartments. "Avícolas", shops where live chickens were sold, became popular at this time. Some of these "avícolas" started to have facilities for slaughtering the chicken chosen by the consumer; and in the 1960s, the first slaughter-houses appeared.

Statistics from IBGE's Livestock Censuses show that by the 1970s the South Region occupied second place in terms of the size of its poultry flock, while the Southeast Region prevailed thanks to its proximity to the main centres of urban consumption such as Rio de Janeiro, São Paulo and Belo Horizonte.

FIGURE 15
Brazil's poultry flock by region, 1970 to 2006



Source: elaborated with data from IBGE Livestock Census 1970, 1975, 1980, 1985, 1996 and 2006. Figures include layers, cocks, chickens and broilers for meat. IBGE s Livestock Censuses do not include turkeys, geese, ducks or quail.

[19] Statement by Dr Vasconcellos in Arashiro (1989: pp. 205– 212).

Dr Haroldo Vasconcellos[20] states that during the visit of poultry technicians from the United States of America to Brazil most of the Southeast Region's poultry entrepreneurs and leaders were convinced that they knew all about poultry. According to Dr Vasconcellos, the project[21] was successful in places where the poultry sector was not yet developed. He specifically quotes as a success story the State of Rio Grande do Sul were farmers kept 30 to 100 head of chicken, males for meat and females for eggs.

Breeding of small animals was practised in the South Region thanks to the Italian and German immigrants who brought the tradition with them from their old countries. Some of these immigrants established themselves in hilly country in the State of Rio Grande do Sul, where the land could be bought for very affordable prices as it was unsuitable for extensive cattle breeding, which was the main economic activity of Rio Grande do Sul and which was then concentrated in big properties in the Pampa.

The immigrants would buy properties of 10 to 20 ha which would be cultivated by the family, growing various crops (maize, tobacco, fruits, grapes for wine, etc), complementing the activity mostly with pigs and chickens, and keeping one or two cows for milk.

As the family grew up and the sons established families of their own, they would sell the small family properties in order to buy larger stretches of land in new virgin areas. This migration process took farmers first to the western parts of the States of Santa Catarina and Paraná. With them moved the tradition of breeding small animals and processing their meats. In the 1970s, thanks to Government incentives, this migration also affected the Centre-West Region. More details on this governmental programme are presented below. It is interesting to note that this migration is an ongoing movement towards the Centre-West of the country, and even led to emigration, as many of the farmers bought land in the border regions of Paraguay and Bolivia.

Most of the main Brazilian poultry companies have their origins in the states of the South Region. They suffered from very poor transport infrastructure connecting them to their main markets, which were then the cities of Rio de Janeiro, São Paulo and Belo Horizonte. As roads improved in the 1960s and 1970s, the South Region began to have easier access to the main urban market centres of the Southeast Region. Thanks to its more favourable natural conditions for production, the South Region's companies started to add frozen chicken to their pork-fat and meat trade.

The 1970s and 1980s were a period of very high inflation rates, with retail prices for food being corrected weekly or even, in some instances, daily. This factor helped to change the habits of the Brazilian consumer, used at the time to consuming "hot" chicken or at most refrigerated chicken. Price differences taught them to consume frozen products, which came mostly from the South Region. Refrigerated chicken was delivered to retailers two or three times per week and with almost every delivery its price went up to reflect rising costs.

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[20] Statement by Dr Vasconcellos in Arashiro (1989: pp. 205– 212).

[21] The governments of Brazil and the United States of America came to an agreement by which Brazil would receive assistance and projects for its agriculture. This agreement was denominated ETA (Escritório Técnico de Agricultura – Brasil/EUA ((Agricultural Technical Office – Brazil/USA)) and the poultry-specific project was denominated ETA Project 42.

The 1980s were also the days when supermarkets expanded considerably in the major urban centres. The supermarkets would buy large quantities of frozen chicken and keep its price stable until the next delivery as a means to increase customer flow. The price difference between the frozen and fresh and/or refrigerated product was enough to make the consumers learn to consume frozen products, even though in any market research the same consumers would always declare preference for fresh products.

The attractiveness of the prices of frozen chicken also helped to make it accessible to medium-low and low-income segments of the population, who started to consume the product outside the traditional family Sunday lunch – thus enlarging the overall basis of demand for poultry. This change in consumption habits contributed to the migration of chicken production from the Southeast Region towards the South Region. The leading Brazilian poultry companies from the South Region also contributed to Brazilian poultry exports from the early stages.

As Brazilian exports diversified in terms of markets and products – mostly parts – exports helped to enhance the domestic market. Product variety and special cuts became available to the Brazilian consumer, thanks to the fact that the Brazilian market provided the industry with a channel to sell chicken parts that were not exported.

Leading chicken companies and their contribution to the leadership of the South Region

An overview of the main poultry producers in Brazil helps to understand the process of migration of chicken meat production towards the South Region. Table 19 shows the leading chicken producers in Brazil from 1995 to 2006 based on the number of birds slaughtered per annum. After the name of each company, there are sets of two letters that represent the Federal States where those companies have production facilities. Notice that nine out of the ten largest chicken producers in Brazil are companies from the South Region. Notice also the number of companies established after 2000, many of them in the State of Paraná (PR), South Region, a state that has experienced impressive growth in poultry-meat production during the 1995 to 2005 period.

TABLE 19
Leading chicken-producing companies in Brazil

Company	*Chicken (heads per annum)* 1995	2000	2005	2006	Rank in 1995	Rank in 2005
Sadia SC-PR-MG-MT-RS-DF	323 719 000	382 162 664	629 209 878	645 452 443	1	1
Perdigão SC-RS-PR-GO-MT	146 018 351	290 796 007	498 850 657	530 111 245	2	2
Seara[1] SC-PR-SP-MS	131 610 112	177 954 712	277 320 934	257 490 544	3	3
Frangosul RS-MS	113 962 704	196 557 668	237 068 234	214 471 190	4	4
Avipal RS-MS-BA	94 535 406	136 578 075	208 096 594	174 229 179	5	5
Dagranja PR-MG	69 910 173	94 174 078	117 199 849	114 665 884	7	6
Aurora SC-RS	33 754 206	74 215 694	91 826 334	108 743 902	10	7
Diplomata PR-RS-SC	23 347 119	21 833 666	90 754 483	87 636 118	15	8
Penabranca SP	82 118 762	109 416 570	82 155 225	75 173 127	6	9
Copacol PR	30 969 028	39 187 172	72 080 048	70 089 917	11	10

Table 19 - Leading chicken-producing companies in Brazil

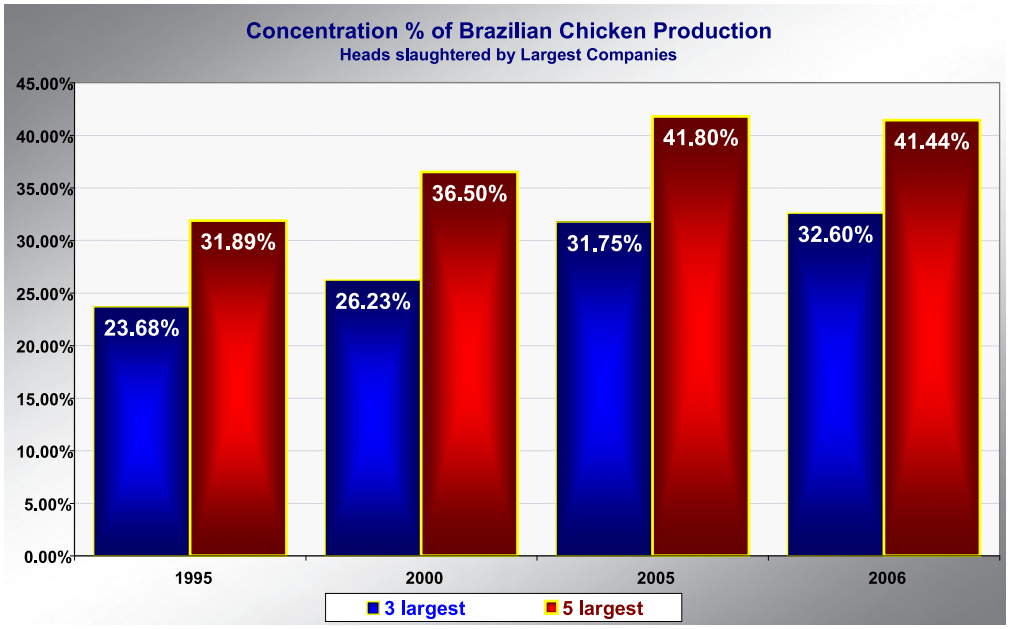
Company	Chicken (heads per annum) 1995	2000	2005	2006	Rank in 1995	Rank in 2005
Rio Branco / Pif Paf MG-RJ	27 084 859	35 249 912	53 192 295	53 733 755	13	11
Frango Sertanejo SP	26 649 376	48 759 901	48 255 906	40 431 245	14	12
Frango Forte SP			48 255 906	55 348 664	...	13
Big Frango/Jandelle PR	11 295 174	21 929 122	48 193 500	49 152 408	30	14
Kaefer Avicultura PR-RO			47 976 472	46 765 711	...	15
Rei Frango SP			45 777 144	51 151 583	...	16
C.Vale PR			42 408 783	48 231 895	...	17
Penasul RS			42 325 268	44 206 550	...	18
Coop. Agroindl. Lar PR			41 075 461	44 899 115	...	19
Ad'oro SP	12 571 196	26 854 971	37 361 755	38 293 177	27	20
Avícola Céu Azul SP	7 229 057	10 971 249	37 103 020	47 163 399	44	21
Anhambi MT-PR		12 345 741	35 222 181	36 844 129	...	22
Reginaves RJ			34 981 484	38 356 394	...	23
Mat. Avíc. Flamboiã SP	9 360 529	21 279 051	33 630 590	33 128 238	33	24
Avícola Paulista SP	8 985 905	18 613 701	32 865 286	25 405 227	34	25
São Salvador GO		11 137 310	32 411 121	37 980 277	...	26
Coopavel PR	11 904 254	30 735 920	32 202 400	29 181 736	28	27
Coperguaçú SP	14 346 569	17 050 123	31 404 872	34 008 781	21	28
Nutriza GO		18 845 176	31 033 287	31 545 647	...	29
Agrovêneto SC		14 826 189	27 313 146	28 488 956	...	30
Avícola Felipe PR		15 054 871	25 948 112	23 353 578	...	31
Macedo Agroindustrial SC	12 898 431	17 337 624	25 732 727	18 730 507	26	32
Comaves PR-MS	14 780 592	28 289 921	25 371 320	23 985 266	20	33
Coop. Languirú RS	13 403 140	15 354 702	24 053 657	24 345 320	25	34
Gonçalves & Tortola PR			22 491 460	23 707 362	...	35
Coroaves PR	15 441 116	18 332 660	21 872 592	22 618 712	18	36
Asa Alimentos DF-GO-TO			21 636 506	20 612 932	...	37
Francap MG	6 745 048	14 401 848	21 115 438	22 171 485	45	38
Frangoeste SP	8 710 848	14 386 934	19 875 689	19 467 728	36	39
Coop. Holambra SP	13 596 441	16 860 283	19 847 930	19 301 571	22	40
Jaguafrangos PR			19 079 358	20 659 231	...	41
Nogueira Rivelli MG			18 745 645	20 419 360	...	42
Abat. Aves Ideal SP		8 894 573	18 612 494	27 275 835	...	43
Polifrigor SP		9 615 924	18 233 778	18 066 595	...	44
Frinal RS	11 780 128	17 815 055	18 172 072	19 612 660	29	45
Agrofrango SC		8 828 964	15 776 702	14 546 717	...	46
Notaro Alimentos PE		9 824 940	14 156 698	14 958 081	...	47
Palmali SP			13 603 752	16 507 381	...	48
Votuporanga SP			13 603 752	14 803 174	...	49

Table 19 - Leading chicken-producing companies in Brazil

Company	*Chicken (heads per annum)* 1995	2000	2005	2006	Rank in 1995	Rank in 2005
Avivar Alimentos MG			11 240 612	15 984 120	...	50
Minuano RS	35 384 499	35 052 630	...	...	9	
Chapecó SC-SP	66 140 341	86 563 540			8	
Batavo PR	27 397 252	17 565 298			12	
Coagri MS	21 101 490				16	
Só Frango DF	19 645 495	22 235 960			17	
Agroeliane SC-MS	15 141 814				19	
Rezende MG		38 141 133			...	
COTREL RS	13 559 546	31 015 713			24	
Coopervale PR		27 627 146			...	
COTREFAL PR		23 240 069			...	
Frig. Nicolini RS		21 703 487			...	
Osato Alimentos SP	10 421 054	18 111 366			31	
Gale Agroindustrial GO		15 411 161			...	
Maristela	13 569 846	13 898 323			23	
Piratini MS	9 734 626				32	
CAESP - SP	8 739 196				35	
Granja Itambi SP	8 489 437				37	
Frango Mineiro MG	8 314 317				38	
Frig. Avic. Lindóia MG	7 971 771				39	
Caldana SP	7 841 305				40	
Sto. Ant. Louveira SP	7 722 346				41	
Frig. Avic. Tanabi SP	7 536 816				42	
Ito Aves SP	7 451 542				43	
Granjas Mara SP	6 733 848				46	
Cogran MG	6 459 599				47	
Avic. Dacar SP	6 111 285				48	
Três Pontes SP	5 774 616				49	
Avic. Paulo Dias SP	4 608 699				50	
Subtotal	1 602 578 264	2 357 038 797	3 476 722 407	3 493 508 051		
Other	937 121 877	887 201 824	950 011 587	902 805 291		
TOTAL	2 539 700 141	3 244 240 621	4 426 733 994	4 396 313 342		

Sources: UBA (http://www.uba.org.br/) and ANAB (National Association of Slaughterhouses) for 1995. Data for 2000 to 2006 are from UBA databank or Annual Reports.

FIGURE 16
Concentration of Brazilian chicken meat production



Source: Source: UBA Annual Reports

Table 19 shows that in Brazil, as in most main producing countries, the poultry business is becoming more concentrated. The three largest Brazilian chicken-meat companies accounted for 23.7 percent of production in 1995 and 31.8 percent in 2005. In the last quarter of 2007, Perdigão announced that it had purchased AVIPAL, the fifth largest chicken-meat producer; soon afterwards, Sadia announced the purchase of a medium-sized company situated in the State of Goiás, Centre-West Region. The five largest Brazilian chicken-meat producers are also the five main exporters

.

TABLE 20
Brazil's largest chicken-meat exporters in 1995 and 2005

Chicken Meat	1995 EXPORTS		2005 EXPORTS	
Company	Tons	Share	Tons	Share
Sadia	124 607	29.05%	733 784	25.78%
Perdigão	100 335	23.39%	495 146	17.40%
Seara	69 641	16.23%	353 269	12.41%
Doux Frangosul	45 246	10.55%	286 805	10.08%
Avipal	38 710	9.02%	215 813	7.58%
Subtotal	378 540	88.24%	2 084 817	73.26%
Other Companies	50 448	11.76%	761 129	26.74%
Total Exports	428 988		2 845 946	

Sources: ABEF (www.abef.com.br).

Turkey production is concentrated in the hands of three companies, Sadia, Perdigão and Frangosul. The two leading poultry companies have been investing in new production facilities in the Centre-West Region – following the grain production towards this new agricultural frontier.

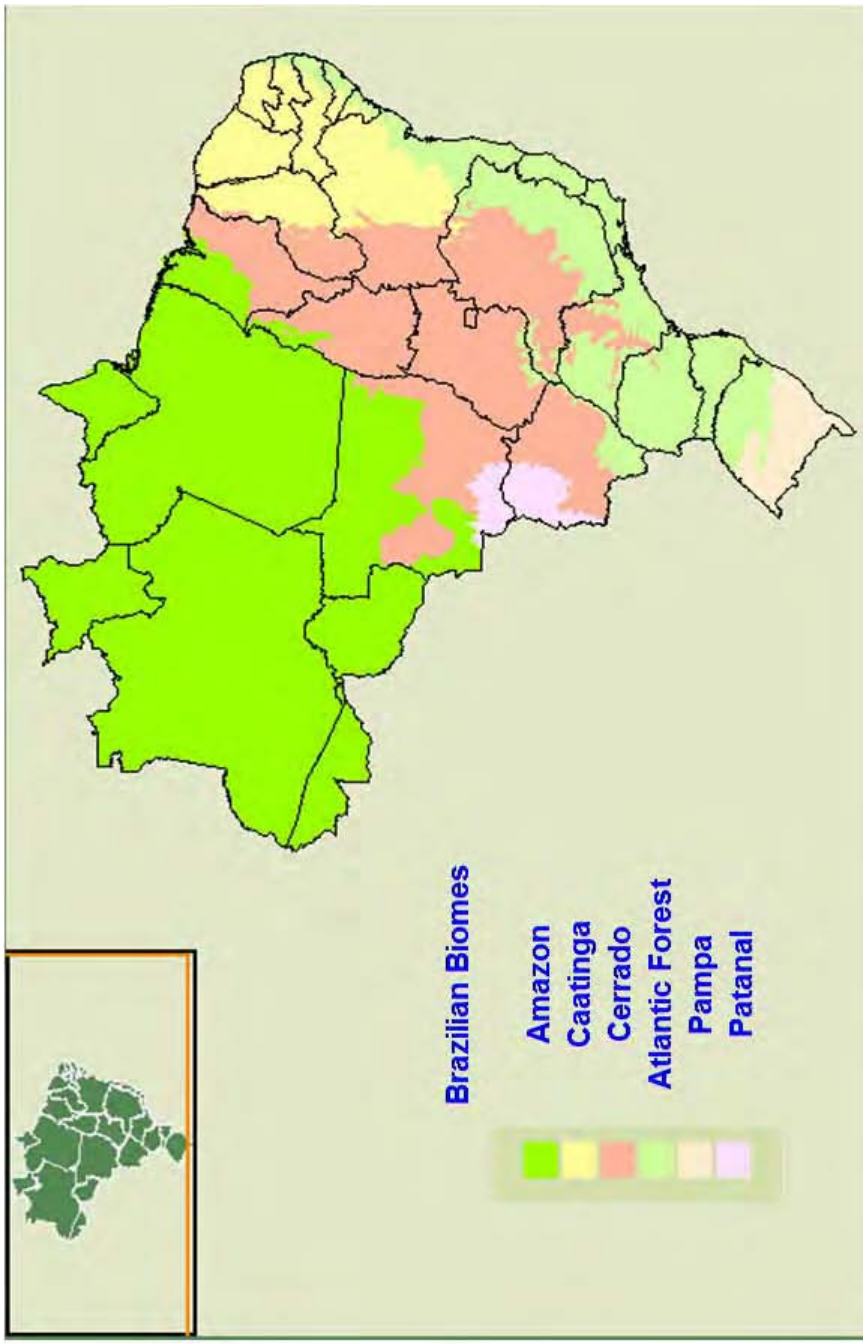
The reasons for the dynamism of the Centre-West Region

Grazing is the prevailing production system for bovines in Brazil, and the Centre-West Region with its extensive pastures has always been the leader in terms of cattle numbers (34.7 percent of the national bovine herd in 2005).[22]

Most of the territory of the Centre-West Region is in the Cerrado. Cerrado is the second largest Brazilian biome, with 204 million hectares; it has major significance for Brazilian and world agriculture, being both an important biodiversity reserve and a potential food-producing region. It occupies 24 percent of the total area of the country and includes 13 Brazilian states and in the Federal District.

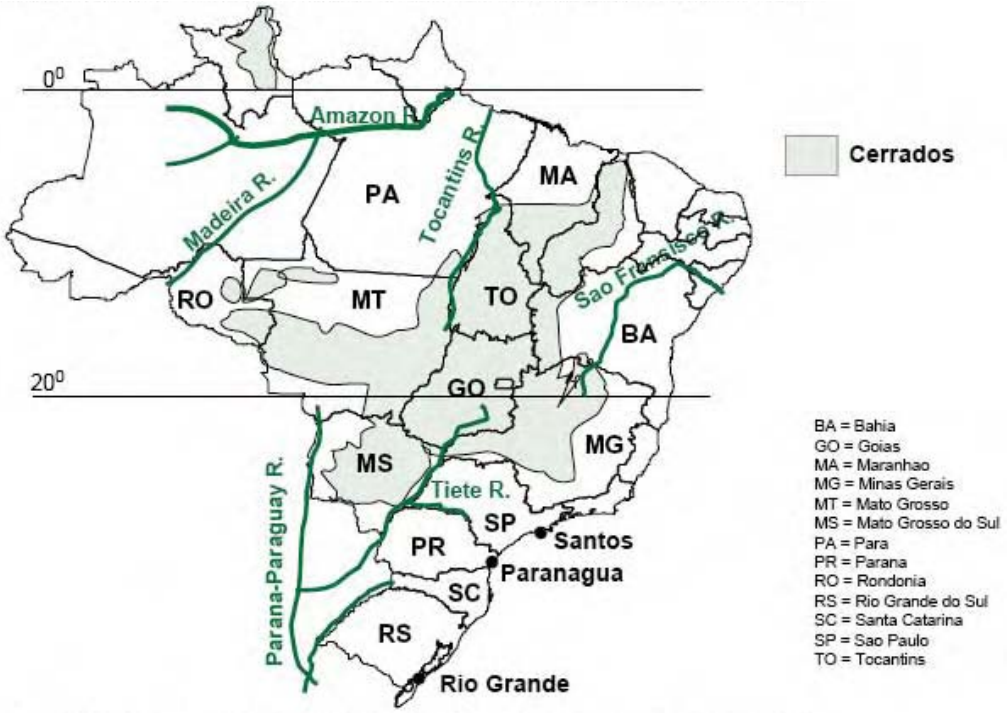
[22] IBGE's SIDRA (http://www.sidra.ibge.gov.br) PPM 2005.

FIGURE 17
Brazilian biomes



Source: IBGE's Mapas interativos (Interactive maps) (http://mapas.ibge.gov.br/biomas2/viewer.htm).

FIGURE 18
Cerrado biome



During the 1970s, in line with the official government policy of promoting the development of the interior of Brazil, resources were allocated to agricultural and livestock research and for technical assistance to farmers, with the objective of solving the main problems that limited the occupation of the Cerrado region. In this context, Embrapa created, in 1975, "Embrapa Cerrados" to study and identify the major agricultural limitations affecting the Cerrados (Empraba, 2005). The accomplishments of this body include new and cheaper forms of animal feed, new high-productivity forages, integration between agriculture and livestock breeding for the renewal of grazing lands, increased use of the native flora of the Cerrado and the reduction of harvest losses caused by climatic factors.

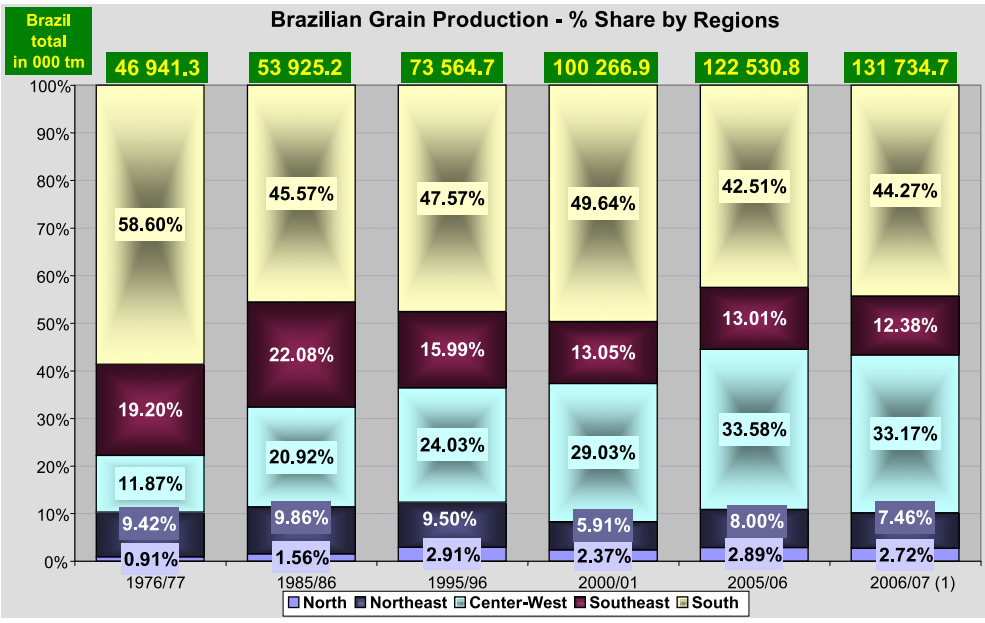
Embrapa estimates that with their present stock of technologies it is possible to produce 350 million tonnes of food in the potential agricultural area of the Cerrados (equivalent to two-thirds of the total area).

"The conquest of the Cerrado was one of the major achievements of twentieth-century tropical agriculture and can be considered a model to be emulated in other developing regions of the world, especially in South America and Africa, which have ecosystems similar to the Brazilian savannas."[23]

[23] Embrapa (2005) pages 5 and 6, extracts from the introduction.

The increasing importance of the Centre-West Region for agriculture and livestock becomes evident if we examine the evolution of Brazilian grain production. From the crop year 1976/77 to 2005/2006, Brazilian grain production expanded by 280.6 percent, while the equivalent figure for the Centre-West Region was 684.1 percent.

FIGURE 19
Brazil's grain production by regions



Source: Source: CONAB – Companhia Nacional de Abastecimento (National Company for Food Supply) (http://www.conab.gov.br) (state company within the structure of the MAPA).

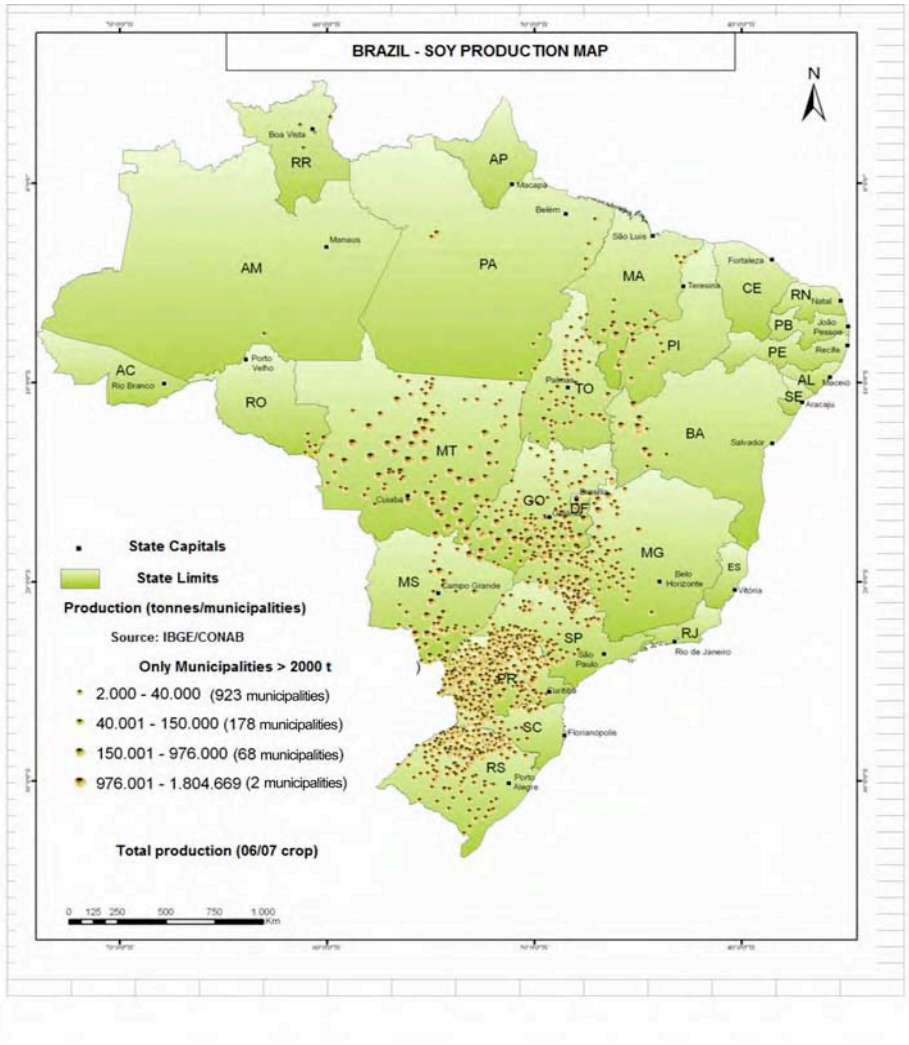
Soybean and maize are the two main sources of feed ingredients used for poultry and pork production in Brazil. In the period being analyzed, soy production in the Centre-West Region expanded by 5 027.7 percent against 353.1 percent for the country as a whole and 112.0 percent for the South Region, birthplace of soy in Brazil.

TABLE 21
Brazil's soy production by region (1 000 tonnes)

	1976/77	1985/86	1995/96	2000/01	2005/06	2006/07[(1)]
North	-	0.5	14.2	216.6	1 255.2	1 064.5
Northeast	-	155.5	921.9	2 075.9	3 560.9	3 867.2
Center-West	540.0	5 027.5	8 846.4	17 001.9	27 824.7	26 494.8
Southeast	875.0	1 687.5	2 274.5	2 873.9	4 137.1	4 005.4
South	10 730.0	6 336.5	11 132.7	16 263.5	18 249.2	22 944.5
Brazil	12 145.0	13 207.5	23 189.7	38 431.8	55 027.1	58 376.4

Source: CONAB – Companhia Nacional de Abastecimento (National Company for Food Supply) (http://www.conab.gov.br) (state company within the structure of the MAPA). [1] Preliminary

FIGURE 20
Map of soy production in Brazil



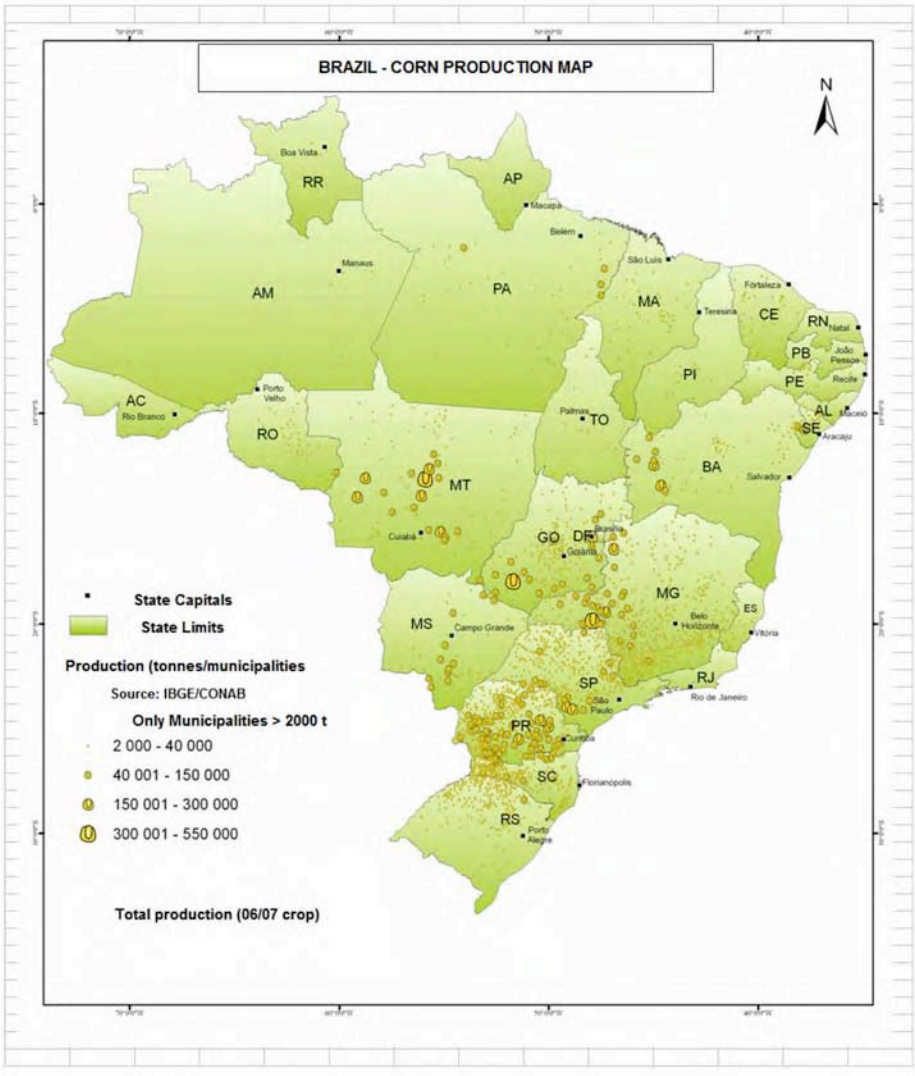
Source: Conab – SigaBRASIL (Brazilian Agriculture Geographic Information System) (http://www.conab.gov.br/conabweb/geotecnologia/sigabrasil/mapa_producao_agricola/soja.jpg).

TABLE 22
Brazil's maize production by region (1 000 tonnes)

	1976/77	1985/86	1995/96	2000/01	2005/06	2006/07[1]	2007/08[1]
North	118. 3	381. 5	963. 5	916. 2	1 129. 2	1 243. 0	1 192. 2
Northeast	1 645. 4	1 809. 6	2 948. 2	1 988. 3	3 242. 4	3 106. 2	4 164. 6
Center-West	1 941. 5	3 139. 6	6 767. 6	8 234. 3	9 592. 2	12 994. 1	14 145. 9
Southeast	5 565. 5	6 727. 8	7 651. 9	8 591. 9	9 651. 9	10 353. 2	10 400. 1
South	9 985. 0	8 206. 3	14 073. 5	22 559. 0	18 899. 2	23 673. 4	23 466. 6
Brazil	19 255. 7	20 264. 8	32 404. 7	42 289. 7	42 514. 9	51 369. 9	53 369. 4

Source: CONAB. [1] Preliminary

FIGURE 21
Map of maize production in Brazil



Source: Conab – SigaBRASIL (Brazilian Agriculture Geographic Information System) (http://www.conab.gov.br/conabweb/geotecnologia/sigabrasil/mapa_producao_agricola/milho.jpg).

Maize was until recently used for crop rotation because of its relatively modest international price. During the period from 1976 to 2005, maize production in the Centre-West grew by 569.3 percent, against 137.1 percent in the South (the leading region in terms of production) and 166.8 percent for the country as a whole. The relatively recent increase in international maize prices resulting from its use in ethanol production in the United States of America is giving rise to new interest in maize production in Brazil.

Feed normally represents around 65 percent of poultry production costs. To remain competitive, poultry production follows grain production. Tables 23, 24 and 25 present the production costs of a live broiler in ten different Brazilian states, in four different regions. Each table calculates the costs in accordance with the type of broiler house used. In all three tables, two states of the Centre-West Region, Mato Grosso (MT) and Goiás (GO) have the lowest production costs, followed by Paraná (PR) in the South Region. The differences are fundamentally due to feed costs.

TABLE 23
Cost of live broilers - Climate Controlled Broiler Houses

Cost Items	RS	SC	PR*	PE	CE	SP	MG	MT	MS	GO
	South Region			Northeast Region		Southeast Region		Center-West Region		
1. Fixed Costs (A)										
1.1 - Depreciation of Installations	R$ 0.022	R$ 0.025	R$ 0.039	R$ 0.056	R$ 0.056	R$ 0.029	R$ 0.039	R$ 0.057	R$ 0.057	R$ 0.040
1.2 - Depreciation of Equipments	R$ 0.071	R$ 0.072	R$ 0.062	R$ 0.089	R$ 0.089	R$ 0.087	R$ 0.062	R$ 0.098	R$ 0.098	R$ 0.042
1.3 - Remun. o/average capital f/ Inst. & Equip.	R$ 0.034	R$ 0.036	R$ 0.042	R$ 0.060	R$ 0.060	R$ 0.087	R$ 0.042	R$ 0.064	R$ 0.064	R$ 0.039
1.4 - Remuneration o/Turning Capital	R$ 0.002	R$ 0.001	R$ 0.001	R$ 0.002	R$ 0.002	R$ 0.003	R$ 0.001	R$ 0.002	R$ 0.002	R$ 0.001
(=) Total Fixed Costs of Contract Farmer	***R$ 0.129***	***R$ 0.134***	***R$ 0.144***	***R$ 0.206***	***R$ 0.207***	***R$ 0.206***	***R$ 0.144***	***R$ 0.221***	***R$ 0.221***	***R$ 0.122***
2. Variable Costs (B)										
2.1 - Litter	R$ 0.032	R$ 0.033	R$ 0.045	R$ 0.065	R$ 0.087	R$ 0.044	R$ 0.056	R$ 0.012	R$ 0.048	R$ 0.020
2.2 - Heating	R$ 0.021	R$ 0.043	R$ 0.011	R$ 0.012	R$ 0.022	R$ 0.040	R$ 0.018	R$ 0.021	R$ 0.009	R$ 0.014
2.3 - Electrical Power	R$ 0.019	R$ 0.019	R$ 0.014	R$ 0.018	R$ 0.074	R$ 0.016	R$ 0.022	R$ 0.098	R$ 0.068	R$ 0.014
2.4 - Water	R$ 0.015	R$ 0.008	R$ 0.000	R$ 0.016	R$ 0.006	R$ 0.001	R$ 0.015	R$ 0.001	R$ 0.001	R$ 0.001
2.5 - Contract farmer manpower	R$ 0.083	R$ 0.034	R$ 0.053	R$ 0.068	R$ 0.037	R$ 0.051	R$ 0.030	R$ 0.050	R$ 0.050	R$ 0.048
2.6 - Loading Manpower	R$ 0.018	R$ 0.019	R$ 0.025	R$ 0.010	R$ 0.007	R$ 0.013	R$ 0.010	R$ 0.015	R$ 0.021	R$ 0.020
2.7 - Maintenance Cost of Installations	R$ 0.017	R$ 0.018	R$ 0.021	R$ 0.030	R$ 0.030	R$ 0.022	R$ 0.021	R$ 0.032	R$ 0.032	R$ 0.020
2.8 - Insurance	R$ 0.002	R$ 0.002	R$ 0.003	R$ 0.004	R$ 0.004	R$ 0.003	R$ 0.003	R$ 0.004	R$ 0.004	R$ 0.002
2.9 - Sundry Costs	R$ 0.010	R$ 0.009	R$ 0.009	R$ 0.011	R$ 0.013	R$ 0.010	R$ 0.009	R$ 0.012	R$ 0.012	R$ 0.007
(=) Total of Variable Costs of Contract Farmer	***R$ 0.217***	***R$ 0.185***	***R$ 0.181***	***R$ 0.233***	***R$ 0.280***	***R$ 0.200***	***R$ 0.184***	***R$ 0.245***	***R$ 0.245***	***R$ 0.146***
(=) Total Costs of Contract Farmers	**R$ 0.346**	**R$ 0.319**	**R$ 0.325**	**R$ 0.439**	**R$ 0.486**	**R$ 0.406**	**R$ 0.328**	**R$ 0.466**	**R$ 0.466**	**R$ 0.268**
3. Fixed Costs (C)										
3.1 - Remuneration o/Turning Capital	R$ 0.020	R$ 0.021	R$ 0.018	R$ 0.024	R$ 0.027	R$ 0.044	R$ 0.022	R$ 0.019	R$ 0.022	R$ 0.019

4.Variable Costs (D)										
4.1 - One-day chicks	R$ 0.550	R$ 0.580	R$ 0.560	R$ 0.700	R$ 0.580	R$ 0.600	R$ 0.660	R$ 0.520	R$ 0.520	R$ 0.640
4.2 - Feed	R$ 2.265	R$ 2.225	R$ 1.954	R$ 2.720	R$ 2.493	R$ 2.143	R$ 2.193	R$ 1.725	R$ 2.318	R$ 1.800
4.3 - Veterinary Products	R$ 0.010	R$ 0.008	R$ 0.012	R$ 0.031	R$ 0.042	R$ 0.014	R$ 0.009	R$ 0.011	R$ 0.011	R$ 0.010
4.4 - Transport	R$ 0.093	R$ 0.136	R$ 0.053	R$ 0.016	R$ 0.460	R$ 0.158	R$ 0.054	R$ 0.221	R$ 0.055	R$ 0.078
4.5 - Funrural (Tax)	R$ 0.070	R$ 0.077	R$ 0.072	R$ 0.086	R$ 0.098	R$ 0.077	R$ 0.094	R$ 0.122	R$ 0.122	R$ 0.081
4.6 - Technical Assistance	R$ 0.009	R$ 0.006	R$ 0.007	R$ 0.008	R$ 0.022	R$ 0.024	R$ 0.010	R$ 0.036	R$ 0.009	R$ 0.043
4.7 - Sundry Costs	R$ 0.148	R$ 0.150	R$ 0.131	R$ 0.176	R$ 0.183	R$ 0.149	R$ 0.149	R$ 0.130	R$ 0.149	R$ 0.131
(=) Total of Variable Costs	***R$ 3.150***	***R$ 3.182***	***R$ 2.790***	***R$ 3.738***	***R$ 3.878***	***R$ 3.170***	***R$ 3.170***	***R$ 2.765***	***R$ 3.184***	***R$ 2.783***
(=) Total Costs of Agroindustry	**R$ 3.170**	**R$ 3.203**	**R$ 2.808**	**R$ 3.762**	**R$ 3.878**	**R$ 3.214**	**R$ 3.192**	**R$ 2.784**	**R$ 3.206**	**R$ 2.802**
(=) Total Fixed Cost (A + C)	**R$ 0.149**	**R$ 0.155**	**R$ 0.162**	**R$ 0.230**	**R$ 0.234**	**R$ 0.250**	**R$ 0.166**	**R$ 0.240**	**R$ 0.243**	**R$ 0.141**
(=) Total Variable Cost (B + D)	**R$ 3.367**	**R$ 3.367**	**R$ 2.971**	**R$ 3.970**	**R$ 4.158**	**R$ 3.370**	**R$ 3.354**	**R$ 3.010**	**R$ 3.429**	**R$ 2.929**
(=) Total Cost	***R$ 3.516***	***R$ 3.521***	***R$ 3.133***	***R$ 4.201***	***R$ 4.391***	***R$ 3.620***	***R$ 3.520***	***R$ 3.250***	***R$ 3.672***	***R$ 3.070***
(=) Cost per kg of broiler	***R$ 1.470***	***R$ 1.531***	***R$ 1.360***	***R$ 1.901***	***R$ 1.756***	***R$ 1.510***	***R$ 1.290***	***R$ 1.230***	***R$ 1.390***	***R$ 1.230***
Feed Conversion	1.890	1.870	1.840	2.030	1.910	1.950	1.880	1.860	1.860	1.890
Final Broiler Weight	2.400	2.300	2.300	2.210	2.720	2.400	2.600	2.650	2.650	2.500

Source: the CONAB Web site (http://www.conab.gov.br/conabweb/index.php?PAG=213) publishes production costs for broilers and pigs, along with several other costs of both summer and winter crops, permanent crops, etc. Broiler costs are calculated in cooperation with Embrapa Suínos e Aves (Pigs and Poultry). Paraná State costs are calculated in cooperation the Department of Rural Economy (DERAL) of the State Secretary of Agriculture and Food Supply (SERAL). These data permit farmers to compare their costs with the averages and to obtain knowledge of the cost structure of the whole chain.

TABLE 24
Costs of live broiler production – automatic broiler houses

Cost Items	RS	SC	PR*	PE	CE	SP	MG	MT	MS	GO
	South Region			Northeast Region		Southeast Region		Center-West Region		
1. Fixed Costs (A)										
1.1 - Depreciation of Installations	R$ 0.027	R$ 0.032	R$ 0.023	R$ 0.045	R$ 0.036	R$ 0.034	R$ 0.033	R$ 0.042	R$ 0.042	R$ 0.042
1.2 - Depreciation of Equipments	R$ 0.065	R$ 0.078	R$ 0.066	R$ 0.111	R$ 0.088	R$ 0.071	R$ 0.057	R$ 0.075	R$ 0.075	R$ 0.038
1.3 - Remun. o/average capital f/ Inst. & Equip.	R$ 0.036	R$ 0.042	R$ 0.034	R$ 0.060	R$ 0.048	R$ 0.083	R$ 0.037	R$ 0.048	R$ 0.048	R$ 0.039
1.4 - Remuneration o/Turning Capital	R$ 0.002	R$ 0.002	R$ 0.001	R$ 0.003	R$ 0.003	R$ 0.003	R$ 0.002	R$ 0.002	R$ 0.002	R$ 0.001
(=) Total Fixed Costs of Contract Farmer	***R$ 0.130***	***R$ 0.153***	***R$ 0.124***	***R$ 0.220***	***R$ 0.176***	***R$ 0.191***	***R$ 0.129***	***R$ 0.167***	***R$ 0.167***	***R$ 0.120***
2. Variable Costs (B)										
2.1 - Litter	R$ 0.040	R$ 0.042	R$ 0.057	R$ 0.175	R$ 0.104	R$ 0.051	R$ 0.071	R$ 0.014	R$ 0.053	R$ 0.021
2.2 - Heating	R$ 0.026	R$ 0.055	R$ 0.013	R$ 0.020	R$ 0.027	R$ 0.047	R$ 0.023	R$ 0.023	R$ 0.010	R$ 0.015
2.3 - Electrical Power	R$ 0.023	R$ 0.023	R$ 0.016	R$ 0.030	R$ 0.074	R$ 0.016	R$ 0.027	R$ 0.108	R$ 0.075	R$ 0.015
2.4 - Water	R$ 0.017	R$ 0.010	R$ 0.001	R$ 0.025	R$ 0.014	R$ 0.001	R$ 0.015	R$ 0.001	R$ 0.001	R$ 0.001
2.5 - Contract farmer manpower	R$ 0.104	R$ 0.044	R$ 0.067	R$ 0.110	R$ 0.070	R$ 0.059	R$ 0.039	R$ 0.055	R$ 0.055	R$ 0.050
2.6 - Loading Manpower	R$ 0.023	R$ 0.020	R$ 0.025	R$ 0.015	R$ 0.008	R$ 0.015	R$ 0.012	R$ 0.014	R$ 0.019	R$ 0.021
2.7 - Maintenance Cost of Installations	R$ 0.018	R$ 0.021	R$ 0.017	R$ 0.030	R$ 0.024	R$ 0.021	R$ 0.018	R$ 0.024	R$ 0.024	R$ 0.019
2.8 - Insurance	R$ 0.002	R$ 0.003	R$ 0.002	R$ 0.004	R$ 0.003	R$ 0.002	R$ 0.002	R$ 0.003	R$ 0.003	R$ 0.002
2.9 - Sundry Costs	R$ 0.013	R$ 0.011	R$ 0.010	R$ 0.020	R$ 0.016	R$ 0.011	R$ 0.010	R$ 0.012	R$ 0.012	R$ 0.007
(=) Total of Variable Costs of Contract Farmer	***R$ 0.266***	***R$ 0.228***	***R$ 0.208***	***R$ 0.428***	***R$ 0.341***	***R$ 0.223***	***R$ 0.217***	***R$ 0.254***	***R$ 0.252***	***R$ 0.151***
(=) Total Costs of Contract Farmers	**R$ 0.400**	**R$ 0.382**	**R$ 0.330**	**R$ 0.648**	**R$ 0.517**	**R$ 0.410**	**R$ 0.350**	**R$ 0.420**	**R$ 0.420**	**R$ 0.270**
3. Fixed Costs (C)										
3.1 - Remuneration o/Turning Capital	R$ 0.020	R$ 0.021	R$ 0.018	R$ 0.029	R$ 0.030	R$ 0.044	R$ 0.022	R$ 0.019	R$ 0.022	R$ 0.019

4.Variable Costs (D)										
4.1 - One-day chicks	R$ 0.550	R$ 0.580	R$ 0.560	R$ 0.700	R$ 0.580	R$ 0.600	R$ 0.660	R$ 0.520	R$ 0.520	R$ 0.640
4.2 - Feed	R$ 2.265	R$ 2.225	R$ 1.954	R$ 3.066	R$ 2.675	R$ 2.143	R$ 2.193	R$ 1.725	R$ 2.318	R$ 1.800
4.3 - Veterinary Products	R$ 0.011	R$ 0.010	R$ 0.013	R$ 0.026	R$ 0.044	R$ 0.015	R$ 0.011	R$ 0.011	R$ 0.011	R$ 0.011
4.4 - Transport	R$ 0.099	R$ 0.165	R$ 0.061	R$ 0.025	R$ 0.456	R$ 0.162	R$ 0.048	R$ 0.238	R$ 0.060	R$ 0.076
4.5 - Funrural (Tax)	R$ 0.070	R$ 0.077	R$ 0.072	R$ 0.098	R$ 0.106	R$ 0.077	R$ 0.090	R$ 0.122	R$ 0.122	R$ 0.081
4.6 - Technical Assistance	R$ 0.011	R$ 0.008	R$ 0.008	R$ 0.018	R$ 0.027	R$ 0.027	R$ 0.013	R$ 0.040	R$ 0.010	R$ 0.045
4.7 - Sundry Costs	R$ 0.148	R$ 0.152	R$ 0.132	R$ 0.193	R$ 0.191	R$ 0.149	R$ 0.149	R$ 0.131	R$ 0.149	R$ 0.131
(=) Total of Variable Costs	***R$ 3.150***	***R$ 3.215***	***R$ 2.800***	***R$ 4.126***	***R$ 4.079***	***R$ 3.170***	***R$ 3.160***	***R$ 2.787***	***R$ 3.190***	***R$ 2.784***
(=) Total Costs of Agroindustry	**R$ 3.170**	**R$ 3.236**	**R$ 2.818**	**R$ 4.154**	**R$ 4.079**	**R$ 3.214**	**R$ 3.182**	**R$ 2.806**	**R$ 3.212**	**R$ 2.803**
(=) Total Fixed Cost (A + C)	**R$ 0.150**	**R$ 0.174**	**R$ 0.140**	**R$ 0.248**	**R$ 0.206**	**R$ 0.240**	**R$ 0.150**	**R$ 0.190**	**R$ 0.190**	**R$ 0.140**
(=) Total Variable Cost (B + D)	**R$ 3.420**	**R$ 3.444**	**R$ 3.010**	**R$ 4.554**	**R$ 4.420**	**R$ 3.390**	**R$ 3.380**	**R$ 3.040**	**R$ 3.440**	**R$ 2.940**
(=) Total Cost	***R$ 3.570***	***R$ 3.618***	***R$ 3.150***	***R$ 4.802***	***R$ 4.626***	***R$ 3.630***	***R$ 3.530***	***R$ 3.230***	***R$ 3.630***	***R$ 3.080***
(=) Cost per kg of broiler	***R$ 1.490***	***R$ 1.573***	***R$ 1.370***	***R$ 1.921***	***R$ 1.699***	***R$ 1.510***	***R$ 1.360***	***R$ 1.220***	***R$ 1.370***	***R$ 1.230***
Feed Conversion	1.890	1.870	1.840	2.030	1.910	1.950	1.880	1.860	1.860	1.890
Final Broiler Weight	2.400	2.300	2.300	2.500	2.720	2.400	2.600	2.650	2.650	2.500

Source: the CONAB Web site (http://www.conab.gov.br/conabweb/index.php?PAG=213) publishes production costs for broilers and pigs, along with several other costs of both summer and winter crops, permanent crops, etc. Broiler costs are calculated in cooperation with Embrapa Suínos e Aves (Pigs and Poultry). Paraná State costs are calculated in cooperation the Department of Rural Economy (DERAL) of the State Secretary of Agriculture and Food Supply (SERAL). These data permit farmers to compare their costs with the averages and to obtain knowledge of the cost structure of the whole chain.

TABLE 25
Costs of live broiler production – manual broiler houses

Cost Items	RS	SC	PR*	PE	CE	SP	MG	MT	MS	GO
	South Region			Northeast Region		Southeast Region		Center-West Region		
1. Fixed Costs (A)										
1.1 - Depreciation of Installations	R$ 0.029	R$ 0.034	R$ 0.028	R$ 0.044	R$ 0.017	R$ 0.034	R$ 0.024	R$ 0.044	R$ 0.044	R$ 0.048
1.2 - Depreciation of Equipments	R$ 0.044	R$ 0.034	R$ 0.035	R$ 0.073	R$ 0.028	R$ 0.043	R$ 0.029	R$ 0.053	R$ 0.053	R$ 0.033
1.3 - Remun. o/average capital f/ Inst. & Equip.	R$ 0.044	R$ 0.034	R$ 0.035	R$ 0.073	R$ 0.028	R$ 0.043	R$ 0.029	R$ 0.053	R$ 0.053	R$ 0.033
1.4 - Remuneration o/Turning Capital	R$ 0.002	R$ 0.002	R$ 0.002	R$ 0.005	R$ 0.003	R$ 0.003	R$ 0.002	R$ 0.002	R$ 0.002	R$ 0.001
(=) Total Fixed Costs of Contract Farmer	***R$ 0.119***	***R$ 0.104***	***R$ 0.100***	***R$ 0.194***	***R$ 0.076***	***R$ 0.123***	***R$ 0.084***	***R$ 0.152***	***R$ 0.152***	***R$ 0.115***
2. Variable Costs (B)										
2.1 – Litter	R$ 0.043	R$ 0.045	R$ 0.067	R$ 0.175	R$ 0.120	R$ 0.051	R$ 0.071	R$ 0.014	R$ 0.055	R$ 0.024
2.2 - Heating	R$ 0.027	R$ 0.060	R$ 0.016	R$ 0.018	R$ 0.031	R$ 0.047	R$ 0.023	R$ 0.024	R$ 0.010	R$ 0.017
2.3 - Electrical Power	R$ 0.022	R$ 0.022	R$ 0.017	R$ 0.029	R$ 0.078	R$ 0.014	R$ 0.025	R$ 0.091	R$ 0.063	R$ 0.016
2.4 - Water	R$ 0.017	R$ 0.010	R$ 0.001	R$ 0.024	R$ 0.016	R$ 0.001	R$ 0.016	R$ 0.001	R$ 0.001	R$ 0.001
2.5 - Contract farmer manpower	R$ 0.111	R$ 0.047	R$ 0.080	R$ 0.293	R$ 0.095	R$ 0.059	R$ 0.039	R$ 0.058	R$ 0.058	R$ 0.058
2.6 - Loading Manpower	R$ 0.024	R$ 0.022	R$ 0.025	R$ 0.020	R$ 0.010	R$ 0.015	R$ 0.012	R$ 0.013	R$ 0.018	R$ 0.025
2.7 - Maintenance Cost of Installations	R$ 0.015	R$ 0.015	R$ 0.013	R$ 0.024	R$ 0.009	R$ 0.017	R$ 0.011	R$ 0.021	R$ 0.021	R$ 0.020
2.8 - Insurance	R$ 0.002	R$ 0.002	R$ 0.002	R$ 0.003	R$ 0.001	R$ 0.002	R$ 0.001	R$ 0.003	R$ 0.003	R$ 0.002
2.9 - Sundry Costs	R$ 0.013	R$ 0.011	R$ 0.011	R$ 0.029	R$ 0.018	R$ 0.010	R$ 0.010	R$ 0.011	R$ 0.011	R$ 0.008
(=) Total of Variable Costs of Contract Farmer	***R$ 0.274***	***R$ 0.234***	***R$ 0.232***	***R$ 0.615***	***R$ 0.378***	***R$ 0.216***	***R$ 0.208***	***R$ 0.236***	***R$ 0.240***	***R$ 0.171***
(=) Total Costs of Contract Farmers	**R$ 0.390**	**R$ 0.338**	**R$ 0.330**	**R$ 0.809**	**R$ 0.454**	**R$ 0.340**	**R$ 0.290**	**R$ 0.390**	**R$ 0.390**	**R$ 0.290**
3. Fixed Costs (C)										
3.1 - Remuneration o/Turning Capital	R$ 0.021	R$ 0.021	R$ 0.018	R$ 0.036	R$ 0.032	R$ 0.044	R$ 0.022	R$ 0.020	R$ 0.022	R$ 0.020

4.Variable Costs (D)										
4.1 - One-day chicks	R$ 0.550	R$ 0.580	R$ 0.560	R$ 0.700	R$ 0.580	R$ 0.600	R$ 0.660	R$ 0.520	R$ 0.520	R$ 0.640
4.2 - Feed	R$ 2.265	R$ 2.225	R$ 1.954	R$ 3.554	R$ 2 675	R$ 2.143	R$ 2.193	R$ 1.725	R$ 2.318	R$ 1.800
4.3 - Veterinary Products	R$ 0.011	R$ 0.010	R$ 0.014	R$ 0.029	R$ 0.047	R$ 0.015	R$ 0.010	R$ 0.012	R$ 0.012	R$ 0.011
4.4 - Transport	R$ 0.124	R$ 0.188	R$ 0.079	R$ 0.080	R$ 0.637	R$ 0.182	R$ 0.069	R$ 0.256	R$ 0.064	R$ 0.095
4.5 - Funrural (Tax)	R$ 0.070	R$ 0.077	R$ 0.072	R$ 0.109	R$ 0.106	R$ 0.077	R$ 0.090	R$ 0.122	R$ 0.122	R$ 0.081
4.6 - Technical Assistance	R$ 0.012	R$ 0.008	R$ 0.010	R$ 0.035	R$ 0.031	R$ 0.027	R$ 0.013	R$ 0.042	R$ 0.011	R$ 0.052
4.7 - Sundry Costs	R$ 0.149	R$ 0.153	R$ 0.133	R$ 0.221	R$ 0.201	R$ 0.150	R$ 0.150	R$ 0.132	R$ 0.149	R$ 0.132
(=) Total of Variable Costs	**R$ 3.180**	**R$ 3.241**	**R$ 2.820**	**R$ 4.727**	**R$ 4.276**	**R$ 3.190**	**R$ 3.190**	**R$ 2.809**	**R$ 3.196**	**R$ 2.811**
(=) Total of Variable Costs	***R$ 3.150***	***R$ 3.182***	***R$ 2.790***	***R$ 3.738***	***R$ 3.878***	***R$ 3.170***	***R$ 3.170***	***R$ 2.765***	***R$ 3.184***	***R$ 2.783***
(=) Total Costs of Agroindustry	**R$ 3.201**	**R$ 3.262**	**R$ 2.838**	**R$ 4.764**	**R$ 4.276**	**R$ 3.234**	**R$ 3.212**	**R$ 2.829**	**R$ 3.218**	**R$ 2.831**
(=) Total Fixed Cost (A + C)	**R$ 0.140**	**R$ 0.125**	**R$ 0.120**	**R$ 0.230**	**R$ 0.107**	**R$ 0.170**	**R$ 0.110**	**R$ 0.170**	**R$ 0.170**	**R$ 0.140**
(=) Total Variable Cost (B + D)	**R$ 3.450**	**R$ 3.475**	**R$ 3.050**	**R$ 5.342**	**R$ 4.654**	**R$ 3.410**	**R$ 3.400**	**R$ 3.050**	**R$ 3.440**	**R$ 2.980**
(=) Total Cost	***R$ 3.590***	***R$ 3.601***	***R$ 3.170***	***R$ 5.572***	***R$ 4.761***	***R$ 3.580***	***R$ 3.510***	***R$ 3.220***	***R$ 3.610***	***R$ 3.120***
(=) Cost per kg of broiler	***R$ 1.500***	***R$ 1.565***	***R$ 1.380***	***R$ 1.990***	***R$ 1.763***	***R$ 1.490***	***R$ 1.350***	***R$ 1.220***	***R$ 1.360***	***R$ 1.250***
Feed Conversion	1.890	1.870	1.840	2.100	1.910	1.950	1.880	1.860	1.860	1.890
Final Broiler Weight	2.400	2.300	2.300	2.800	2.720	2.400	2.600	2.650	2.650	2.500

Source: the CONAB Web site (http://www.conab.gov.br/conabweb/index.php?PAG=213) publishes production costs for broilers and pigs, along with several other costs of both summer and winter crops, permanent crops, etc. Broiler costs are calculated in cooperation with Embrapa Suínos e Aves (Pigs and Poultry). Paraná State costs are calculated in cooperation the Department of Rural Economy (DERAL) of the State Secretary of Agriculture and Food Supply (SERAL). These data permit farmers to compare their costs with the averages and to obtain knowledge of the cost structure of the whole chain.

The movement in the poultry industry towards the Centre-West Region will be paralleled in the pork sector, because the majority of the main meat companies in Brazil produce and process both poultry and pork. This march towards the Centre-West along with the increase in meat exports has probably been one of the most remarkable developments in Brazil's livestock sector during the last decade and will continue to have an impact over the coming decade.

Appendix 2 presents data on Brazil's geographic regions, and their respective areas and populations. To these data are added information on income, expressed in euros, distribution of the active population by economic activity and herd size by species. A graphic shows the share of the region's total chicken for meat flock accounted for by each of its federal states.

The distribution of Brazil's chicken for meat flock

The distribution of the chicken for meat flock across the states of the Brazilian Federation for the years 1995 and 2005 is presented in Table 26.

TABLE 26
Brazil's chicken for meat flock by state, 1995 and 2005

Herd Sizes (Heads) - Herd = Cocks, hens, broilers & 1-day chicks							
	Year = 1995		%		Year = 2005		%
1	Rio Grande do Sul	110 746 770	20.5%	1	Paraná	151 814 509	18.7%
2	Paraná	89 020 286	16.4%	2	Santa Catarina	142 411 820	17.5%
3	São Paulo	78 765 024	14.6%	3	São Paulo	133 671 738	16.5%
4	Santa Catarina	73 718 164	13.6%	4	Rio Grande do Sul	108 730 854	13.4%
5	Minas Gerais	44 235 371	8.2%	5	Minas Gerais	67 618 845	8.3%
6	Bahia	19 874 937	3.7%	6	Goiás	31 801 276	3.9%
7	Rio de Janeiro	15 230 545	2.8%	7	Bahia	21 971 409	2.7%
8	Pernambuco	13 714 285	2.5%	8	Mato Grosso do Sul	21 585 870	2.7%
9	Ceará	11 543 264	2.1%	9	Mato Grosso	15 959 146	2.0%
10	Pará	10 971 675	2.0%	10	Pernambuco	15 882 854	2.0%
11	Maranhão	9 986 025	1.8%	11	Ceará	15 367 090	1.9%
12	Goiás	9 637 610	1.8%	12	Distrito Federal	13 505 480	1.7%
13	Mato Grosso	8 245 753	1.5%	13	Rio de Janeiro	12 737 252	1.6%
14	Espírito Santo	7 314 354	1.4%	14	Pará	9 918 115	1.2%
15	Mato Grosso do Sul	6 851 789	1.3%	15	Espírito Santo	9 593 088	1.2%
16	Piauí	6 074 203	1.1%	16	Maranhão	8 368 394	1.0%
17	Rondônia	5 626 581	1.0%	17	Piauí	7 599 507	0.9%
18	Paraíba	4 028 487	0.7%	18	Paraíba	6 146 814	0.8%
19	Distrito Federal	3 782 236	0.7%	19	Sergipe	3 536 628	0.4%
20	Tocantins	2 475 136	0.5%	20	Alagoas	3 038 943	0.4%
21	Alagoas	2 189 239	0.4%	21	Rondônia	2 954 770	0.4%
22	Sergipe	2 188 508	0.4%	22	Rio Grande do Norte	2 906 662	0.4%
23	Amazonas	1 740 261	0.3%	23	Tocantins	2 402 603	0.3%
24	Rio Grande do Norte	1 529 545	0.3%	24	Amazonas	1 527 537	0.2%
25	Acre	849 471	0.2%	25	Acre	722 181	0.1%
26	Roraima	528 455	0.1%	26	Roraima	648 000	0.1%
27	Amapá	295 968	0.1%	27	Amapá	46 515	0.0%

Source: IBGE's SIDRA – PPM 2005.

TABLE 27
Chicken flock growth by state, 1995 to 2005 (head)

Brazil 271.303.598					
Santa Catarina	68 693 656	Espírito Santo	2 278 734	Tocantins	-72 533
Paraná	62 794 223	Pernambuco	2 168 569	Acre	-127 290
São Paulo	54 906 714	Paraíba	2 118 327	Amazonas	-212 724
Minas Gerais	23 383 474	Bahia	2 096 472	Amapá	-249 453
Goiás	22 163 666	Piauí	1 525 304	Pará	-1 053 560
Mato Grosso do Sul	14 734 081	Rio Grande do Norte	1 377 117	Maranhão	-1 617 631
Distrito Federal	9 723 244	Sergipe	1 348 120	Rio Grande do Sul	-2 015 916
Mato Grosso	7 713 393	Alagoas	849 704	Rio de Janeiro	-2 493 293
Ceará	3 823 826	Roraima	119 545	Rondônia	-2 671 811

Source: IBGE's SIDRA – PPM 2005

TABLE 28
Chicken flock growth by state, 1995 to 2005 (in percentage terms)

Federal State	Chicken Herd Δ% 1995-2005	State Rank in 1995	State Rank in 2005	Federal State	Chicken Herd Δ% 1995-2005	State Rank in 1995	State Rank in 2005
Distrito Federal	257.1%	19	12	Espírito Santo	31.2%	14	15
Goiás	230.0%	12	6	Piauí	25.1%	16	17
Mato Grosso do Sul	215.0%	15	8	Roraima	22.6%	26	26
Mato Grosso	93.5%	13	9	Pernambuco	15.8%	8	10
Santa Catarina	93.2%	4	2	Bahia	10.5%	6	7
Rio Grande do Norte	90.0%	24	22	Rio Grande do Sul	-1.8%	1	4
Paraná	70.5%	2	1	Tocantins	-2.9%	20	23
São Paulo	69.7%	3	3	Pará	-9.6%	10	14
Sergipe	61.6%	22	19	Amazonas	-12.2%	23	24
Minas Gerais	52.9%	5	5	Acre	-15.0%	25	25
Paraíba	52.6%	18	18	Maranhão	-16.2%	11	16
Alagoas	38.8%	21	20	Rio de Janeiro	-16.4%	7	13
Ceará	33.1%	9	11	Rondônia	-47.5%	17	21
				Amapá	-84.3%	27	27

Sources: IBGE's SIDRA – PPM 2005.

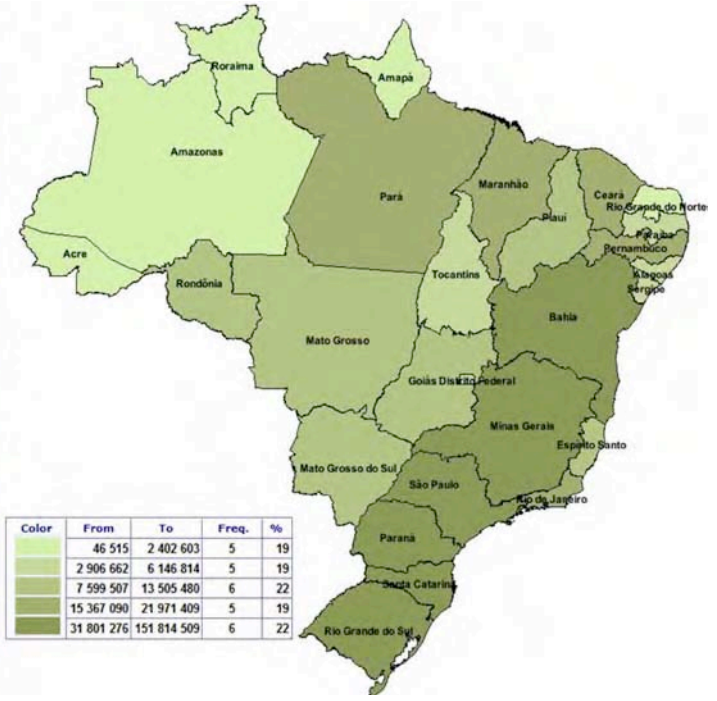
Tables 26 to 28 show that:

- in both 1995 and 2005, the two leading states were from the South Region; and
- Rio Grande do Sul (RS) State is losing ground due to its lack of self-sufficiency in maize and its distance from the main consuming centres situated in the Southeast Region; Rio Grande do Sul maintains a strong position due to the tradition of poultry keeping and the presence of small farmers who favour the vertical integration system;[24].
- Paraná (PR) is the leading state in terms of herd size, but it was Santa Catarina (SC), home state of the three largest poultry companies, that has showed the highest growth in bird numbers (an increase of 68 693 656 head); and
- the states of the Centre-West Region – Goiás (GO), Mato Grosso do Sul (MS), Mato Grosso (MT) – and the Federal District (situated in the State of Goiás) had the highest percentage growth, confirming the progressive migration of grain-fed animals.

Figures 22 and 23 show the chicken for meat flock size in the years 1995 and 2005.

FIGURE 22
Brazil's chicken for meat flock size by state, 1995

Variable = Herd Numbers (Heads)		
Species = Cocks, chickens, broilers and chicks		
Year = 1995		
#	Brazil & Federation Unity	
1	Brazil	541 163 942
2	Rio Grande do Sul	110 746 770
3	Paraná	89 020 286
4	São Paulo	78 765 024
5	Santa Catarina	73 718 164
6	Minas Gerais	44 235 371
7	Bahia	19 874 937
8	Rio de Janeiro	15 230 545
9	Pernambuco	13 714 285
10	Ceará	11 543 264
11	Pará	10 971 675
12	Maranhão	9 986 025
13	Goiás	9 637 610
14	Mato Grosso	8 245 753
15	Espírito Santo	7 314 354
16	Mato Grosso do Sul	6 851 789
17	Piauí	6 074 203
18	Rondônia	5 626 581
19	Paraíba	4 028 487
20	Distrito Federal	3 782 236
21	Tocantins	2 475 136
22	Alagoas	2 189 239
23	Sergipe	2 188 508
24	Amazonas	1 740 261
25	Rio Grande do Norte	1 529 545
26	Acre	849 471
27	Roraima	528 455
28	Amapá	295 968

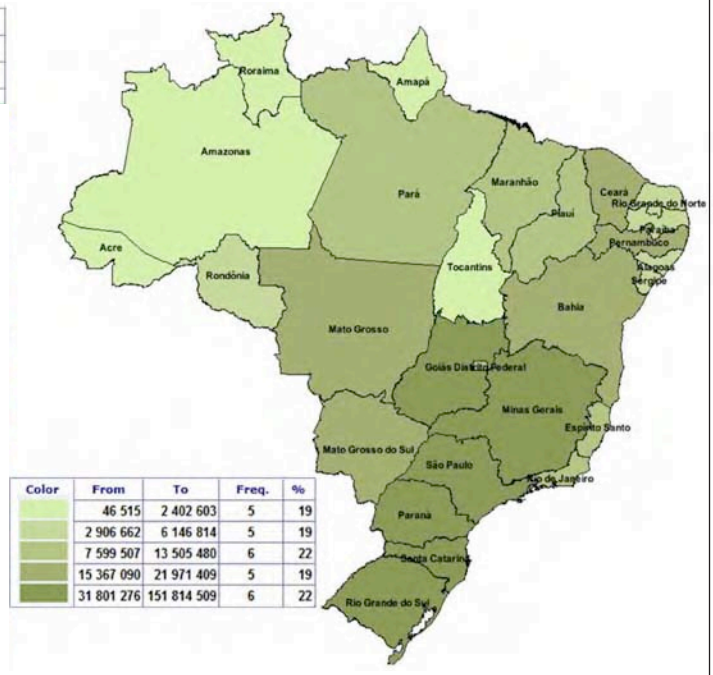


Color	From	To	Freq.	%
	46 515	2 402 603	5	19
	2 906 662	6 146 814	5	19
	7 599 507	13 505 480	6	22
	15 367 090	21 971 409	5	19
	31 801 276	151 814 509	6	22

[24] The Brazilian vertically integrated farmers or contract farmers are known as "integrados", which in Brazilian Portuguese means "he who is integrated".

FIGURE 23
Brazil's chicken for meat flock size by state, 2005

Variable = Herd Numbers (Heads)		
Species = Cocks, chickens, broilers and chicks		
Year = 2005		
#	Brazil & Federation Unity	
1	Brazil	812 467 900
2	Paraná	151 814 509
3	Santa Catarina	142 411 820
4	São Paulo	133 671 738
5	Rio Grande do Sul	108 730 854
6	Minas Gerais	67 618 845
7	Goiás	31 801 276
8	Bahia	21 971 409
9	Mato Grosso do Sul	21 585 870
10	Mato Grosso	15 959 146
11	Pernambuco	15 882 854
12	Ceará	15 367 090
13	Distrito Federal	13 505 480
14	Rio de Janeiro	12 737 252
15	Pará	9 918 115
16	Espírito Santo	9 593 088
17	Maranhão	8 368 394
18	Piauí	7 599 507
19	Paraíba	6 146 814
20	Sergipe	3 536 628
21	Alagoas	3 038 943
22	Rondônia	2 954 770
23	Rio Grande do Norte	2 906 662
24	Tocantins	2 403 603
25	Amazonas	1 527 537
26	Acre	722 181
27	Roraima	648 000
28	Amapá	46 515

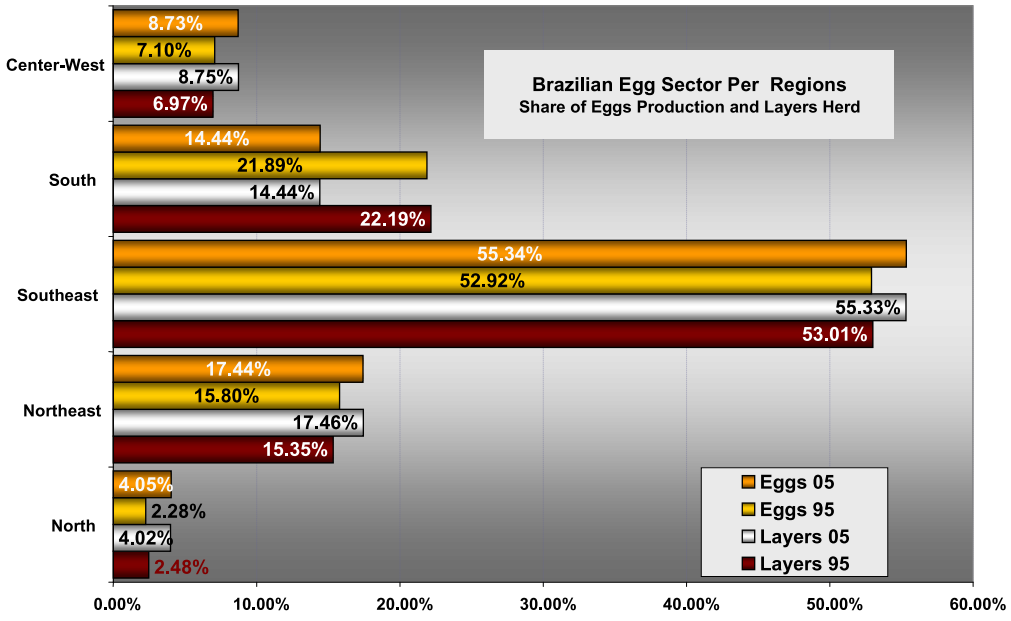


Color	From	To	Freq.	%
	46 515	2 402 603	5	19
	2 906 662	6 146 814	5	19
	7 599 507	13 505 480	6	22
	15 367 090	21 971 409	5	19
	31 801 276	151 814 509	6	22

The distribution of Brazil's poultry for eggs flock

The pioneer Southeast Region maintains its leadership in egg production and is responsible for over 55 percent of Brazil's production and of its layer flock. With the exception of the South Region, whose production grew by only 1.2 percent between 1995 and 2005, every region had substantial production gains during this period. In egg production, proximity to the centres of consumption is the most important determinant of the location of production facilities, even though feed is one of the most important costs.

FIGURE 24
Brazil's egg production and layer flock by region



Source: data from UBA and APA.

TABLE 29
Brazil's commercial layer flock by regions and federal state

Region	1995		2005		2006	
Brazil	**48 930 560**	**%**	**86 534 744**	**%**	**93 206 329**	**%**
North Region	**1 212 479**	**2.48%**	**3 501 314**	**4.05%**	**3 906 487**	**4.19%**
Acre	0	0.00%	105 300	0.12%	73 441	0.08%
Amazonas	535 707	1.09%	1 871 721	2.16%	1 882 292	2.02%
Pará	460 550	0.94%	481 146	0.56%	746 295	0.80%
Rondônia	59 286	0.12%	563 263	0.65%	456 425	0.49%
Roraima	74 200	0.15%	204 967	0.24%	253 705	0.27%
Amapá	30 772	0.06%	-	0.00%	19 248	0.02%
Tocantins	51 964	0.11%	274 917	0.32%	475 081	0.51%
Northeast Region	**7 511 555**	**15.35%**	**15 106 000**	**17.46%**	**15 473 943**	**16.60%**
Pernambuco	2 962 349	6.05%	5 556 434	6.42%	5 328 128	5.72%
Ceará	1 860 983	3.80%	3 111 277	3.60%	3 935 885	4.22%
Bahia	436 269	0.89%	2 093 377	2.42%	2 061 359	2.21%
Rio Grande do Norte	603 631	1.23%	1 432 136	1.65%	1 146 223	1.23%
Alagoas	92 466	0.19%	670 440	0.77%	802 733	0.86%
Sergipe	213 421	0.44%	602 551	0.70%	562 998	0.60%
Maranhão	439 350	0.90%	175 045	0.20%	138 257	0.15%
Piauí	295 294	0.60%	565 297	0.65%	536 478	0.58%
Paraíba	607 792	1.24%	899 443	1.04%	961 882	1.03%
Southeast Region	**25 939 959**	**53.01%**	**47 868 574**	**55.32%**	**51 947 539**	**55.73%**
São Paulo	19 777 025	40.42%	31 507 624	36.41%	34 665 335	37.19%
Minas Gerais	4 215 082	8.61%	11 907 058	13.76%	11 894 112	12.76%
Rio de Janeiro	756 890	1.55%	492 552	0.57%	563194	0.60%
Espírito Santo	1 190 962	2.43%	3 961 340	4.58%	4 824 898	5.18%
South Region	**10 857 324**	**22.19%**	**12 490 281**	**14.43%**	**14 639 085**	**15.71%**
Rio Grande do Sul	4 255 271	8.70%	5 379 039	6.22%	5 548 426	5.95%
Paraná	5 445 775	11.13%	5 584 710	6.45%	7 527 056	8.08%
Santa Catarina	1 156 278	2.36%	1 526 532	1.76%	1563603	1.68%
Center-West Region	**3 409 243**	**6.97%**	**7 568 575**	**8.75%**	**7 239 275**	**7.77%**
Goiás	1 920 386	3.92%	4 415 950	5.10%	4154762	4.46%
Mato Grosso	224 706	0.46%	1 521 273	1.76%	1 696 970	1.82%
Mato Grosso do Sul	583 837	1.19%	1 181 541	1.37%	1122072	1.20%
Distrito Federal	680 314	1.39%	449 811	0.52%	265 471	0.28%

Source: data from UBA and APA.

TABLE 30
Brazil's egg production by region and federal state (1 000 units)

Region	1995		2005		2006	
Brazil	**16.065.504**	**%**	**24.638.506**	**%**	**26.536.498**	**%**
North Region	**366.413**	**2,28%**	**996.935**	**4,05%**	**1.111.612**	**4,19%**
Acre	11.368	0,07%	29.958	0,12%	20.779	0,08%
Amazonas	141.657	0,88%	533.244	2,16%	536.144	2,02%
Pará	135.576	0,84%	136.782	0,56%	211.758	0,80%
Rondônia	22.617	0,14%	160.790	0,65%	129.735	0,49%
Roraima	24.304	0,15%	58.473	0,24%	72.451	0,27%
Amapá	8.135	0,05%	-	0,00%	5.486	0,02%
Tocantins	22.756	0,14%	77.689	0,32%	135.258	0,51%
Northeast Region	**2.538.943**	**15,80%**	**4.296.909**	**17,44%**	**4.406.058**	**16,60%**
Pernambuco	985.894	6,14%	1.581.205	6,42%	1.520.493	5,73%
Ceará	726.874	4,52%	888.477	3,61%	1.121.921	4,23%
Bahia	174.685	1,09%	592.650	2,41%	585.937	2,21%
Rio Grande do Norte	163.587	1,02%	406.023	1,65%	323.922	1,22%
Alagoas	23.635	0,15%	189.699	0,77%	229.292	0,86%
Sergipe	72.155	0,45%	171.903	0,70%	160.465	0,60%
Maranhão	106.281	0,66%	50.499	0,20%	39.373	0,15%
Piauí	72.858	0,45%	160.312	0,65%	151.988	0,57%
Paraíba	212.975	1,33%	256.140	1,04%	272.668	1,03%
Southeast Region	**8.502.422**	**52,92%**	**13.636.148**	**55,34%**	**14.795.344**	**55,75%**
São Paulo	6.456.032	40,19%	8.978.388	36,44%	9.878.469	37,23%
Minas Gerais	1.355.528	8,44%	3.390.420	13,76%	3.382.307	12,75%
Rio de Janeiro	238.608	1,49%	140.358	0,57%	160.815	0,61%
Espírito Santo	452.254	2,82%	1.126.982	4,57%	1.373.754	5,18%
South Region	**3.517.232**	**21,89%**	**3.558.243**	**14,44%**	**4.171.019**	**15,72%**
Rio Grande do Sul	1.333.813	8,30%	1.533.962	6,23%	1.582.233	5,96%
Paraná	1.821.937	11,34%	1.590.940	6,46%	2.143.744	8,08%
Santa Catarina	361.482	2,25%	433.341	1,76%	445.041	1,68%
Center-West Region	**1.140.495**	**7,10%**	**2.150.271**	**8,73%**	**2.052.465**	**7,73%**
Goiás	638.261	3,97%	1.256.377	5,10%	1.177.837	4,44%
Mato Grosso	80.688	0,50%	431.105	1,75%	481.273	1,81%
Mato Grosso do Sul	166.742	1,04%	336.233	1,36%	318.621	1,20%
Distrito Federal	254.804	1,59%	126.556	0,51%	74.734	0,28%

Source: data from UBA and APA.

Compared to the poultry-meat sector, the egg sector is less concentrated. The most important producers have at maximum 3.5 percent of the production output. It is interesting to note that many egg entrepreneurs in Brazil are of Japanese origin. The city of Bastos in the State of São Paulo is considered the "Egg Capital of Brazil"; it is predominantly colonized by Japanese immigrants.

TABLE 31
Largest egg producing companies by number of layers, 2005 and 2006

Rank	Company	State	*Layers ('000)* 2005	2006	% 2005
1	Granja Mantiqueira	MG	3 100	3 200	3.62%
2	Granja Yabuta	SP	3 000	3 000	3.51%
3	Somai Nordeste	MG	2 200	2 200	2.57%
4	Grupo Saito	SP	2 000		2.34%
5	Grupo Emape	CE	1 750	1 500	2.04%
6	Granja Shigueno	SP	1 200	1 200	1.40%
7	Granja Katayama	SP	1 200	1 200	1.40%
8	SOLAR	RS	1 000	1 000	1.17%
9	Gaasa Alimentos Ltda.	GO	1 000	1 000	1.17%
10	Aviário Santo Antônio	MG	1 000	1 000	1.17%
11	Granja Sumaré	SP	900	1 000	1.05%
12	Avicultura Josidith	GO	900	1 000	1.05%
13	Granja Sossêgo	BA	800	800	0.93%
14	Grupo Berger	ES	700		0.82%
15	Regina Alimentos	CE	700	700	0.82%
16	Granja Koga	SP	700	700	0.82%
17	Ademar Kerckoff	ES	600	800	0.70%
18	Oscar Hayashida	PR	600	600	0.70%
19	Granjas Tok	SP	600	600	0.70%
20	Granja Shinoda	SP	600	600	0.70%
21	Granja Kakimoto	SP	600	600	0.70%
22	Cooperativa Agropecuária Serrana	ES	600	600	0.70%
23	Agrop. Carnaúba	AL	600	600	0.70%
24	Yoshiharu Morishita	SP	600	500	0.70%
25	Produovos	SP	600	400	0.70%
26	Avipal Nordeste	BA	550		0.64%
27	Luiz Carlos Figueiredo e Outros	PR	520	520	0.61%
28	Luna Avícola	AL	500	700	0.58%
29	Straglioto	MT	500	500	0.58%
30	Roberto Kiotaka Tsuru e Outros	SP	500	500	0.58%
31	Kazuhiko Ino e Outros	SP	500	500	0.58%
32	Granja Yorozuya	SP	500	500	0.58%
33	Amauri Pinto Costa	MG	500	500	0.58%
34	Supergema	MG	450	450	0.53%
35	Agenor F Silva	PE	450	450	0.53%
36	Granja Áurea	SC	412	400	0.48%
37	Mauricéia Alimentos	PB	400	500	0.47%
38	Tsunehiro Nakanishi e Outros	SP	400	400	0.47%
39	Sumihiro Murakami	SP	400	400	0.47%
40	Ovomalta Ltda.	PE	400	400	0.47%
41	Kenichi Iwata	PE	400	400	0.47%
42	Granja Santa Marta	MG	400	400	0.47%
43	Agro-Avícola Moresco Ltda.	RS	400	400	0.47%
44	SS Avicultura	RN	400		0.47%
45	Inácio Shida	SP	350	400	0.41%
46	Massashi Yokochi	SP	350	350	0.41%
47	Granja Mizohata	SP	350	350	0.41%
48	Avícola Ledur Ltda.	RS	320	320	0.37%
49	Avine	CE	300	600	0.35%
50	Granja Alexaves	GO	300	400	0.35%
51	Granja Casagrande	PR	300		0.35%
52	Altino Loyola	MG	300		0.35%
53	Edilson A.Santos Jr.	PE	300		0.35%
54	Edgar Navais C.Araujo	PE	300		0.35%
55	Granja Antunes	SP		1 000	
56	Waldemiro Berger	ES		500	
57	Ernesto Guarese	RS		400	
58	Erasmo Berger	ES		400	
	Subtotal		**39 302**	**37 440**	
	Other		**46 281**	**55 766**	
	Total		**85 583**	**93 206**	

Source: UBA statistics and annual reports (www.uba.org.br).

1.6. Production systems

The Brazilian Poultry Union (UBA) keeps accurate records of parent stock and of day-old-chick lodgings, as these elements of the poultry sector are highly concentrated in Brazil. UBA reports that the number of hatcheries does not surpass 150 units, including both independent commercial operations and those belonging to medium- and large-scale integrated poultry companies.

From the day-old-chick lodgings, and by closely following the figures for mortality and for condemnation at slaughterhouse level, UBA is able to calculate a precise figure for the number of birds slaughtered. This estimated figure is checked against the available information on the number of chickens that are slaughtered under the Federal Inspection Service (SIF) of the Ministry of Agriculture, Livestock and Food Supply. In addition, the companies that are member of UBA supply their slaughtering figures and the weight produced, either directly or through the state associations. As UBA member companies cover 80 percent the chickens slaughtered under federal inspection, this allows a final check on the numbers.

The figures presented in Table 32 indicate the size of commercial or industrial chicken production operation in Brazil, versus what could be considered backyard production or even commercial production of flocks to be sold as live chickens.

TABLE 32
Chickens slaughtered (head)

	1995	2005	2006
Under Federal Inspection	1 670 255 415	3 866 793 706	3 778 773 132
W/out Federal Inspection	869 444 726	559 940 288	615 540 210
Total	**2 539 700 141**	**4 426 733 994**	**4 396 313 342**
Under Federal Inspection	65.8%	87.4%	86.0%
W/out Federal Inspection	34.2%	12.6%	14.0%
Estimated backyard	152 382 008	265 604 040	263 778 801

Source: UBA.

There are 172 SIF poultry slaughterhouses in Brazil, belonging to 134 different companies, which are responsible for more than 85 percent of the chicken production. The remaining birds are either sold live or slaughtered under state or municipal inspection.

The number of birds slaughtered under federal inspection increased, due to the growing concentration of poultry production described above. A company can not become large without the right to sell in the whole of Brazil, which is reserved to those that slaughter

and process under federal inspection. The export boom in the Brazilian poultry industry also contributed to this evolution, given that only slaughterhouses under federal inspection may export.

Federal inspectors consider the demands imposed by the importing country. As a consequence, production standards increase for all the output of the slaughterhouse, including the products destined for the domestic market. Production that takes place without such inspection will be driven by productivity alone and consequently the quality of products and their safety will be jeopardized. The increasing proportion of poultry slaughtered or processed under SIF results in better-quality products, enhances food safety and helps to build consumers' confidence in poultry products. It is another example of the positive contribution of exports to the overall progress of the poultry sector and to the development of the domestic market in Brazil.

The market for live birds is declining. It is still present in parts of the North and Northeast Regions. In small cities and in even the peripheries of big cities, the "avícolas"[25] still survive, and in rural areas, the consumers themselves will slaughter the chickens. UBA estimates that a good percentage of the chickens slaughtered without federal inspection are sold to the "live market". There are also slaughterhouses that are under state or municipal inspection, although precise figures for the number of birds slaughtered under these types of inspection are not available.

Backyard production

Backyard production in Brazil is not as widespread as it is in some other parts of the world, but it does exist. It is present in the rural areas of states where chicken production is not one of the main activities. Of course, there are no statistics for backyard production. UBA estimated, based on field research conducted some five years ago by its executive director, Mr. Clovis Puperi, that backyard production could represent 6 percent of the total. The figures thus calculated are also given in Table 32.

In states and regions where poultry-keeping activity is strong and where industrial-scale integrated operations are present, "integrados" (contract farmers) account for almost all chicken production. To ensure that they do not keep lots for family consumption, the "integrados" are entitled to up to 20 birds from each lot. This does not preclude that other small farmers keep small numbers of chickens, one or two pigs and a milk cow for their own subsistence. This represents a constant biosecurity concern for the poultry industry.

Many regions of the world regularly face outbreaks of animal disease – highly pathogenic avian influenza (HPAI), porcine reproductive and respiratory syndrome (PRRS), etc. – because of the high sanitary risk associated with different species "living together". Backyard production will prevent these regions from enjoying sanitary peace during the coming decades. Individual backyard production is the worst enemy of biosecurity.

[25] "Avícolas" is the name given to shops where live chickens are sold. In some of them, there is a facility to slaughter and prepare the chicken (removal of feathers and inedible giblets) at the request of the client. They are normally small-scale operations and are not under permanent inspection by the sanitary authorities, but have to follow municipal rules applied to any establishment dealing with food.

Another concern is the "weekend farmer". Urban Brazilians of comfortable income have "weekend" farms for recreational purposes in rural areas not too far from their city of residence. Some of them like to breed ornamental birds or what they call "natural" or "raised the old way" chickens. Breeding "the old way" in the face of biosecurity concerns associated with diseases carried by migratory birds is a risk to the sustainability of modern poultry production.

A further sanitary risk is posed by a government policy of giving day-old chicks to landless farmers who receive land from the governmental land allocation programmes. This is highly criticized by UBA and other poultry organizations, which constantly convey the sanitary risks involved in such measures.

Independent chicken farmers

In some regions of Brazil there are still independent farmers who sell their poultry to slaughterhouses. They are becoming restricted to slaughterhouses that do not export or that do not have federal inspection.

Companies that export are increasingly required to be able to trace their produce back to the parent stock. Many important markets prohibit the use of certain medicines or growth promoters. In other markets, clients require inter alia genetically modified organism (GMO)-free feed, no use of non-vegetable feed components, and above all, total traceability not only with respect to feed, but also with respect to animal welfare, ethical and environmentally friendly procedures in breeding and slaughtering, and HACCP (hazard analysis and critical control point) procedures over the entire process. These demands, along with the need for medium- and long-term planning of production, the need to tailor products to precise market requirements, and above all the efficiency of the vertical integration model, have meant that the independent poultry breeder has become the exception and rather than the rule.

In the Southeast Region, independent poultry producers sell their products to slaughterhouses that offer refrigerated products to the big cities. Increasingly, they establish a supply arrangement with the slaughterhouse guaranteeing the supply of a certain number of head during a fixed period. They act almost as contract farmers, but in contrast to the "integrados" they provide the day-old chicks and feed for themselves, and their relation with the slaughterhouse is restricted to the supply of birds of a certain live-weight range.

In the recent past, there were independent chicken farmers who would speculate around once their birds had reached the commercial weight. During the 1995 to 2005 period, the poultry industry and market became too complex, and the space for this sort of maverick operation almost disappeared.

In the Northeast and North Region, where the live-chicken market is still present, the independent poultry producers will sell to "avícolas", traders of live chickens or in some cases directly to the consumer through their own "avícolas" (normally situated in front of the farm when this is near a town or city). As a general rule, these independent poultry producers will have a few broiler houses of 12 000 or 15 000 birds with breeding cycles of 42 days and will raise six to seven lots *per annum*.

Small-scale, medium-scale and large-scale chicken meat companies

There is no official size criterion by which to classify poultry companies in Brazil, but the poultry sector considers companies that slaughters up to 100 000 birds per day to be small scale and those that slaughter from 100 000 to 500 000 birds per day to be medium scale; above that level, companies are considered to be large scale. It may appear peculiar to consider a company that slaughters up to 100 000 birds per day, an impressive number in any country, to be small. Nonetheless, in Brazil a company that has this sort of output represents 0.5 percent of total production.

Table 19 lists the leading chicken-producing companies and the number of birds slaughtered *per annum* in 1995, 2000, 2005 and 2006. Many companies in the 1995 column did not reach 2005, either because they ceased operation or (in the majority of cases) because they changed ownership. In addition, many new companies appeared after 2000 – some of them with very substantial production figures.

For the above reasons, we classify Brazilian chicken-meat companies by size in accordance with the number of birds slaughtered in the years 2005 and 2006. To calculate the daily slaughter figures for each company we have considered the average of 252 working days in the year, although companies may surpass this limit when adjusting the size of their flocks or when there are unexpected peaks in demand. Table 33 shows the annual number of birds slaughtered within each size category. Tables 34 to 36 list the 50 largest Brazilian companies classified according to the three categories.

A certain number of companies report their production figures to UBA, but do not authorize their disclosure. These companies were responsible for 8.8 percent of the chickens slaughtered in 2005; in Table 33, these companies are categorized as "other under federal inspection".

TABLE 33
Slaughter of chickens (head per annum) by size-category of the companies, 2005

Large-Scale	1 850 546 297	41.8%
Medium-Scale	1 255 618 310	28.4%
Small-scale	370 557 800	8.4%
Other under Federal Inspection	390 071 299	8.8%
Total under Federal Inspection	***3 866 793 706***	***87.4%***
Other w/out Inspection	559 940 288	12.6%
Total 2005	**4 426 733 994**	

Source: elaborated with data from UBA – Brazilian Poultry Union – Annual Report 2006/2007, pages 44 and 45.

TABLE 34
Large-scale chicken-meat companies

	Chicken (heads per annum) 2005	2006
Sadia SC-PR-MG-MT-RS-DF	629 209 878	645 452 443
Perdigão SC-RS-PR-GO-MT	498 850 657	530 111 245
Seara SC-PR-SP-MS	277 320 934	257 490 544
Frangosul RS-MS	237 068 234	214 471 190
Avipal RS-MS-BA	208 096 594	174 229 179

Source: elaborated with data from UBA – Brazilian Poultry Union – Annual Report 2006/2007, pages 44 and 45.

TABLE 35
Medium-scale chicken-meat companies

	Chicken (heads slaughtered per annum) 2005	2006
Dagranja PR-MG	117 199 849	114 665 884
Aurora SC-RS	91 826 334	108 743 902
Diplomata PR-RS-SC	90 754 483	87 636 118
Penabranca SP	82 155 225	75 173 127
Copacol PR	72 080 048	70 089 917
Frango Forte SP	48 255 906	55 348 664
Rio Branco / Pif Paf MG-RJ	53 192 295	53 733 755
Rei Frango SP	45 777 144	51 151 583
Big Frango/Jandelle PR	48 193 500	49 152 408
C.Vale PR	42 408 783	48 231 895
Avícola Céu Azul SP	37 103 020	47 163 399
Kaefer Avicultura PR-RO	47 976 472	46 765 711
Coop. Agroindl. Lar PR	41 075 461	44 899 115
Penasul RS	42 325 268	44 206 550
Frango Sertanejo SP	48 255 906	40 431 245
Reginaves RJ	34 981 484	38 356 394
Ad'oro SP	37 361 755	38 293 177
São Salvador GO	32 411 121	37 980 277
Anhambi MT-PR	35 222 181	36 844 129
Coperguaçú SP	31 404 872	34 008 781
Mat. Avíc. Flamboiã SP	33 630 590	33 128 238
Nutriza GO	31 033 287	31 545 647
Coopavel PR	32 202 400	29 181 736
Agrovêneto SC	27 313 146	28 488 956
Abat. Aves Ideal SP	18 612 494	27 275 835
Avícola Paulista SP	32 865 286	25 405 227

Source: elaborated with data from UBA – Brazilian Poultry Union – Annual Report 2006/2007, pages 44 and 45.

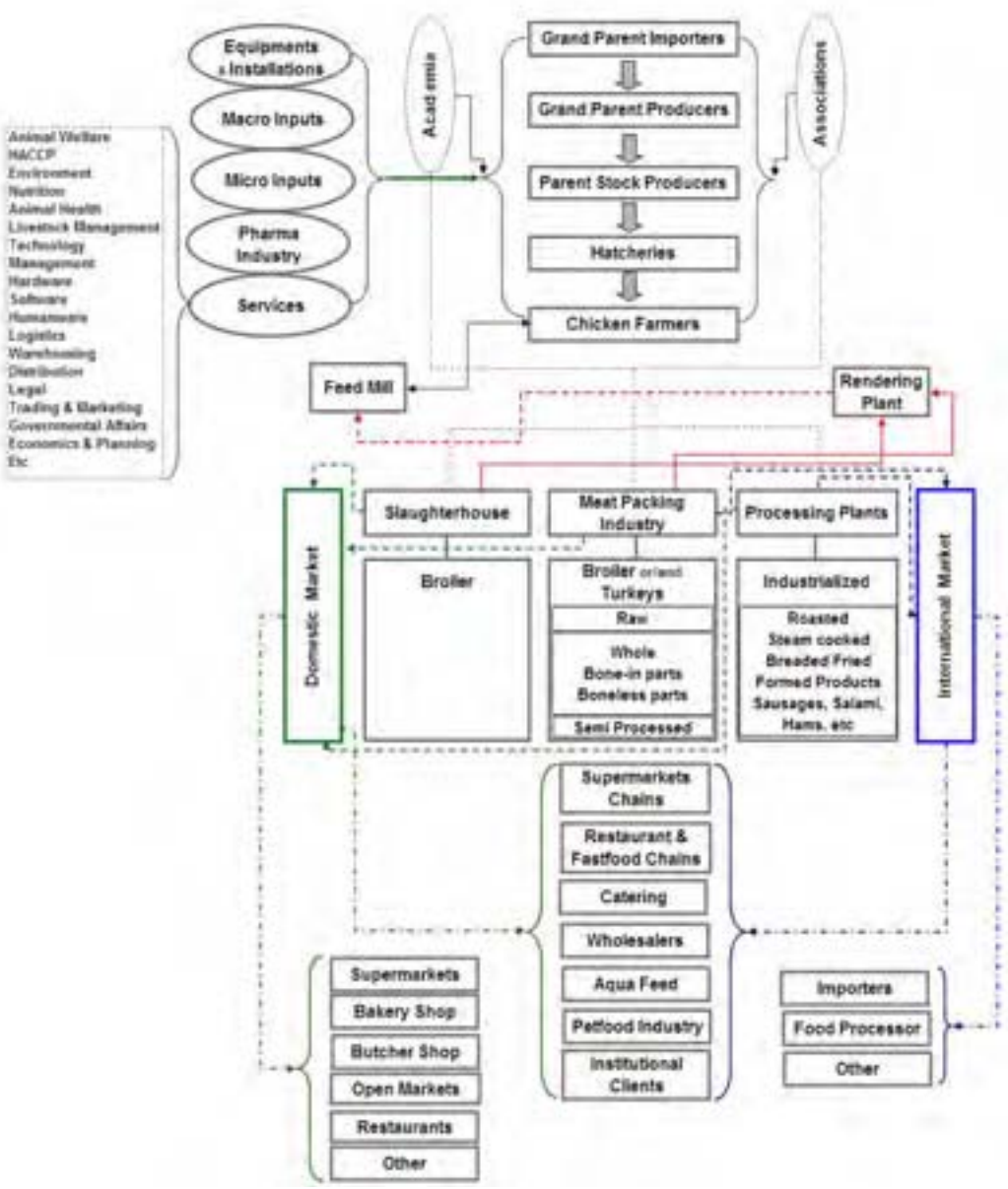
TABLE 36
Small-scale chicken-meat companies

	Chicken (heads slaughtered per annum) 2005	2006
Coop. Languirú RS	24 053 657	24 345 320
Comaves PR-MS	25 371 320	23 985 266
Gonçalves & Tortola PR	22 491 460	23 707 362
Avícola Felipe PR	25 948 112	23 353 578
Coroaves PR	21 872 592	22 618 712
Francap MG	21 115 438	22 171 485
Jaguafrangos PR	19 079 358	20 659 231
Asa Alimentos DF-GO-TO	21 636 506	20 612 932
Nogueira Rivelli MG	18 745 645	20 419 360
Frinal RS	18 172 072	19 612 660
Frangoeste SP	19 875 689	19 467 728
Coop. Holambra SP	19 847 930	19 301 571
Macedo Agroindustrial SC	25 732 727	18 730 507
Polifrigor SP	18 233 778	18 066 595
Palmali SP	13 603 752	16 507 381
Avivar Alimentos MG	11 240 612	15 984 120
Notaro Alimentos PE	14 156 698	14 958 081
Votuporanga SP	13 603 752	14 803 174
Agrofrango SC	15 776 702	14 546 717

Source: elaborated with data from UBA – Brazilian Poultry Union – Annual Report 2006/2007, pages 44 and 45.

Figure 25 illustrates the complete poultry chain, from import of genetic material to the commercialization of products in both domestic and international markets. The expression "meat packing plant" denotes an industrial operation that slaughters the birds, processes the meat and packs it for distribution. A further-processing operation may also be present on the site. Such a facility necessarily operates under SIF and is entitled to sell its products nationally and, when approved, also for export. We use the expression to differentiate such operations from "slaughterhouses", which slaughter birds and supply basic products (whole chickens and bone-in parts) and which may or not be under SIF inspection. If the "slaughterhouse" operates without SIF inspection, its products cannot be moved outside the municipality or state in which it is located (depending on whether it is submitted to municipal- or state-level inspection).

FIGURE 25
The poultry industry chain



Source: Source: CONAB – Companhia Nacional de Abastecimento (National Company for Food Supply) (http://www.conab.gov.br) (state company within the structure of the MAPA).

A processing plant for poultry meat may be an independent company that obtains its raw material from a meat-packing plant or, as is the case with the leading Brazilian poultry companies, be part of a larger operation.

The vertical integration system

UBA estimates that at least 85 percent of Brazilian chicken production is vertically integrated. All the main poultry producers use this system. We carried out a sample survey of producers, which revealed that there were only two exceptions among the fifteen companies interviewed. One small-scale company from Minas Gerais State reported that some of their slaughtered birds came from their own broiler farms and some from broiler farms belonging to shareholders, but even these operated under vertical integration. A medium-scale company situated in São Paulo State reported that vertical integration prevailed but that they bought 7 percent of their birds from independent chicken farmers.

Many consider that the vertical integration system is one of the pillars of Brazil's strength and competitiveness in poultry-meat production. A poultry entrepreneur who had operations both in European countries and in Brazil once said that, more than the abundance of grains, the main factor explaining the boom in the Brazilian poultry industry was the vertical integration system based largely on properties belonging to and worked by individual families. He remarked

"the difference is that the last thing the 'integrado' does before going to bed is the same as the first thing he does when he wakes up – to look at the flock and see how the birds are".

The entrepreneur in question has actually extended the vertical integration system in his Brazilian operation to include parent-stock breeding, which is not a normal practice.

The vertical integration system is being used by other agribusiness sectors – fruits, vegetables, silk, seeds, genetic material, alcohol and sugarcane, and tobacco, as a result of its proven success in the poultry and pork sectors.

The system of "integrated" agricultural and livestock production was introduced for chicken production in the State of Santa Catarina in the 1960s. The core idea is integration between agricultural production and industrial processing. Excerpts from the paper "Integration – a partnership that proved right" published by the Brazilian Poultry Union in 2001 can be found in Appendix 3. It provides a very accurate and useful appraisal of the integration system in the Brazilian poultry sector.

As mentioned above, the vertical integration system boomed from the end of the 1970s or early 1980s when roads permitted producers from the South Region to have access to the major centres of consumption situated in the Southeast Region – mainly Rio de Janeiro, São Paulo and Belo Horizonte.

The vertical integration system was not so popular or widespread in the poultry industry of the Southeast Region before the 1980s. The region was the leading poultry producer until the mid-1980s and was characterized by a mixed system of breeding, in which slaughterhouses and meat-packing industries would buy live birds from independent producers or complement their own breeding activity with live birds bought in the market.

In the South Region, the integration system is fundamental to the economic feasibility of one-family rural properties of 10–20 hectares, while the industry provides job opportunities for the children when they become adults. It is not uncommon that an "integrado" has several family members working directly or indirectly for the industry.

The industry in Brazil is increasingly replacing activities they used to perform themselves

by "contract services" that are inspired by the positive experience of vertical integration. All transport operations – carrying day-old chicks and feed to the farms, birds to the slaughterhouses, and products to warehouses, ports and markets – used to be carried out by the various companies using their own trucks. Today, a visitor to the poultry-producting areas of Brazil will see hundreds of trucks bearing the colours and logos of the poultry companies (Brazil continues to depend on road transport). All these trucks belong to individuals or small entrepreneurs. They enter into contracts with the industry, which establish standards for equipment and operations, provide training and ensure a constant demand for transport services.

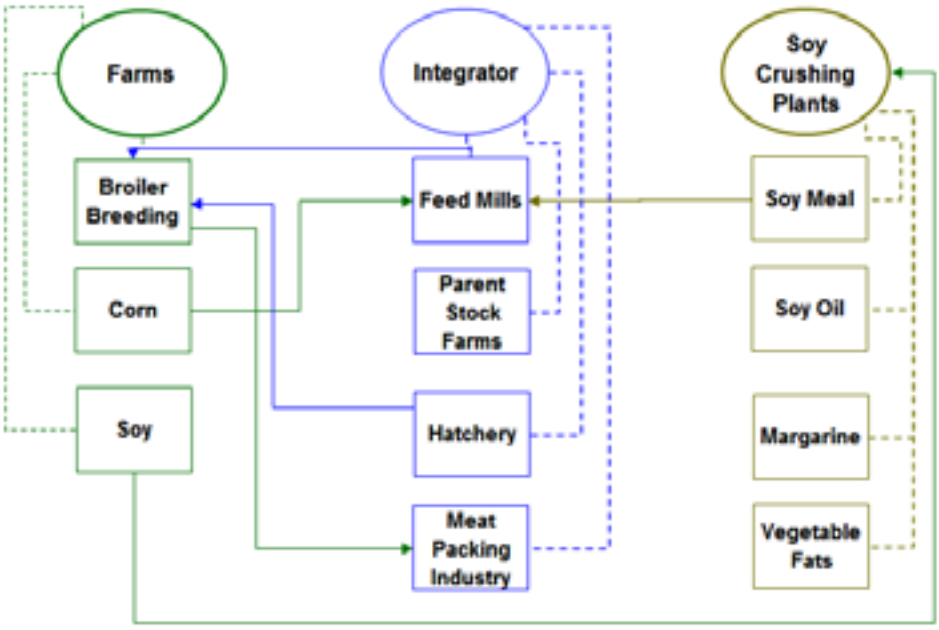
The same sort of procedure is adopted in cafeteria services, security services, cleaning services, laundering, healthcare, etc. The Portuguese word for it is "terceirização" which means outsourcing. "Terceirização" became extreme popular with managers in Brazil during the 1980s and early 1990s who understood that companies should dedicate themselves to their core business and hand over support or parallel activities to third parties.

Many of the Centre-West Region's farmers came from the South Region and had knowledge or first-hand experience of integrated production. In this new area of abundant land and big properties, the model continued to be followed. In addition to the remunerative benefits of the operation in itself, the extension services provided by the industry to its integrated farmers and the opportunity to use chicken litter as a source of fertilizer has favoured the continuation of the system. Above all from the farmers' perspective, the industry's feed mills provide a market for the maize and soy they grow. This interdependency is an aspect of the success of the vertically integrated system.

As the main poultry and pork companies are making considerable investments in the Centre-West Region, even big farmers are joining the integration system. In contrast to the South Region "integrado" – where the average is to have one or at most two broiler houses per property – in the Centre-West, three to five broiler houses per property is very common.

Figure 26 shows a flowchart of the vertically integrated system in poultry production. The soy crushing plant may belong to the integrator – this is the case in many of the largest companies.

FIGURE 26
The vertically integrated poultry chain



Source: Source: CONAB – Companhia Nacional de Abastecimento (National Company for Food Supply) (http://www.conab.gov.br) (state company within the structure of the MAPA).

The vertically integrated poultry chain

Normally, companies do not divulge how many integrated farmers they have – unless as part of information packs supplied to the financial community. UBA does not record these numbers and very few state poultry association divulge them. The exception is ASGAV – Associação Gaúcha de Avicultura (Rio Grande do Sul State Poultry Association) – which in a 2006 leaflet reported that 9 000 integrated farm families were involved in producing 675 million head of chicken and 5.2 million head of turkey. In that state, the integration system includes the production of fertile eggs. Several leading figures in the poultry industry estimate the number of integrated farmers in Brazil, for poultry alone, to be around 60 000. This figure represents an opinion rather than a researched figure.

The preliminary results of IBGE's Agricultural and Livestock Census 2006 reveal that 2 712 438 rural properties kept chickens – a total of 1 244 260 918 birds – but as in the previous census, integrated farmers are not distinguished.

1.7. The role of poultry associations

Poultry Associations in Brazil are organized both geographically and by segment. The master association is the UBA, which is the institutional entity that represents the national poultry sector before the Brazilian Federal Government and Judiciary Power. It focuses on the sanitary, quality and legal issues that affect the development of the sector.

UBA brings together ABEF, APINCO (Association of One-Day Chicks Producers), FACTA (Apinco Foundation for Poultry Science and Technology) and ACAV (Associação de Criadores de Avestruzes –Ostrich Breeders Association). UBA also includes all state poultry associations, breeding companies, chicken-meat and egg producing companies, poultry-meat packing companies, turkey producers, poultry input suppliers and providers of related services.

UBA representatives also have seats on various governmental bodies that deal with animal health and food safety, among which is the Consulting Council of the PNSA – Plano Nacional de Sanidade Avícola (National Plan of Poultry Animal Health), and the poultry-sector associations that interact with several other ministries and governmental authorities.

Participation in associations is not compulsory and each association has its bylaws regulating membership, fees, voting systems, mission, administration, etc. Poultry associations do not receive any public money and depend entirely on their members' contributions. Approaches to fee collection vary greatly – fixed monthly sums are the general rule, but in some associations the contribution is linked to production level. Even in the latter organizations, decisions are taken on the basis of one member, one vote. Brazilian poultry companies cooperate with their respective associations, with UBA having a central role with respect to issues that cross regional or segmental boundaries.

UBA organizes a monthly meeting at which the activity of the poultry industry during the previous month is assessed and a short-term forecast is made. These meeting involve representatives from the various regional and segment associations, as well as representatives from the commercial companies.

UBA collects and publishes data on the poultry sector. It is interesting to note that industry associations organize, process and keep most of the data. UBA consolidates regional data and segment data. ABEF takes care of all data related to exports. APINCO handles information on day-old chicks. This is an ongoing process that dates backs to 1996.

The view that "secrecy is the key to success" prevailed in Brazil until the mid-1990s. Subsequently, the very good initiatives undertaken within UBA by associations such as ABEF, APINCO and APA[26] promoted the concept that "information is the key to success". Although suspicion and reluctance to provide data still exist today, it would be fair to state that the majority has recognized the value of information for the development of the whole poultry chain. The reliability of some of the data collected by the associations has meant that they are used and disseminated by many official departments. The quality of data gathering is improving with time. The format and availability of data collected since the beginning of the twenty-first century have made them an important resource for planning purposes. Unfortunately, the quality and availability of "historical data" are less good.

Many of the main poultry companies are also pork producers and are involved in further processing of all meats. As the Brazilian market expanded, competition among these companies – which in some cases dated back to the 1940s – became intense. The same

[26] APA's magazine "Birds and Eggs" (no longer available) published data on egg and meat production.

companies were among the export pioneers and they also became competitors for international market share. The associations have been important for the Brazilian poultry sector as they provided a forum in which fierce competitors could share common cause. It was through the associations that the poultry companies adopted common positions on issues that affected directly or indirectly the whole poultry sector.

UBA and other national associations such as ABEF also allowed a national perspective for the poultry sector to emerge. The fact that their meetings involved representatives from all over Brazil prevented the main producing states, regions or companies from imposing their individual perspectives. Regions with less production and smaller producers were represented and their views were thus reflected in the common positions adopted by the poultry sector. The fact that these associations reflected a common national position, and not that of a specific group or region, contributed to their credibility with the government authorities.

In addition to the monthly meetings that review the state of the poultry sector, UBA and the other associations also have a most important role whenever a crisis affects the sector. They serve as a rallying point – meetings held at these dark hours have an enormous attendance. The discussions are neutral; specialists are called in to present their analysis of the situation, and recommendations are issued. More than once these "crisis meetings" have helped the poultry sector through difficult times. When the crisis is over, attendances fall dramatically.

The last example of this kind of crisis was in early 2006 when importers from countries affected by HPAI cancelled or postponed shipment of their orders, generating a surplus of goods in the Brazilian domestic market. Several poultry associations, companies and specialists remained mobilized by UBA from January to March. This joint action allowed the poultry sector to weather the crisis – despite considerable losses. By the second half of July 2006 attendances at the crisis meetings had fallen, as the collective actions had borne fruit and the sector had resumed its growth.

An absolute golden rule of the Brazilian poultry associations is their neutrality. Most associations have professional executive directors to manage their affairs, and company representatives participate on their boards of directors or councils of administration. To ensure absolute and fundamental neutrality, associations never become involved in commercial matters and restrict their actions to institutional affairs. They will support an individual company when dealing with governmental authorities, but they never get involved in the commercial activities of any company. Neither do they involve themselves in recommending suppliers or products to their member companies.

Foreign companies looking for suppliers frequently contact meat exporters' associations such as ABEF, ABIEC (Brazilian Association of Beef Meat Industry Exporters) and ABIPECS. Their response is normally to indicate all their member companies, details of which can be found on the Web sites of the respective associations. When the associations have their stands at international fairs their aim is to promote Brazil as a source of poultry meat and any specific request from a potential buyer is conveyed to all member companies.

ABEF, the poultry exporters association, has been a decisive factor in making Brazil one of the leading countries in the poultry trade. The country does not have a very strong position in international negotiations and has few ways to retaliate against protectionism and

sanitary barriers. It was only as a result of very efficient work conducted under the auspices of ABEF that it was possible for Brazil to open markets for its exports.

We consider the action of ABEF to be the most perfect example of the "hunt in a pack" concept, particularly given the fierce competition that exists among the main Brazilian poultry companies in both domestic and international markets.

Historically, ABEF had a board of directors on which the main exporting companies would have a seat; an executive secretary would conduct the day-to-day work. Today, the association has an entirely professional staff and the representatives of the main exporting companies constitute a directive council. This professional management prevents the normal market disputes among companies from hindering the common objectives – opening new markets for Brazilian exports and keeping the existing markets open against protectionism in its various forms.

ABEF was founded in 1976 by nine companies interested in promoting chicken-meat exports. Today, the member companies are responsible for 75 percent of Brazilian chicken production and 92 percent of the production designated for foreign trade. The main objectives are monitoring the process of accessing new markets for chicken meat and the tax and non-tax barriers imposed by buyer countries, cooperating with member companies and linking them to the public authorities.[27]

Associations are financed via the contributions made by the member companies and receive no funds from any level of government or from official organizations. Normally, their board approves an annual budget for the association, and the participation of each company is directly linked to its size, level of production or exports.

As noted above, one of the major structural changes in the poultry sector has been the shift that has taken place in relations between the official organizations and authorities and the private companies. The evolution from a state of trench warfare to one of synergy, common strategy and joint action would not have occurred without the work of the associations.

Professionally managed, neutral and dedicated exclusively to institutional tasks, poultry associations were vital to the progress of the sector. They incarnated the quintessence of the "hunt in a pack" concept, but above all they operated a much-needed "pack defence" in which the stronger members of the pack constituted the first and outer lines. Brazilian companies, even those considered by many to be benchmarks in the world poultry industry, would not have achieved the position they hold today in the international market had they chosen to act outside the pack.

Poultry associations in Brazil have become strong and credible thanks to their representation of the poultry sector as a whole rather than parts of the sector or individual companies. Member companies may disagree entirely with an association decision or even feel that a decision jeopardizes their corporate interests. Some may even leave an association for a period – this has happened more than once. Nevertheless, none of the dissidents have ever tried to form an alternative association, nor has a company or group of companies dominated any of the associations. Above all, the merit of the associations has lain in their provision of a neutral forum where fierce competitors can focus on their common interests rather than their differences.

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[27] ABEF Web site (www.abef.com.br).

2 DRIVERS THAT HAVE CAUSED STRUCTURAL CHANGE OVER THE PAST DECADE (1995 TO 2005) – GOVERNMENT POLICIES

2.1 Trade policies and the general role of the state

The military governments that ruled Brazil from 1964 to 1985 strongly believed in the role of the state in the promotion of economic development. State monopolies were abundant, state-owned companies dominated the economic scene, and the state used fiscal and financial incentives to direct private-sector investment. Exports were encouraged, internalization of economic development towards the Centre-West and North Regions was promoted, investments were made in infrastructure, and the country experienced an economic boom. Conditions started to deteriorate with the second oil-price shock in the second half of the 1970s.

The civilian governments that succeeded the military tried to cope with inflation through heterodox economic juggling and had to grapple with a suffocating external debt. These governments retained some of the agencies used by the military to "orientate" the private sector through price controls and other forms of state intervention in day-to-day economic life. They eliminated fiscal and financial incentives to exports and kept a strict control on foreign currency, essential to secure oil imports and the rolling of the external debt.

The policies implemented at this time represented the worst of scenarios. Government stopped granting fiscal or financial subsidies, imposed restrictions on imports and kept strict control on exports due to foreign currency shortages; it interfered, via various government agencies, in commercialization and prices.

1994 saw the launch of an economic plan which did not include price controls or other heterodox economic measures. State companies were privatized, state monopolies were eliminated, and the degree of intervention in the economy diminished. To keep inflation in check, credit and monetary expansion were strictly controlled.

Since 1994, the principles of the market economy have been observed and livestock and feed products have benefited. There is no longer a state organization or agency setting the prices of particular products or dictating whether they can be sold abroad or internally. It is no longer necessary to obtain an export permit which might or might not be granted by a bureaucrat who never left his desk or seen a slaughtering operation in his life. Neither is it necessary to beg for an import license for equipment or for an essential input. If a company is duly registered and authorized, if the object of the transaction is legal and is not subject to restrictions, any company can sell any livestock or feed products locally or internationally.

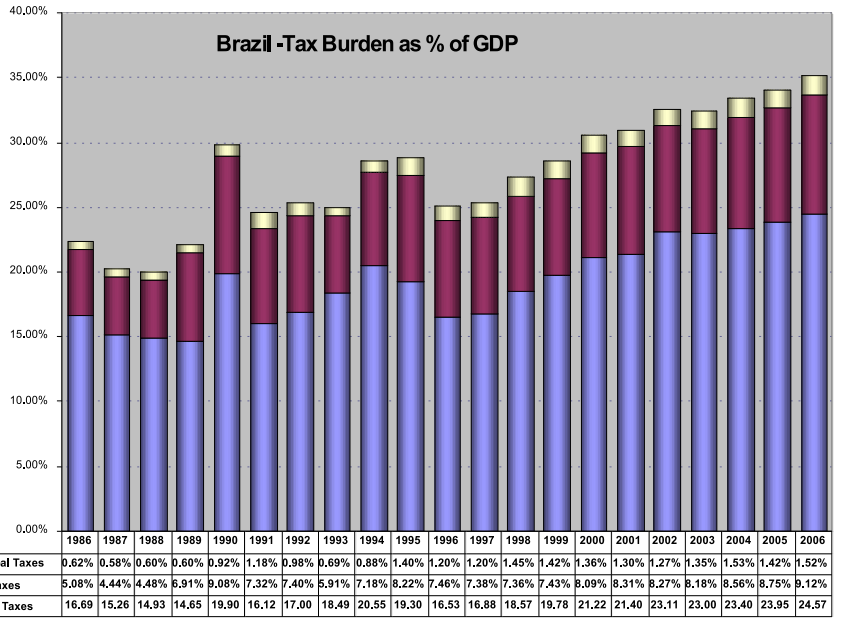
Of course, there was another side to the coin. The total tax burden continued to increase. In 1986 the tax burden represented 22.39 percent of Brazil's GDP; it increased to 28.92 percent in 1995, and reached 34.12 percent in 2005. In both 2006 and 2007 it continued to increase. This represents a fiscal charge higher than most developed countries, but the quality of public services is very much that of a developing country.

The fiscal voracity of the Brazilian state was not translated into corresponding investments and improvements in infrastructure, which continues to lag behind the country's growth. Privatized sectors such as telecommunications have boomed, but sectors that have been in the hands of the government – roads, ports and electrical energy, to name a few –

have shown neither the expansion nor the efficiency required by the country's agricultural growth. Tax is not paid on exported poultry products, but the state does not reimburse the tax burden associated with feed inputs, packing materials, labour force, transport, energy, etc.

FIGURE 27
Fiscal burden as a proportion of GDP in Brazil

Total Taxes as % of GDP	
1986	22.39%
1987	20.38%
1988	20.01%
1989	22.16%
1990	29.90%
1991	24.62%
1992	25.38%
1993	25.09%
1994	28.61%
1995	28.92%
1996	25.19%
1997	25.46%
1998	27.38%
1999	28.63%
2000	30.67%
2001	31.01%
2002	32.65%
2003	32.53%
2004	33.49%
2005	34.12%
2006	35.21%



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Municipal Taxes	0.62%	0.58%	0.60%	0.60%	0.92%	1.18%	0.98%	0.69%	0.88%	1.40%	1.20%	1.20%	1.45%	1.42%	1.36%	1.30%	1.27%	1.35%	1.53%	1.42%	1.52%
State Taxes	5.08%	4.44%	4.48%	6.91%	9.08%	7.32%	7.40%	5.91%	7.18%	8.22%	7.46%	7.38%	7.36%	7.43%	8.09%	8.31%	8.27%	8.18%	8.56%	8.75%	9.12%
Federal Taxes	16.69	15.26	14.93	14.65	19.90	16.12	17.00	18.49	20.55	19.30	16.53	16.88	18.57	19.78	21.22	21.40	23.11	23.00	23.40	23.95	24.57

Source: based on data from IBPT (2007).

Fiscal burden as a proportion of GDP in Brazil

Chicken meat "in natura" is subject to 18.67 percent tax, while the rate paid on industrialized poultry products is 35.50 percent, including 18 percent ICMS (state-level tax on circulation of goods and services). Eggs are exempt from ICMS but are subject to other taxes.

The Brazilian state is not simply expensive. It is also complicated. A study by IBPT (Brazilian Institute for Fiscal Planning) (Amaral et al., 2007) affirms that in 19 years, since the constitution was promulgated in 1988, the Brazilian governmental authorities (federal government, 27 states, one federal district and 5 564 municipalities) have issued 3.6 million legal instruments, which is an average of 766 new documents per working day. Of these, 235 900 were on fiscal matters – an average of two new fiscal legal instruments per hour.

According to World Bank and PricewaterhouseCoopers (2008), Brazil ranked last in terms of the number of hours per year required to comply with tax obligations – 2 600 hours. The study notes that:

"The issues range from the number of taxes charged, to the competence to each gov-

ernment authority (Federal, State and Municipal) to charge such taxes. … Each one of these governmental bodies has the power to legislate on the tax computation and collection."

The complexity of the state, its costs, and deficiencies in infrastructure that depends on the public sector are part of what many economists refer to as "cost Brazil". It adds to costs, it hinders progress and it makes life harder for entrepreneurs, but it does prevent naturally competitive economic sectors from prevailing. The following anecdote exemplifies this state of affairs and reveals much about the agricultural entrepreneur of the new agricultural frontier of Brazil in the Centre-West Region.

While visiting a medium-sized agricultural entrepreneur in the State of Mato Grosso, we asked what motivated him to invest so much in a region where roads were bad, logistics for transporting products to the market were deficient and expensive, and where there was a long list of other discouraging factors. His answer after some consideration was as follows: *"I am competitive today with all these problems you listed. Imagine when they are solved"*.

If life for the Brazilian poultry producer is not a bed of roses, neither is it only thorns. The Brazilian government and some of its agencies and organisms have made decisive contributions to agribusiness and the poultry industry. Embrapa's research efforts have made all the difference in enabling the Cerrado Biome to be utilized for agricultural production. Professors from public universities have been fundamental to the development of the Brazilian poultry industry – supplying know-how and technology adapted to local environmental conditions. The Ministry of Agriculture's agencies dealing with livestock defence, products of animal origin and international relations have made essential contributions to the results achieved by the sector.

Since 1995, there has been strong interaction between UBA and ABEF and MAPA (Ministério da Agricultura, Pecuária e Abastecimento – Ministry of Agriculture, Livestock and Food Supply) and MDIC (Ministério do Desenvolvimento, Indústria e Comércio Exterior – Brazilian Ministry of Economic Development, Industry and Foreign Trade) with regard to international sanitary agreements, promotion of bilateral agreements aimed at opening new markets, joint action to resolve conflicts, and other matters related to foreign trade in poultry products. ABEF has conducted joint projects with ApexBrasil[28] in trade promotion and business intelligence. Over the period, 1995 to 2005, relations between the poultry sector and the state have, for the most part, evolved towards cooperation and interaction.

The Brazilian state is not the lever that moves the poultry sector, nor does it provide the sector with incentives, special credit lines and subsidies, as it did in the 1970s and early 1980s when developing exports was vital for the country. Brazilian poultry exports boomed precisely from 1995 to 2005 when no incentives or subsidies existed. The freedom of market action that has prevailed from 1994 onwards has compensated for the incentives and subsidies of the past – without forgetting the economic stability the country has known since that time. Another major change is that the state now views the poultry sector as a modern and competitive industry with a global dimension.

[28] ApexBrasil (Brazilian Trade and Investment Promotion Agency) is within the structure of MDIC (http://www.apexbrasil.com.br/eng/).

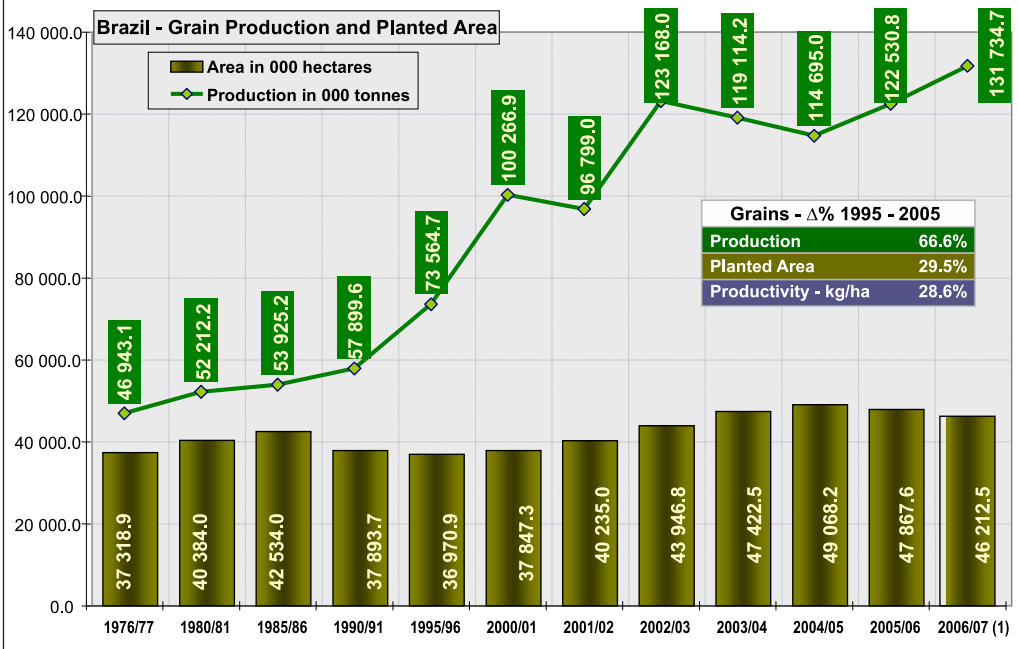
2.2 Feed products

As in the case of livestock, a market economy prevails for grains and microelements. The latter, however, require registration with the relevant authorities at federal level, prior to manufacturing, trade or import.

As far as grains are concerned, official policies impose restrictions on GMOs. The GMO debate in Brazil has been conducted on a very emotional basis and has been permeated by activism. At present, planting and trading of GMO soy and cotton is permitted, but this is not the case for maize. GMO soy is still subject to restrictions imposed by certain state governments, and the issue is constantly argued in courts. The ban on GMO maize creates difficulties for poultry producers in some regions of Brazil, mainly the Northeast Region, which brings in its maize mostly by truck from the Centre-West. It would be much more economical for the Northeast's producers to import maize by sea from Argentina, but the ban closes this alternative source of maize for the moment.

MAPA operates a minimal prices guarantee policy, several lines of rural credit and several programmes to stimulate agricultural production. Despite budgetary restrictions and insufficient credit lines, these actions are of fundamental importance to the rural producer. Brazil is expanding both its grain production and its planted area. But increases in grain production are more the result of rising productivity than of the expansion of the planted area.

FIGURE 28
Brazil's grain production and planted area



Source: CONAB – Brazilian crop grains assessment 4th 2007/2008January 2008.
[1] Preliminary

As described above, bovines and poultry are the most important species in Brazil for meat production, consumption and exports. Grazing predominates in cattle raising in Brazil and feedlot production is minimal. Milk cows are the major feed consumers among bovines, and poultry accounts for over 55 percent of feed consumption in Brazil.

TABLE 37
Feed consumption by livestock species in Brazil

	Total	Poultry for Meat[1]	Poultry for Eggs[2]	Poultry % /Total	Swine	Bovine[3]	Other	Total
1995	15 128	12 383	2 745	63.6%	6 801	1 050	794	23 773
1996	15 252	12 622	2 630	58.6%	8 493	1 239	1 029	26 013
1997	16 341	13 889	2 452	57.7%	8 950	1 425	1605	28 321
1998	17 138	14 637	2 502	56.9%	9 871	1 599	1 492	30 100
1999	19 237	16 140	3 097	59.2%	9 425	2 070	1775.2	32 507
2000	20 178	16 866	3 312	58.6%	10 085	2 469	1 727	34 458
2001	21 756	18 047	3 709	56.1%	12 050	2 982	2024	38 812
2002	23 145	19 195	3 950	55.6%	12 590	3 620	2 239	41 594
2003	24 190	20 250	3 940	55.4%	13 222	3 880	2395.5	43 687
2004	24 923	20 842	4 081	55.5%	12 554	5 165	2 291	44 932
2005	26 771	22 856	3 915	56.7%	12 393	5 375	2669.6	47 209
% Growth 1995-2005	77.0%	84.6%	42.6%		82.2%	411.9%	236.2%	98.6%

[1]Broilers & parent stock [2]Layers + parent stock [3]Mainly milk cows
Source: Sindirações – Sindicato Nacional da Indústria de Alimentação Animal (Animal Feed Industry National Syndicate) (http://www.sindiracoes.org.br/) and UBA Annual Reports 2001, 2002, 2004/2005, 2005/2006 and 2006/2007.

Poultry feed in Brazil is essentially maize and soybean meal. The evolution of soy and maize production and the share of each region is described above. Table 38 presents the evolution of demand for maize and soybean meal in the poultry sector.

TABLE 38

The Brazilian poultry sector's demand for maize and soy bean meal

Poultry - Maize Demand (in 000 tonnes)	1996	1999	2000	2003	2004	2005	2006
Poultry	9 361.7	12 528.5	13 109.1	16 093.2	17 372.7	18 910.4	19 220.0
Chicken for meat	7 812.0	10 666.5	11 305.9	13 403.9	14 516.4	15 889.7	16 048.5
Layers	1 549.7	1 862.0	1 803.2	2 116.9	2 193.1	2 263.3	2 421.7
Turkey				572.4	663.2	757.4	749.8

Poultry - Soybean Meal Demand (in 000 tonnes)	1996	1999	2000	2003	2004	2005	2006
Poultry	3 301.0	4 414.3	4 628.1	5 731.9	6 197.4	6 756.8	6 848.9
Chicken for meat	2 836.6	3 858.8	4 090.2	4 843.3	5 245.3	5 741.5	5 789.9
Layers	464.4	555.5	537.9	631.5	654.2	675.1	722.3
Turkey				257.1	297.9	340.2	336.7

Source: Sindirações - Sindicato Nacional da Indústria de Alimentação Animal (Animal Feed Industry National Syndicate) (http://www.sindiracoes.org.br/) and UBA Annual Reports 2001, 2002, 2004/2005, 2005/2006 and 2006/2007.

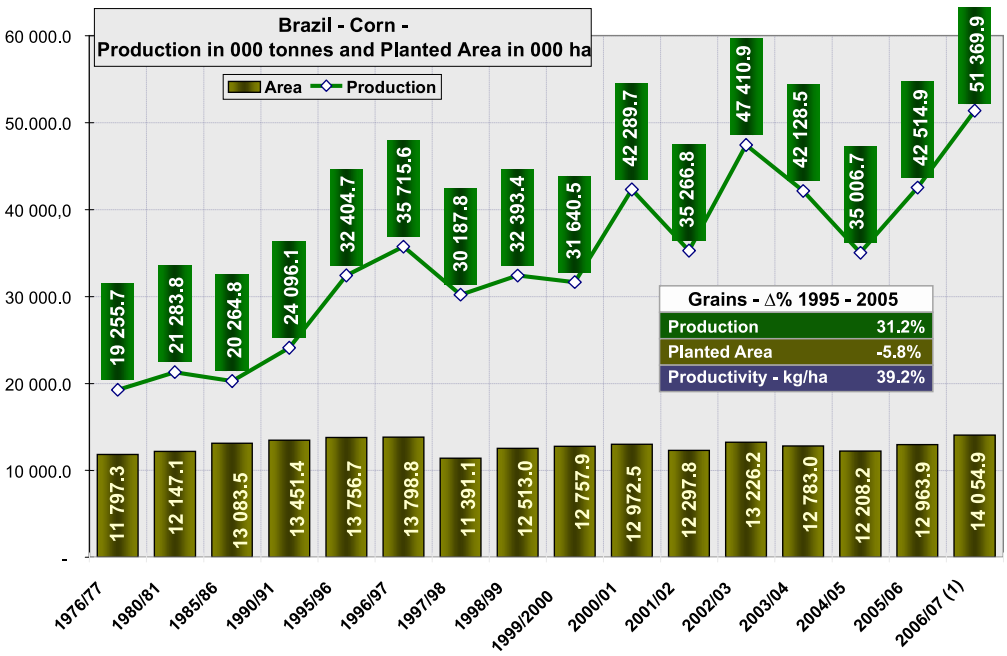
Brazil's domestic maize production is able to meet demand, but the country's exports are soaring because of rising demand for maize for ethanol production in the United States of America and for feed in Asia. Brazilian maize also receives premium prices from clients requiring GMO-free grains. Exports of maize in 2007 reached 10 million tonnes and domestic maize prices went up by 75 percent compared to the previous year. There is pressure from farmers for approval of GMO maize. Poultry and pork producers would welcome this, because it would permit imports of maize from Argentina.

Brazil is self-sufficient in macro-nutrients but entirely dependent on imports for feed additives, the prices of which have increased considerably in recent years. Feed-sector imports amounted to US$700 million in 2007. Among the major imports are DL-methionine, vitamins and minerals, coccidiostats and histomonostats.

The rising cost of feed is a concern for the livestock sector. In contrast to other countries, where the debate regarding grains for food or for ethanol centres on neo-Malthusian concerns, the debate in Brazil centres in how increased meat prices might affect local and international demand.

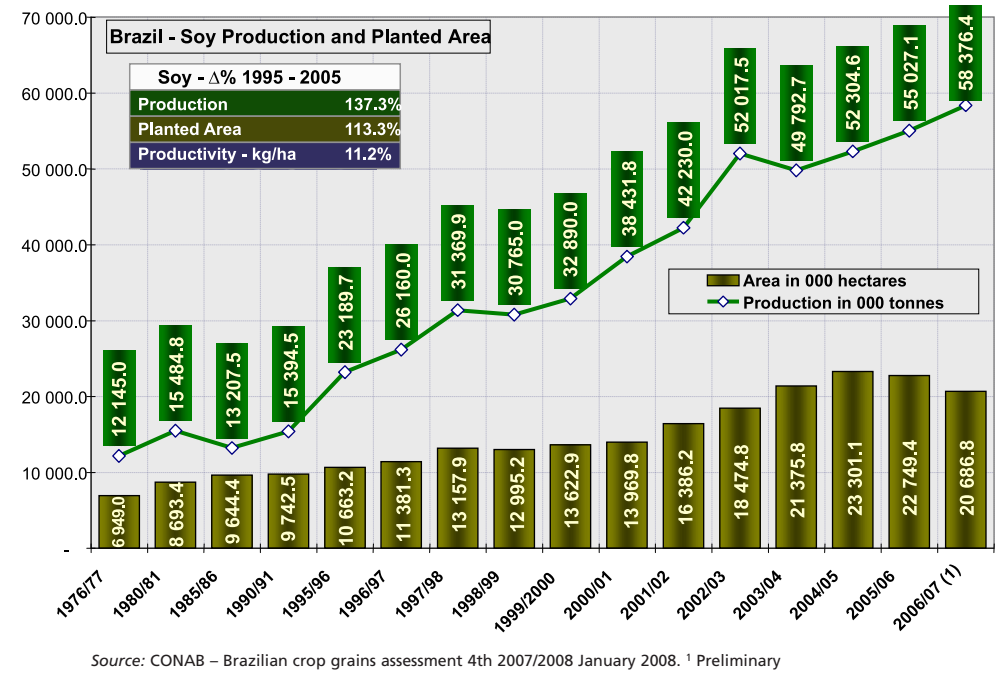
Figures 29 and 30 show the expansion of maize and soy production and planted area. Gains in productivity are shown in Figure 31.

FIGURE 29
Brazil's maize production and planted area



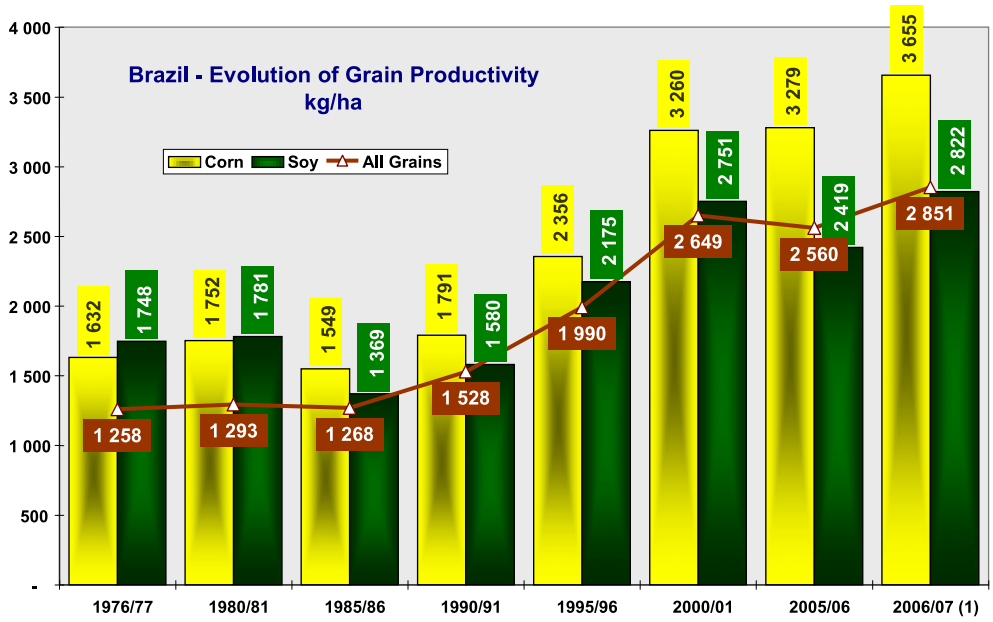
Source: CONAB – Brazilian crop grains assessment 4th 2007/2008 January 2008. [1] Preliminary

FIGURE 30
Brazil's soy production and planted area



Source: CONAB – Brazilian crop grains assessment 4th 2007/2008 January 2008. [1] Preliminary

FIGURE 31
Evolution of grain productivity in Brazil

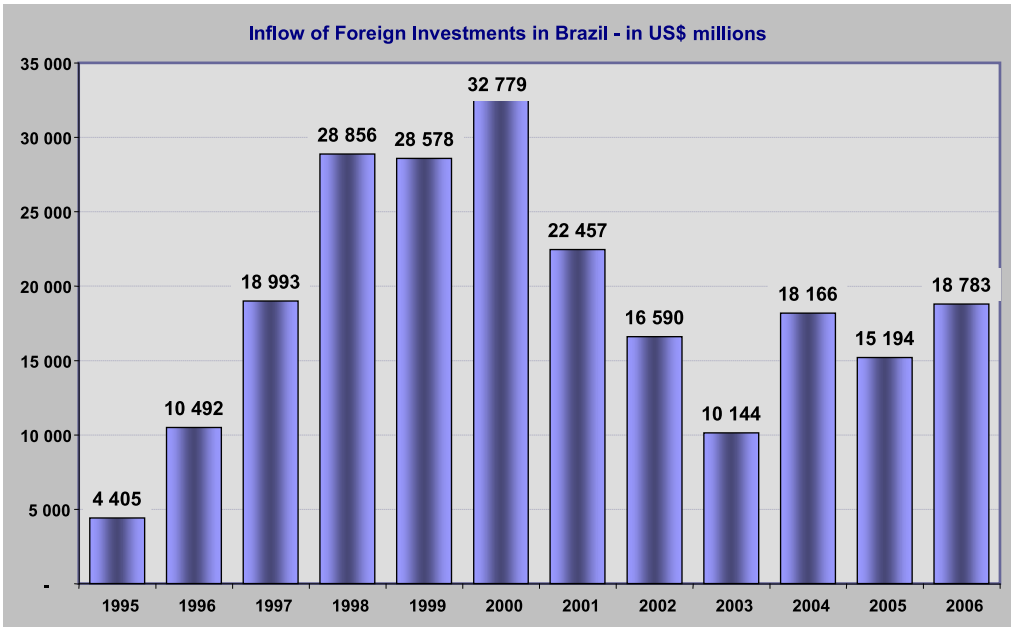


Source: CONAB – Brazilian crop grains assessment 4th 2007/2008 January 2008. [1] Preliminary

2.3 Foreign direct investments

The Brazilian constitution guarantees equal treatment to foreign capital. There are restrictions on foreign capital only in cabotage, domestic flights, and radio and television networks. Like most developing countries, Brazil seeks to attract foreign investments; several government agencies are involved in this task. The aim of these efforts is to increase the volume of foreign investment which has declined since its peak in 2000.

FIGURE 32
Foreign investments in Brazil



Source: elaborated by MDIC with data from BACEN (http://investimentos.desenvolvimento.gov.br/renai_en/arquivos/IEDfluxoSITERENAI.pdf).

All this effort by the Brazilian government to attract foreign investments indicates the openness of the country. The policy is very transparent, and there are critics saying that Brazil could do more to compete with other developing countries. The fiscal burden and its complexity, labour laws that date back to the 1950s and 1960s, bureaucracy, and deficiencies in the infrastructure are pointed to as areas where Brazil has to make changes. The "Doing Business Project"[29] of the World Bank allows comparisons between countries, and the ranking of Brazil seems to corroborate the need for such changes. The deficiencies affect both Brazilian and foreign investors.

Since 1995, the Brazilian poultry sector has been receiving foreign investments; two of the five largest Brazilian poultry producers are now foreign owned. The natural competitiveness of the country in poultry-meat production and its proven efficiency at the international level are attracting foreign investors to Brazil. Large international meat companies are seeking to buy existing poultry companies, but face competition from their Brazilian counterparts who are enlarging their operations through acquisitions. Foreign-investor interest in the Brazilian poultry sector is expected to continue during the coming decade. However, foreign direct investments did not stimulate structural changes in the past.

[29] http://www.doingbusiness.org/

2.4 Public and veterinary health policies and food-safety standards

Several episodes of animal disease marked the period between 1995 and 2005 (bovine spongiform encephalopathy; foot-and-mouth disease; HPAI), affecting demand, disrupting traditional trade flows and eroding the confidence of consumers in many countries. Bans on the use of meat meals in feed and prohibition of growth promoters were imposed; food safety, sustainability, animal welfare, total traceability, sanitation standard operating procedures (SSOP), HACCP, and auditing by clients and consumer organizations became minimal requirements. Quality was no longer enough for consumers, who demanded further assurances about their food. In this period, Brazil became the main poultry exporter to Europe, and after the outbreaks of HPAI from 2004 onwards, one of the few world poultry-meat suppliers not affected by the disease.

These developments led to changes in the Brazilian animal health system with the objective of preventing the entry of poultry diseases, particularly avian influenza, into the country. At the same time, the veterinary inspection services had to guarantee compliance with the new requirements of the importing countries.

Public and veterinary health policies are under the Secretariat of Agricultural and Livestock Defence (SDA) of MAPA. Within the structure of this secretariat there are three departments dealing with animals: Department of Livestock Inputs Control; Department of Inspection of Animal Origin Products (Departamento de Inspeção de Produtos de Origem Animal –DIPOA); and Department of Animal Health (Departamento de Defesa Animal – DDA).

Established in September 1994, the PNSA – Programa Nacional de Sanidade Avícola (National Programme of Poultry Health) – undertakes programmes of cooperation with both public and private institutions. PNSA sets standards for, *inter alia*, biosecurity and disinfection measures; sanitary monitoring of parent-stock producing farms; monitoring of migratory birds; control and inspection of borders, ports and airports; interstate transit of live birds; sample collection; and laboratory analysis for bird diseases.

PNSA has established procedures aimed at:

- controlling Newcastle disease;
- monitoring and controlling avian salmonellosis;
- establishing technical rules for the import and export of day-old chicks and fertile eggs for reproduction purposes;
- establishing technical rules for the control and certification of poultry establishments free from *Mycoplasma gallisepticum;*
- establishing technical rules for the control and certification of poultry establishments free from *Salmonella gallinarum* and *Salmonella pullorum* and free from, or controlled for, *Salmonella enteridis* and *Salmonella typhimurium*; and
- establishing technical rules for registration, inspection and sanitary control of establishments for incubation, breeding and lodging of ratites.

PNSA has developed several specific poultry-health programmes, among which are the National Plan for the Control and Prevention of Newcastle Disease and the Plan for the Prevention of Avian Influenza. UBA has cooperated in all these programmes through its Vice-Presidency for Technical and Scientific Matters.

PNSA, along with poultry producers' associations and state-level animal health authori-

ties, is placing particular emphasis on implementing measures to prevent and control avian influenza. Information centres have been established, basic information is being disseminated among small producers and among those travelling to countries that have active outbreaks of the disease. It has also established procedures to be followed in the event of a suspected outbreak among wild birds or backyard flocks. A manual on the prevention and control of the disease in very small-scale poultry production has been produced.

In each state of the federation, there is a Ministry of Agriculture vet who is responsible for PNSA at state level along with a counterpart from the sanitary and animal health authorities of the state government. PNSA and UBA, along with state-level secretariats of agriculture and state-level associations, are implementing a plan aimed at the regionalization of the Brazilian poultry sector. The cooperation between the private sector through its associations, and DDA has been exemplary.

The main poultry producers have adopted additional biosecurity measures – severely restricting visits, reinforcing vigilance measures, promoting training and information dissemination among farmers, adopting individual disease-prevention plans and control plans to be implemented in the event of an outbreak.

DIPOA is in charge of the sanitary inspection of livestock products and observance at production level of the international sanitary agreements that Brazil has concluded with other countries. Each slaughterhouse producing meat for export has to be approved by the SIF. SIF veterinarians are allocated to each plant, their numbers depending on how many slaughtering lines the plant has, how many shifts it operates, the volume produced, etc. Only plants with SIF inspection can sell goods outside the federal state where they are located.

Various importing countries have bilateral sanitary agreements concerning requirements for export; consequently, a slaughtering plant under SIF may be authorized to sell to some countries but banned from others if it has not been approved by inspectors from the latter countries. Every product manufactured by the plant has to be registered with MAPA.

If an importing country bans the import of poultry meat that contains certain substances, SIF inspectors include these restrictions in their inspection of the production process or of the finished products. Goods can only leave the producing plant accompanied by the Certificate of Sanitary Inspection. For exports, these certificates will have a model approved in the bilateral sanitary agreement. Upon leaving the plant for the port, export goods are sealed in the container or truck by the plant SIF inspector, who issues a transit Certificate of Sanitary Inspection. Upon receiving it at the port, the veterinary inspector of the port warehouse will verify the integrity of the seal and may conduct additional random inspections. After that, a Certificate of Sanitary Inspection for export will be issued.

Good management practices (GMP), good production practices (GPP), HACCP and standard operating procedures (SOP) have become mandatory for poultry production for export. As Brazilian poultry producers started to supply major international supermarkets, fast-food and restaurants chains, food processors and other clients in food services, private inspections and audits by the clients or by auditors appointed by them became the norm. Such clients will not even consider visiting the plant of a prospective supplier before receiving documentation of an audit on total traceability up to the parent-stock level, HACCP, SOP, etc. To have an audit approving a plant for the production of one line of products

does not mean automatic approval for all products from the plant. To have a product approved does not assure that the product can be supplied to the same client in another country, which might require its own auditing. All these requirements and the need to meet ever-higher standards have enhanced the operation and control of poultry facilities, with positive repercussions for the domestic consumer and for the competitiveness of the poultry operations.

SIF's animal product inspection is complemented at consumer and distribution levels by state and municipal sanitary surveillance authorities to ensure proper handling and storage.

Disease outbreaks (particularly HPAI)

There have been no outbreaks of HPAI in Brazil, and its prevention is one of the top priorities of PNSA – with the full support of all elements of the poultry chain. Besides prevention of avian influenza, another priority is the prevention and control of Newcastle disease, of which there were outbreaks in Brazil in 1996, 1999, 2000, 2001 and 2006.[30] The outbreaks of 2006 occurred in backyard production in Rio Grande do Sul and Mato Grosso.

Within the framework of active surveillance implemented under PNSA's National Plan for the Control and Prevention of Newcastle Disease and the Plan for the Prevention of Avian Influenza samples were taken from several premises keeping poultry for on-farm consumption located within a 10 km radius of sites used by migratory birds. One of the samples form a farm near the urban area of Manaus tested positive in 2006, before the birds presented any clinical signs of the disease. This outbreak, as well as the one in Mato Grosso, occurred in an area where no commercial production was present. All birds were destroyed and the premises disinfected. The Rio Grande do Sul outbreak occurred in an area near to commercial production units, and so additional measures were taken – a surveillance zone was established, virological tests performed and sentinel birds introduced. In March 2007, Brazil communicated its final report on the three outbreaks to OIE, thus bringing the episodes to a close.

2.5 General economy and household income development

Several points regarding the Brazilian economy have been raised in this paper. The following points are to be highlighted for the period from 1995 to 2005:

- the importance of agribusiness for the country's economy and foreign trade;
- the contribution of meat exports, particularly poultry meat, to the country's trade surplus and foreign currency situation;
- economic stability and the decline of inflation;
- the reduction of state intervention in the economy and the prevalence of the market economy; and
- growing cost of the Brazilian state without corresponding improvements in the quality of public services and the country's infrastructure.

[30] Source: OIE, HANDISTATUS II Multiannual animal disease status for data up to 2004. Data from 2005 to 2008 is from WAHID Interface – OIE World Animal Health Information Database.

General Data

The following data are drawn from the BrazilTradeNet section "Investing in Brazil".[31]

- Territory: 8 514 215 km²
- Population: 189 334 953 inhabitants (07/2007)
- Gross Domestic Product (GDP): US$ 1 067 325 millions (2006)
- International Reserves: US$85.8 billion (Annual Report 2006 – BACEN)
- Human Development Index (HDI): 0.792 (2005)
- Currency: real (R$)

Language: Portuguese

TABLE 39
Macroeconomic indicators for Brazil 2001–2007

	2001	2002	2003	2004	2005	2006f	2007f
GDP Brazil (US$ billion)	509.6	459.6	508.6	603.9	797.4	940.7	1 011.2
GDP Brazil (R$ billion)	1198.7	1346.0	1556.2	1766.6	1937.6	2 029.7	2 199.5
Real GDP Growth Rate (% - market price)	1.3	1.9	0.5	4.9	2.3	3.0	3.5
- Agriculture and livestock (% - value added)	5.8	5.5	4.5	5.3	0.8	3.0	3.5
- Industry (% - value added)	-0.5	2.6	0.1	6.2	2.5	4.0	4.1
- Services (% - value added)	1.8	1.6	0.6	3.7	2.0	2.5	3.3
Population Brazil (million)	173.8	176.4	179.0	181.6	184.2	186.8	189.3
Per capita GDP (US$)	2 932	2 606	2 841	3 326	4 329	5 036	5 341
Unemployment Rate (% of working force, IBGE week - avg)	6.2	11.7	12.4	11.5	9.8	9.7	9.0
Inflation - IPC-Fipe (end of period, %)	7.1	9.9	8.2	6.6	4.5	1.9	4.0
Inflation - IPCA (end of period, %)	7.7	12.5	9.3	7.6	5.7	3.1	4.5
Inflation - IGP-M (end of period, %)	10.4	25.3	8.7	12.4	1.2	3.6	4.5
Nominal Interest Rate Over- Selic (end of period, % pa)	19.0	25.0	16.5	17.8	18.0	13.8	12.5
Nominal Interest Rate Over - Selic (average, % pa)	17.3	19.1	23.2	16.2	19.0	15.1	13.1
Real Interest Rate (average, IPCA, % pa)	8.9	5.9	12.8	8.0	12.6	11.6	8.2
Nominal Devaluation (end of period, %)	29.0	43.8	-18.9	-10.0	-11.8	-8.1	2.3
Public Sector - Primary Result (% GDP)	3.6	3.9	4.3	4.6	4.8	4.3	4.3
- Federal Government and Central Bank (% GDP)	1.8	2.4	2.5	3.0	-2.9	na	na
- State and Local Government (% GDP)	0.9	0.8	0.9	1.0	-1.1	na	na
- State Enterprises (% GDP)	0.9	0.7	0.9	0.6	-0.9	na	na
Harmonized Result (% GDP)	-3.6	-4.6	-5.1	-2.7	-3.3	-3.0	-2.3
Nominal Result (% GDP)	-5.2	-10.3	-3.6	-2.5	-3.0	-3.0	-2.3
Net Public Sector Debt (% GDP)	52.6	55.5	57.2	51.7	51.6	50.1	49.2
Trade Balance (US$ billion)	2.7	13.1	24.8	33.6	44.8	42.5	35.1
- Exports (US$ billion)	58.2	60.4	73.1	96.5	118.3	132.0	135.8
- Imports (US$ billion)	55.6	47.2	48.3	62.8	73.6	89.5	100.7
Services and Income (US$ billion)	-27.5	-23.1	-23.7	-25.2	-34.1	-37.7	-34.4
- Interest Payments (US$ billion)	-14.9	-13.1	-13.0	-13.4	-13.5	-12.3	-8.6
- Profits and Dividends (US$ billion)	-5.0	-5.2	-5.6	-7.3	-12.7	-16.8	-15.5
- International Travel (US$ billion)	-1.5	-0.4	0.2	0.4	-0.9	-1.2	-1.5
- Other (US$ billion)	-6.2	-4.5	-5.0	-4.8	-7.1	-7.4	-8.8
Unrequited Transfers (US$ billion)	1.6	2.4	2.9	3.3	3.6	3.5	3.5
Current Account (US$ billion)	-23.2	-7.6	4.0	11.7	14.2	8.3	6.0
Current Account (% GDP)	-4.6	-1.7	0.8	1.9	1.8	0.9	0.6
Capital and Financial Account (US$ billion)	27.1	8.9	5.5	-7.3	-8.8	-4.9	-3.1
Capital Account (US$ billion)	0.0	0.4	0.5	0.3	0.7	0.5	0.5
Financial Account (US$ billion)	27.1	7.6	4.6	-8.0	-9.5	-5.4	-3.6
- Foreign Direct Investment (US$ billion)	22.5	16.6	10.1	18.2	15.2	15.0	15.0
- Foreign Portfolio Investment (US$ billion)	0.1	-5.1	5.3	-4.8	4.9	3.0	3.0
- Others (US$ billion)	4.6	-3.9	-10.8	-21.4	-29.5	-23.4	-21.6
International Reserves (US$ billion, cash)	35.9	37.8	49.3	52.9	53.8	73.0	74.0
Total External Debt (US$ billion)	209.9	210.7	214.9	201.4	153.7	136.9	133.7

Source: IBGE, Central Bank and Citibank.

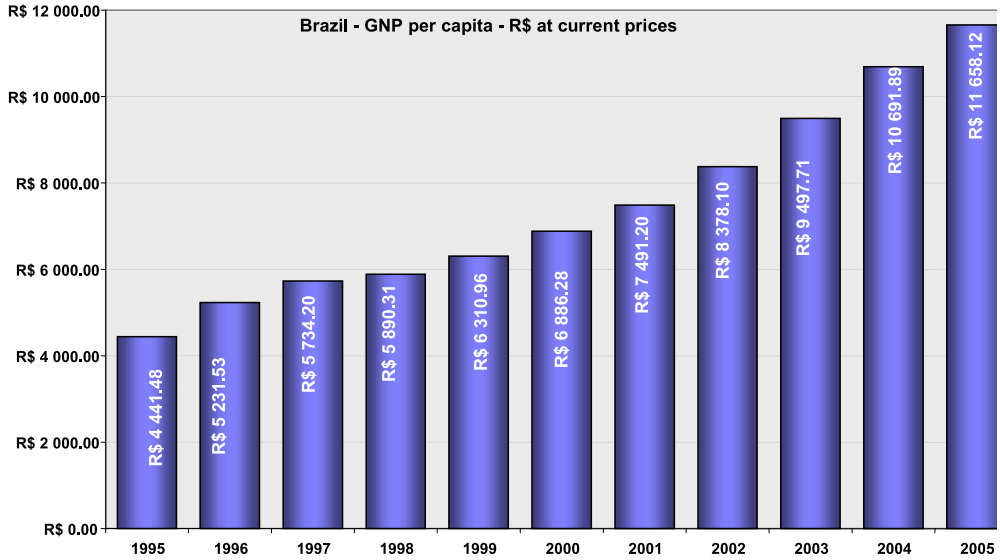
Figures as presented on the Braziltradenet site. Population data is not updated to the latest figures available at IBGE site and are overestimated for 2007.

[31] http://www.braziltradenet.gov.br/CDINVESTIMENTO/?Idioma=I

Income development

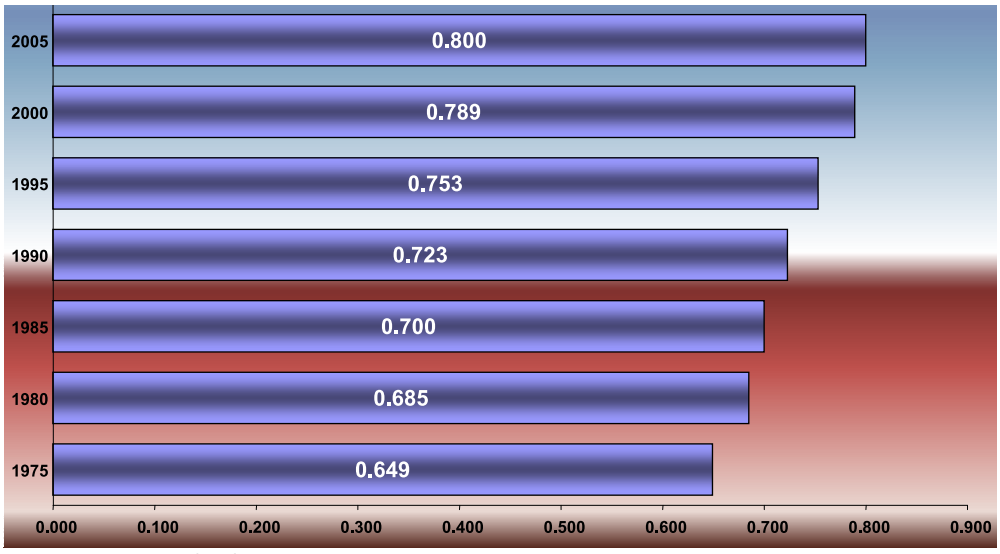
The Brazil of 2005 differs from that of 1995 in a positive way. Several parameters can be used to support this opinion (e.g. per capita income and HDI trends – Figures 33 and 34). However, the progress that has taken place during this period has not eliminated the severe income disparities among the different regions of the country (Table 40). There are also great income disparities within regions.

FIGURE 33
Brazil's GNP per capita, 1995 to 2005



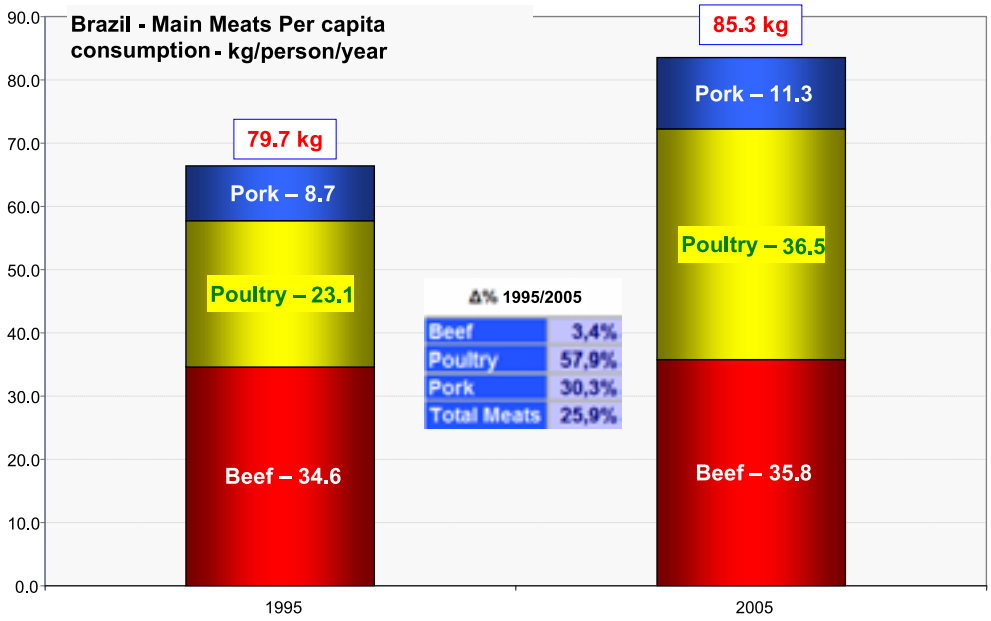
Source: IBGE, Diretoria de Pesquisas (Research Directory), Departamento de Contas Nacionais (Department of National Accounts). FTP directory /Contas_Nacionais/Sistema_de_Contas_Nacionais/Referencia_2000/2004_2005_novembro2007/Tabelas_Sinoticas/ at ftp.ibge.gov.br

FIGURE 34
Trends in Brazil's human development index



Source: UNDP (2007)

FIGURE 35
Brazil's per capita consumption of meats



Source: elaborated with data from ABEF, UBA, ABIEC and ABIPECS.

TABLE 40
Average incomes of working people by region

	Reais - R$	US$	Euro - €
Brazil	**R$ 800.80**	**$328.84**	**€266.64**
North Region	R$ 642.40	$263.80	€213.90
Northeast Region	R$ 490.40	$201.38	€163.29
Southeast Region	R$ 935.90	$384.32	€311.63
South Region	R$ 901.40	$370.16	€300.14
Center-West Region	R$ 931.70	$382.60	€310.23

Sources: IBGE – PNAD – 2005.
The yearly average exchange rate of the real to the US dollar and euro is estimated.

TABLE 41

Monthly Income for working people above 10 years of age, Brazil 2005 (classified by minimum salaries)

Average minimum salary in 2005 = R$ 286,67 = US$ 119,45	Brazil	North	Northeast	Southeast	South	Center-West
			Geographical Regions			
			2005			
			People 10 years old or more			
	152 740 402	11 420 982	41 212 826	66 575 129	22 784 949	10 746 516
1 to 2 minimum salaries	38 243 804	3 051 574	16 002 809	12 464 526	4 347 242	2 377 663
> 1 minimum salary	29 669 537	2 141 276	5 962 685	14 092 480	5 216 975	2 256 121
> 2 to 3 minimum salaries	11 165 917	674 663	1 464 863	6 062 423	2 183 440	780 528
> 3 to 5 minimum salaries	10 463 858	551 645	1 210 096	5 916 576	2 060 562	724 979
> 5 to 10 minimum salaries	6 828 965	303 111	812 717	3 802 090	1 359 333	551 714
> 3 to 5 minimum salaries	2 583 108	107 398	325 228	1 441 377	479 155	229 930
> 20 minimum salaries	1 023 622	35 369	113 409	606 304	162 375	106 165
No declaration or no income	51 573 651	4 524 976	15 139 754	21 367 632	6 854 647	3 686 642
			%			
	Brazil	North	Northeast	Southeast	South	Center-West
1 to 2 minimum salaries	25.0	26.7	38.8	18.7	19.1	22.1
> 1 minimum salary	19.4	18.7	14.5	21.2	22.9	21.0
> 2 to 3 minimum salaries	7.3	5.9	3.6	9.1	9.6	7.3
> 3 to 5 minimum salaries	6.9	4.8	2.9	8.9	9.0	6.7
> 5 to 10 minimum salaries	4.5	2.7	2.0	5.7	6.0	5.1
> 3 to 5 minimum salaries	1.7	0.9	0.8	2.2	2.1	2.1
> 20 minimum salaries	0.7	0.3	0.3	0.9	0.7	1.0
No declaration or no income	33.8	39.6	36.7	32.1	30.1	34.3

Source: IBGE – PNAD 2005–2006.

During the high inflation period in Brazil it became usual to represent values in minimum salaries. Minimum salaries were frequently corrected and used to fix salary levels and even to arrange rental contracts

TABLE 42
Households classified by monthly income expressed in minimum salaries – by geographic region, 2005

Household classified by income 2005	Minimum Salary average value in 2005			R$ 286,67	=	US$ 119,45
	Brazil	North	Northeast	Southeast	South	Center-West
Total Number of Households	**57 463**	**4 183**	**14 862**	**25 405**	**8 897**	**4 116**
Persons per household	**3.2**	**3.5**	**3.4**	**3.1**	**3.0**	**3.2**
Up to 1/4 of the minimum salary	4 894	491	2 863	989	335	216
> 1/4 to 1/2 minimum salary	9 475	991	3 812	3 012	998	663
> 1/2 to 1 minimum salary	15 335	1 210	4 063	6 588	2 258	1 217
> 1 to 2 minimum salaries	13 249	789	2 025	6 879	2 602	955
> 2 to 3 minimum salaries	4 782	225	543	2 647	1 027	340
> 3 to 5 minimum salaries	3 734	169	420	2 082	789	275
> 5 minimum salaries	3 470	116	387	2 024	640	304
W/out Income	**1 574**	**166**	**586**	**554**	**148**	**120**
W/out Declaration	**949**	**27**	**165**	**631**	**102**	**25**

Source: IBGE – PNAD 2005–2006.

During the high inflation period in Brazil it became usual to represent values in minimum salaries. Minimum salaries were frequently corrected and used to fix salary levels and even to arrange rental contracts

TABLE 43
Households classified by monthly income expressed in minimum salaries – by geographic region, 2006

Household classified by income 2006	Minimum Salary average value			R$ 337,50	=	US$ 155,55
	Brazil	North	Northeast	Southeast	South	Center-West
Total Number of Households	**59 094**	**4 294**	**15 238**	**26 196**	**9 117**	**4 248**
Persons per household	**3.2**	**3.5**	**3.4**	**3.0**	**3.0**	**3.1**
Up to 1/4 of the minimum salary	5 060	515	2 983	989	358	216
> 1/4 to 1/2 minimum salary	9 735	1 014	3 862	3 131	1 035	693
> 1/2 to 1 minimum salary	6 125	1 298	4 287	6 882	2 403	1 255
> 1 to 2 minimum salaries	13 760	781	2 114	7 106	2 719	1 040
> 2 to 3 minimum salaries	4 893	221	551	2 727	1 047	347
> 3 to 5 minimum salaries	3 518	143	400	1 999	722	255
> 5 minimum salaries	3 361	113	386	1 975	598	291
W/out Income	**1 465**	**174**	**483**	**562**	**145**	**101**
W/out Declaration	**1 175**	**37**	**173**	**825**	**90**	**50**

Source: IBGE – PNAD 2005–2006.

During the high inflation period in Brazil it became usual to represent values in minimum salaries. Minimum salaries were frequently corrected and used to fix salary levels and even to arrange rental contracts

The last detailed research on food acquisition and intake available is IBGE's POF (Family Budget Research) covering 2002–2003. The North and Northeast Regions are the poorest, and consequently food expenses represent more than 25 percent of household expenditure, against 20 percent for the other regions. Obviously, this disparity affects consumption patterns, choice and quantity. POF divided households by income category (but expressed in reals and not in minimum salaries). Minimum monthly salary was R$200.00 in 2002 and R$240.00 in 2003.

TABLE 44
Average income, total and food expenses, 2002–2003

	Brazil	North	Northeast	Southeast	South	Center-West
Average Income	1 789.66	1 259.91	1 085.82	2 204.71	1 946.30	1 781.45
Total Expenses	1 465.31	1 115.93	978.58	1 757.15	1 564.85	1 433.61
Food Expense	304.12	303.37	262.18	331.94	312.12	259.40
	20.75 %	27.19%	26.79%	18.89%	19.95%	18.09%

Source: IBGE – POF -2002–2003; PNAD for 2005 and 2006.

POF 2002–2003 data also confirmed that the North and Northeast Regions had the highest average number of people per household. Over 65 percent of households had monthly incomes below R$1 000.00 (approximately US$330.00).[32] Among these households, 51.3 percent had a monthly income below R$1 000.00; the figures for the Northeast and North Regions were 72.8 percent and 65.1 percent, respectively. This level of income normally translates into a food intake below the average of the country.

[32] The average approximate exchange rate to the US dollar for 2002 was R$ 2.921 and R$ 3.078 for 2003.

TABLE 45
Households and income by region, 2002–2003

Total Number of Households	Brazil	North	Northeast	Southeast	South	Center-West
	48 534 638	3 143 142	12 235 500	21 897 577	7 768 891	3 489 528
	%	6.5%	25.2%	45.1%	16.0%	7.2%
Persons per household	3.62	4.34	4.01	3.42	3.33	3.50
Monthly Income in R$	**Houselholds per category of monthly income and %**					
Up to 400	7 949 351	702 405	3 999 064	1 979 146	700 786	567 950
	16.4%	22.3%	32.7%	9.0%	9.0%	16.3%
> 400 to 600	6 747 421	578 323	2 444 761	2 295 627	873 753	554 958
	13.9%	18.4%	20.0%	10.5%	11.2%	15.9%
> 600 to 1000	10 181 484	766 966	2 466 316	4 305 075	1 821 858	821 269
	21.0%	24.4%	20.2%	19.7%	23.5%	23.5%
> 1 000 to 1 200	3 528 908	213 898	656 923	1 799 612	611 078	247 398
	7.3%	6.8%	5.4%	8.2%	7.9%	7.1%
> 1 200 to 1 600	5 086 643	276 115	773 351	2 694 869	993 369	348 938
	10.5%	8.8%	6.3%	12.3%	12.8%	10.0%
> 1 600 to 2 000	3 349 073	161 241	492 570	1 810 308	674 564	210 390
	6.9%	5.1%	4.0%	8.3%	8.7%	6.0%
> 2 000 to 3 000	4 571 410	205 338	608 171	2 565 389	919 985	272 527
	9.4%	6.5%	5.0%	11.7%	11.8%	7.8%
> 3 000 to 4 000	2 416 195	88 703	281 389	1 490 844	412 375	142 883
	5.0%	2.8%	2.3%	6.8%	5.3%	4.1%
> 4 000 to 6 000	2 236 892	72 182	241 130	1 428 590	364 906	130 084
	4.6%	2.3%	2.0%	6.5%	4.7%	3.7%
> 6 000	2 467 262	77 971	271 825	1 528 117	396 217	193 131
	5.1%	2.5%	2.2%	7.0%	5.1%	5.5%

Source: IBGE – POF 2002–2003 (http://www.sidra.ibge.gov.br/bda/pesquisas/pof/default20022003.asp?z=p&o=8).

TABLE 46
Proportion of households with monthly income below R$1 000.00

Brazil	North	Northeast	Southeast	South	Center-West
51.3%	65.1%	72.8%	39.2%	43.7%	55.7%

Source: IBGE – POF – 2002–2003 (http://www.sidra.ibge.gov.br/bda/pesquisas/pof/default20022003.asp?z=p&o=8).

POF investigated the annual per capita food purchase in terms of kilograms. As in every consumption study, the results reflect the observations made during the visit of the researcher and the subjective views of the questionnaire respondents. Therefore, the data presented in Table 47 reflects consumption patterns more than actual quantities – otherwise we would have to accept that the per capita consumption of all poultry meat in 2002–2003 was 13.86 kg and that of eggs 1.72 kg. Abundant data indicate that this is not the case.

TABLE 47
Annual per capita food purchases by household income category

Food Category	Household Food Purchase - Annual per capita (Kg) By category of household monthly monetary and non-monetary income (R$)						
	Brazil Annual Average	Up to 400(1)	>400 600	>600 1 000	>1 000 1 600	>1 600 3 000	> 3 000
Total in kg	*328.65*	*233.04*	*277.65*	*303.31*	*341.77*	*377.77*	*436.00*
Index - Brasil Average = 100	100.0	70.9	84.5	92.3	104.0	114.9	132.7
	% of each food category in total annual per capita food purchase						
Cereals and pulses	14.72%	22.21%	20.00%	17.18%	14.56%	11.25%	8.72%
Vegetables	8.82%	6.74%	8.07%	8.48%	9.13%	9.58%	9.69%
Fruits	7.45%	4.75%	5.06%	6.12%	7.16%	8.85%	10.52%
Flours. starches & pasta	6.93%	12.28%	10.26%	8.17%	6.14%	4.97%	3.56%
Bakery industry products	6.18%	5.32%	5.59%	6.06%	6.24%	6.57%	6.65%
Meats	7.68%	7.23%	7.26%	7.74%	8.01%	8.35%	7.12%
Offals	0.26%	0.35%	0.31%	0.29%	0.26%	0.22%	0.20%
Fish	1.40%	2.47%	2.20%	1.51%	1.17%	0.94%	0.89%
Poultry	4.22%	4.40%	4.52%	4.68%	4.50%	4.09%	3.34%
Eggs	0.52%	0.59%	0.54%	0.59%	0.57%	0.56%	0.32%
Dairy	15.18%	11.50%	12.64%	14.74%	15.90%	16.34%	17.26%
Sugar. sweets and confectionery	7.15%	9.37%	8.96%	7.89%	7.12%	6.06%	5.26%
Salts & Spices	1.82%	2.05%	2.08%	1.73%	1.82%	1.71%	1.72%
Oils & Fats	3.11%	3.59%	3.57%	3.15%	3.28%	2.98%	2.51%
Beverages and infusions	13.78%	6.82%	8.51%	11.18%	13.44%	16.57%	20.77%
Industrial Food Preparations and Mixes	0.78%	0.32%	0.43%	0.48%	0.67%	0.96%	1.45%
Other products	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Source: IBGE – POF 2002–2003 (http://www.sidra.ibge.gov.br/bda/pesquisas/pof/default20022003.asp?z=p&o=80).

Table 48 presents the food purchase disparity among the different income categories – 1.00 representing Brazil's average. Poultry meat and eggs are the animal products with the most universal access, as all households with an income level above R$600 (69.7 percent of the total) consumed more than the national average. The more expensive food items are restricted to the higher income groups and the difference in intake from one category to the other is large. These differences show that Brazilian internal consumption still has huge growth potential.

TABLE 48
Food purchase disparity by income category

Household Food Purchase - Disparity per income - Brazil average = 1,000 By category of household monthly monetary and non-monetary income (R$)						
	Up to 400	>400 600	>600 1 000	>1 000 1 600	>1 600 3 000	> 3 000
All Foods	0.709	0.845	0.923	1.040	1.149	1.32
Meats (Beef, pork, other)	0.668	0.799	0.930	1.085	1.251	1.229
Poultry Meats	0.740	0.905	1.024	1.110	1.114	1.051
Eggs	0.803	0.870	1.048	1.136	1.226	0.826
Roasted or Smoked Chicken	0.306	0.554	0.706	1.146	1.283	2.026
Breaded Chicken	0.089	0.282	0.492	0.923	1.409	2.927

Source: IBGE – POF 2002–2003 (http://www.sidra.ibge.gov.br/bda/pesquisas/pof/default20022003.asp?z=p&o=8).

Urbanization rate

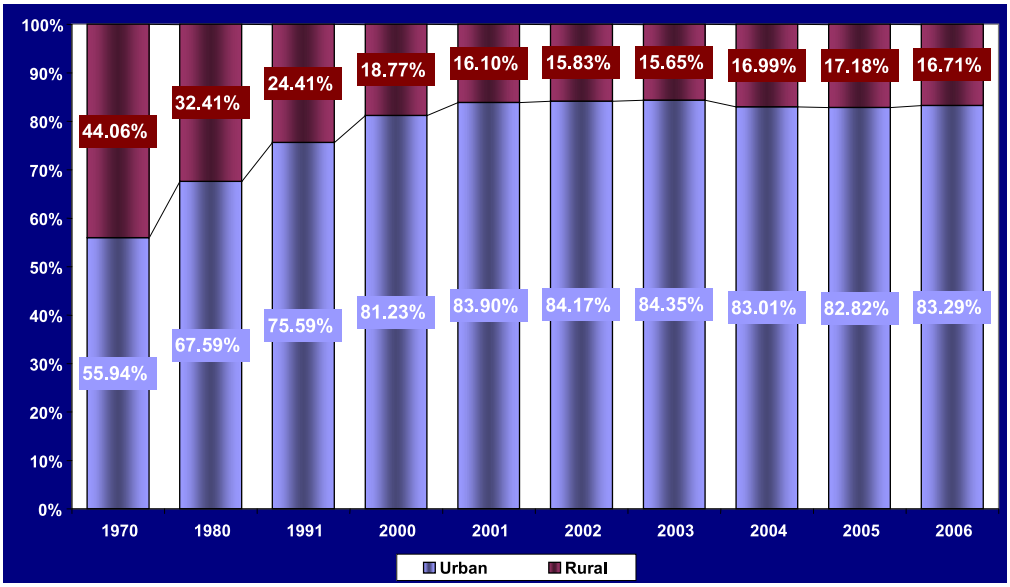
Demographic trends in Brazil follow those of most developed and higher developing countries: diminishing population growth, increasing life expectancy, rising average ages and a high rate of urbanization.

TABLE 49
Brazil's population – total, urban and rural

	Brazil - Population (000)					
	1970	1980	1991	2000	2005	2006
Total	93 135	119 011	146 825	169 591	184 601	187 228
Urban	52 097	80 437	110 991	137 756	152 892	155 934
Rural	41 038	38 574	35 834	31 835	31 709	31 294

Source: IBGE data for 1970 to 2000 are from Demographic Census (http://www.ibge.gov.br/home/estatistica/populacao/default_censo_2000.shtm); data for 2001 to 2006 are from IBGE's PNAD.

FIGURE 36
Brazil's urban and rural populations (percentage figures)



Source: IBGE – Data for 1970 to 2000 are from Demographic Census (http://www.ibge.gov.br/home/estatistica/populacao/default_censo_2000.shtm); data from 2001 to 2006 are from IBGE's PNAD.

Countries colonized by the Portuguese tend to have huge urban agglomerations. Portugal had a small population in the sixteenth and seventeenth centuries, and a colonial empire in three continents. For defensive purposes, the populations would cluster around cities on the coastline, from which goods could be shipped to the metropolis and to which military reinforcement could be sent in the event of attacks. Brazil is no exception to this pattern, and has 14 cities with populations of more than 1 million people.

TABLE 50
Brazilian cities with over 1 million inhabitants

	State	Municipality	Population 2006
1	SP	São Paulo	11 016 703
2	RJ	Rio de Janeiro	6 136 652
3	BA	Salvador	2 714 018
4	CE	Fortaleza	2 416 920
5	MG	Belo Horizonte	2 399 920
6	DF	Brasília	2 383 784
7	PR	Curitiba	1 788 559
8	AM	Manaus	1 688 524
9	PE	Recife	1 515 052
10	RS	Porto Alegre	1 440 939
11	PA	Belém	1 428 368
12	SP	Guarulhos	1 283 253
13	GO	Goiânia	1 220 412
14	SP	Campinas	1 059 420

Source: IBGE data for 1970 to 2000 are from Demographic Census (http://www.ibge.gov.br/home/estatistica/populacao/default_censo_2000.shtm); data for 2001 to 2006 are from IBGE's PNAD.

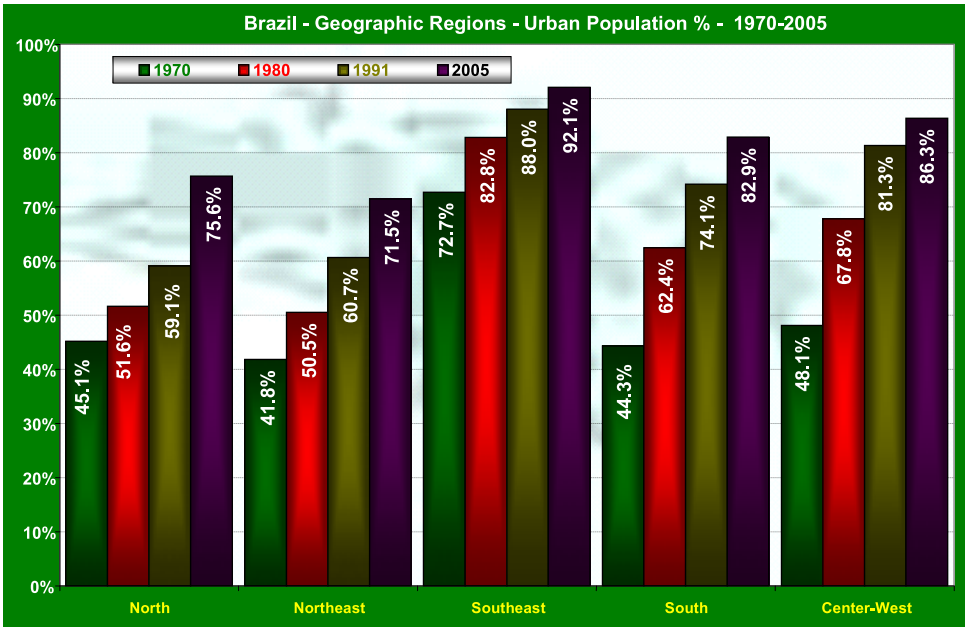
Each year, IBGE estimates the population of each Brazilian municipality for the purpose of tax distribution and resource allocation. Table 51 shows that in 2006 municipalities with over 100 000 inhabitants corresponded to 4.8 percent of the total, but accounted for 54.2 percent of the population. Figure 37 shows that the process of urbanization covers all regions of Brazil.

TABLE 51
Brazilian municipalities by population size

(000) inhabitants	#	Inhabitants	%
> 1000	14	38 492 524	20.6%
>500-<1000	22	15 511 967	8.3%
>400-<500	15	6 684 100	3.6%
>300-<400	28	9 680 717	5.2%
>200-<300	51	12 301 333	6.6%
>100-<200	137	18 562 320	9.9%
>50-<100	311	21 795 317	11.7%
<50	4 986	63 742 284	34.1%
Brazil Total	**5 564**	**186 770 562**	

Source: IBGE, Coordination of Population and Social Indicators.

FIGURE 37
Brazil's urban population by region



Source: IBGE Demographic Census and PNAD 2005.

Market demand – volume and quality – for eggs and poultry meat

Volume of demand is discussed above, and the appendix 1 to this report details chicken-meat balance and wholesale prices from 2005 to 2007, on a monthly basis. It is also noted above:

- that reducing income-related disparities in consumption provides fertile ground for the growth of the Brazilian domestic market for poultry meat, which already represents the fourth largest world market after the United States of America, China and the EU-27;
- that per capita intake of eggs is not in line with the Brazilian tradition of heavy consumption of animal products;
- that for the Brazilian consumer poultry means chicken; and
- that the market for live chickens is declining and concentrated in rural areas and small cities in the interior, but that they are still popular in the North Region and some areas of the Northeast Region, with the exception of the main cities, which are served by supermarkets and modern retail outlets.

In contrast to live chickens, whole chicken is still a very popular product in Brazil, normally sold packed in plastic bags with all edible giblets, feet and head inside the carcass. Brazilians eat white-skinned chickens and their favourite retail weight for broilers is below 2 000 grams and above 1 700 grams. Grillers are available as well as dressed broilers and chicken parts. In the South Region, due to the influence of the Italian immigrants, small-sized grillers and spent hens are very much in demanded for some traditional and typical dishes. Brazilians consume chicken prepared in every way, but roasted whole chicken is highly popular. In the main cities, most supermarkets and retail outlets will offer roasted chicken prepared on their premises – competing in a segment of the market that until the 1990s was dominated by individual shops specialized in cooked foods to take away and by bakeries which on Sundays operate roasting machines. Some restaurant chains are known for their chicken dishes, but most of the fast-food chains that specialized in chicken-only dishes have failed – although chicken sandwiches and nuggets are successful in most hamburger fast-food chains. Chicken can be found on every restaurant menu, from the most sophisticated to the very popular and affordable "meals by the kilogram", where customers select their food from a buffet and pay by weight.

Familiar national and regional brands are preferred by the consumer; but in the case of whole chickens, price has a large influence on consumer choice. As chicken products become more sophisticated and expensive – parts, marinated raw meats, breaded chicken products, prepared chicken dishes, specialties, etc – brand reputation becomes paramount and the leading national brands prevail. These brands normally do not dispute the market for basic whole chickens, where competition includes state or municipally inspected products.[33]

Quality is normally connected to brand; among the unknown brands average consumers will judge the product when cooking – mostly based on carcass integrity and water content. The consumer involves the retailer in his/her view of "quality" and will say that "chicken" bought at shop "α" or "β" is bad or good. Brands with high visibility and publicity are identified as quality brands.

[33] In contrast to SIF – federal inspection – in state and municipal slaughterhouses it is not mandatory to have an official resident veterinarian; requirements are much simpler, equipment and installations less sophisticated. Controls are effected through visits and audits. In federally inspected slaughterhouses, every slaughtered bird is checked by assistants to the official resident veterinarian(s).

Although averages are misleading, Table 52 reflects monthly average prices in the São Paulo market (price for live birds at the farm, wholesale price and retail price for the refrigerated broiler).

TABLE 52
Wholesale and retail prices for refrigerated broilers, São Paulo market (US$/kg)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Live chiken at farm in the interior of São Paulo State - Average monthly price - US$ per kg												
1995	USD 0.75	USD 0.66	USD 0.53	USD 0.51	USD 0.57	USD 0.62	USD 0.71	USD 0.70	USD 0.63	USD 0.49	USD 0.59	USD 0.68
2000	USD 0.49	USD 0.50	USD 0.40	USD 0.32	USD 0.36	USD 0.45	USD 0.55	USD 0.64	USD 0.61	USD 0.58	USD 0.57	USD 0.51
2005	USD 0.52	USD 0.53	USD 0.46	USD 0.47	USD 0.54	USD 0.58	USD 0.59	USD 0.63	USD 0.69	USD 0.64	USD 0.59	USD 0.50
2006	USD 0.46	USD 0.46	USD 0.38	USD 0.46	USD 0.53	USD 0.50	USD 0.42	USD 0.55	USD 0.71	USD 0.82	USD 0.59	USD 0.54
Wholesale price for refrigerated broiler with giblets, feet and head, packed in polybags, in São Paulo market - US$ per kg												
1995	USD 1.20	USD 1.14	USD 0.98	USD 0.93	USD 0.92	USD 0.94	USD 1.05	USD 1.08	USD 1.02	USD 0.98	USD 1.03	USD 1.08
2000	USD 0.67	USD 0.64	USD 0.58	USD 0.49	USD 0.50	USD 0.57	USD 0.68	USD 0.79	USD 0.76	USD 0.74	USD 0.75	USD 0.70
2005	USD 0.66	USD 0.67	USD 0.65	USD 0.66	USD 0.72	USD 0.72	USD 0.73	USD 0.79	USD 0.88	USD 0.86	USD 0.84	USD 0.76
2006	USD 0.62	USD 0.63	USD 0.55	USD 0.66	USD 0.69	USD 0.65	USD 0.58	USD 0.72	USD 0.85	USD 0.96	USD 0.86	USD 0.85
Retail price for refrigerated broiler with giblets, feet and head, packed in polybags, in São Paulo market - US$ per kg												
1995	USD 1.35	USD 1.24	USD 1.10	USD 1.03	USD 1.02	USD 1.02	USD 1.13	USD 1.15	USD 1.17	USD 1.08	USD 1.13	USD 1.17
2000	USD 0.74	USD 0.70	USD 0.65	USD 0.57	USD 0.57	USD 0.65	USD 0.74	USD 0.85	USD 0.83	USD 0.80	USD 0.80	USD 0.77
2005	USD 0.74	USD 0.75	USD 0.73	USD 0.73	USD 0.79	USD 0.79	USD 0.78	USD 0.85	USD 0.97	USD 0.95	USD 0.94	USD 0.85
2006	USD 0.74	USD 0.74	USD 0.66	USD 0.75	USD 0.80	USD 0.76	USD 0.73	USD 0.85	USD 0.98	USD 1.11	USD 1.02	USD 0.97

Source: Jox Assessoria Agropecuária (www.jox.com.br).

From wholesale to retail, the added margin averages around 10 percent. Normally the wholesale price corresponds to that of the slaughterhouse. Brazilian consumers declare their preference for refrigerated chicken, but will promptly accept frozen products for a few cents price difference. Free-range chicken is a relatively knew concept and is restricted to wealthier consumers.

In the egg market, the margins between wholesale and retail prices are much larger; between 1995 and 2005 they averaged 91.5 percent, while those between the producer and the wholesaler averaged 16.6 percent. The diversity of retail distribution channels and the absence of well-known or strong brands may partially explain the huge difference.

TABLE 53
Average annual egg prices

	R$ per carton with 30 dozens		
	Producer	**Wholesale**	**Consumer**
1995	R$ 11.35	R$ 20.05	R$ 27.38
1996	R$ 16.82	R$ 20.40	R$ 36.81
1997	R$ 16.99	R$ 20.08	R$ 39.40
1998	R$ 16.11	R$ 18.83	R$ 37.43
1999	R$ 16.91	R$ 19.91	R$ 35.80
2000	R$ 20.27	R$ 23.57	R$ 42.55
2001	R$ 21.15	R$ 24.00	R$ 48.25
2002	R$ 24.80	R$ 27.86	R$ 52.60
2003	R$ 35.85	R$ 39.49	R$ 77.10
2004	R$ 30.10	R$ 34.50	R$ 71.53
2005	R$ 31.66	R$ 33.50	R$ 71.70
2006	R$ 25.11	R$ 27.80	R$ 65.70

Sources: elaborated by José Carlos Teixeira Consultoria Ltda base on data from APA and IEA (Istituto di Econmia Agríclola – Agricultural Economy Institute) (http://www.iea.sp.gov.br/out/banco/menu.php).

A retailer cannot afford to ignore some of the leading poultry-meat brands, as the consumer perceives them as an indicator of quality and would consider their absence to represent a lack of quality on the part of the retailer. In the case of eggs, the consumer would have enormous difficulty spontaneously naming a few egg brands, thus permitting the retailer to replace suppliers with practically no consequences.

As mentioned above, Brazilian consumers claim preference for brown eggs, but white eggs are predominant. There are no expressed quality parameters for eggs; the consumer will check that there are no broken eggs and will check the production and expiry dates (normally 20 days). Eggs are classified and priced in accordance with their weight; types 2 and 3 are the most commonly found in supermarkets.

TABLE 54
Size categories for eggs

Type	Commercial name	g per piece
1	Jumbo	> 66g
2	Extra	60g - 65g
3	Big	55g - 60g
4	Medium	50g - 55g
5	Small	45g - 50g
6	Industrial	< 45g

Source: APA/IEA

The role of large retailers

In metropolitan areas, supermarkets are the main retail channel for consumer products such as food, and personal hygiene and house cleaning items. According to IBGE's Annual Trade Research, there were 10 632 supermarkets in 2005, which were responsible for 23.8 percent of all retails sales. Sources from the poultry industry estimate that 30.2 percent of food and 9.3 percent of perishable goods were sold in supermarkets in 2005. According to ABRAS (Brazilian Association of Supermarkets), in 2006 there were 73 695 supermarkets in the country, and supermarket sales amounted to R$124.1 billion.

As in most countries, the supermarket sector marches towards concentration. In 2006, the three leading chains respectively accounted for 13.0 percent, 10.4 percent and 10.4 percent of the sales volume, while the share of the fourth largest chain dropped to 1.4 percent. The four largest supermarket companies are all foreign owned.

During the years of high inflation, the Brazilian consumer used to make a monthly purchase at a hypermarket, thus avoiding the almost daily corrections in the prices of household items. Now the economy is more stable, this habit, although still very much present, is giving way to more frequent visits to retailers, both large retailers and local operations.

Although the three largest retailers have an impressive market share and a predominant role in food distribution in some of the major Brazilian cities, competition between these companies is very tough. They also face competition from regional chains. Even the largest retailer is not present in all the federal states. Nonetheless, they have very strong bargaining power with suppliers, and relations are often characterized by "nice speeches and tough realities". Many poultry companies opt to concentrate their sales in smaller chains, traditional retail organizations, food processors, restaurant chains and distributors.

The leading poultry companies in Brazil are usually also pork producers and are involved in the further processing of several food products. Their sales of whole chickens in the domestic market are minimal, but they are extremely strong in terms of differentiated chicken products and processed poultry-meat products. Consumers recognize and demand their brands, which enhances their negotiating power with the major supermarket chains.

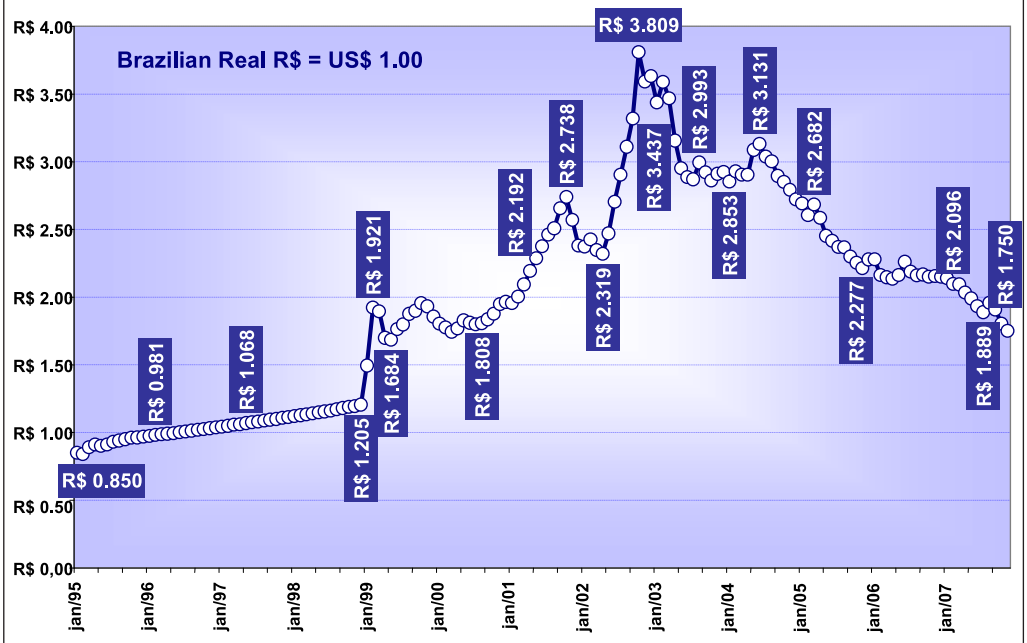
In addition, the major poultry producers have horizontal distribution networks that permit them to cover all parts of the food distribution chain. One of these companies has almost 100 000 active clients in the Brazilian domestic market and delivers almost 300 000 orders per month. In a country of continental dimensions such as Brazil, poorly served by railways and waterways, this distribution requires an enormous fleet of refrigerated trucks and vans covering over 2 million kilometres per month. This national horizontal presence reinforces awareness of the companies' brand among consumers.

Finally, yet importantly, chicken meat is an item that attracts consumers to supermarkets. Supermarkets in Brazil normally place meat sections at the back of the shop to ensure that before reaching it the consumer (87.5 kg/per capita/year of all meats in 2007) has plenty of opportunity for impulse buying. A chicken-meat price promotion is a sure booster of consumer flow in any shop.

Although none of the large retailers has a presence in all states of the federation, they are present in areas that account for no less than 70 percent of Brazilian demand. It is impossible to build a national brand if it is not stocked by these large retailers. Interdependence among major poultry producers and retailers does not necessarily mean harmonious relations, and as both segments move towards further concentration, this is unlikely to change.

Normally, in the streets of major Latin American cities it is possible to study 500 years of retail evolution. Brazil is no exception, and modern supermarkets with e-trade operation can be found alongside very traditional forms of retail.

FIGURE 38
R$–US dollar exchange rate



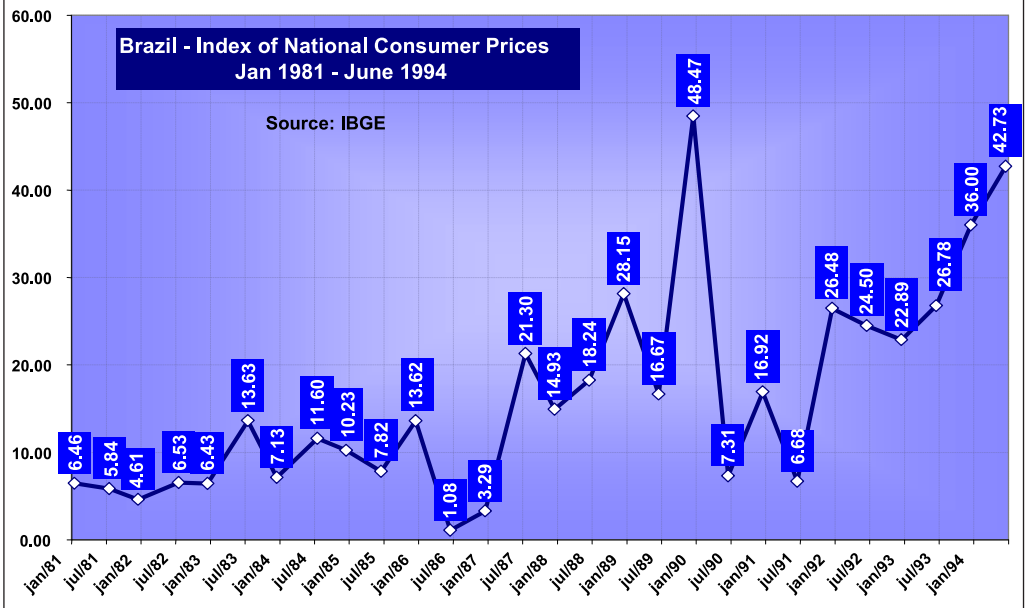
Source: BACEN (http://www5.bcb.gov.br/pec/taxas/port/PtaxRPesq.asp?idpai=TXCOTACAO).

Grain and soybean prices

The rollercoaster behaviour of the Brazilian currency in the period 1995 to 2007 makes any evaluation relating to value particularly difficult. For decades, Brazilians used US dollars as a parameter of monetary stability. Many companies in Brazil would do their budget in the national currency and in US dollars, as this was a measure of value that was accessible and understood by every one.

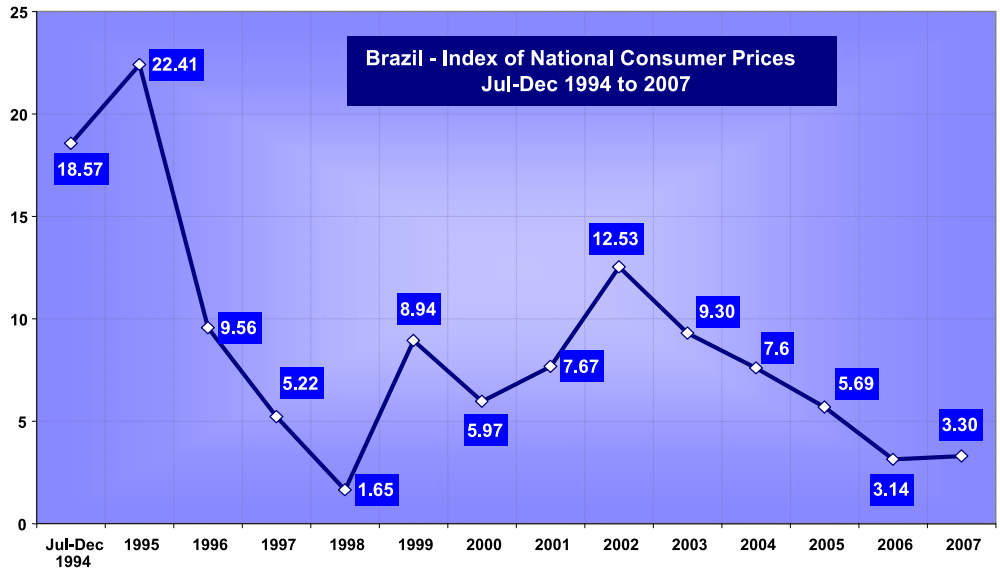
The Brazilian farmer had to live with high inflation rates (Figures 39 and 40) and various heterodox economic plans implemented to control it, which involved the name of the currency being changed six times and more than 18 zeros being cut from it.

FIGURE 39
Brazil's monthly inflation rates, 1991 to 1994



Source: IBGE (http://www.ibge.gov.br/home/estatistica/indicadores/precos/inpc_ipca/defaultinpc.shtm).
The index is known in Brazil as INPC.

FIGURE 40
Brazil's annual inflation rates, 1994 to 2007



Source: IBGE (http://www.ibge.gov.br/home/estatistica/indicadores/precos/inpc_ipca/real_200710.shtm).

In order to survive this jungle of economic concepts, indexes and theories, the poultry farmers adopted what they knew best – they needed maize and soybean meal to produce chicken meat or eggs. These concrete things had nothing to do with concepts the farmers could neither understand nor influence. The basic question for the industry became: how many kilograms of live chicken had to be produced to buy a 60 kg bag of maize or 1 kg of soybean meal?

Appendix 4 contains tables that list, on a monthly basis from 2005 to 2007, the prices of maize, soybean meal and live chickens ready for slaughter. In order to permit comparison we have also included the prices of ready-for-slaughter cattle and pigs – expressed in "arrobas" due to market tradition. The "arroba" in Portugal and colonial Brazil was a measure equivalent to 14.689 kg, traditionally rounded up to 15 kg, used to trade cattle and pigs. Although not recognized as an official measurement, it is still used today – mostly for cattle; pigs are increasingly traded in kilograms. The values presented in the tables in Appendix 4 are not averages, but those recorded on the last working day of each month. Tables 55, 56 and 57 show the same data on an annual basis – representing, respectively, average, maximum and minimum annual prices.

TABLE 55
Prices of maize, soy meal and live chickens, 1995 to 2007 (average annual prices)

YEAR	US$/R$ EXCHANGE RATE	CORN U$$/60 KG BAG	SOYBEAN MEAL US$/Kg	LIVE CHICKEN[1] US$/Kg	LIVE BOVINE[1] US$/@[2]	LIVE SWINE[1] US$/@[2]	Kgs of Live Chicken per kg of Corn	Kgs of Chicken per Kg soymeal	Kgs Live Chicken/ kg live bovine	Kgs Live Chicken/ kg live swine
1995	R$ 0.950	$8.230	$0.190	$0.624	$24.96	$17.47	0.227	0.314	2.76	1.82
1996	R$ 1.007	$8.853	$0.256	$0.682	$23.06	$16.72	0.218	0.377	2.27	1.65
1997	R$ 1.080	$7.876	$0.277	$0.616	$24.80	$20.57	0.216	0.458	2.73	2.46
1998	R$ 1.164	$8.194	$0.163	$0.661	$23.90	$16.61	0.209	0.247	2.45	1.98
1999	R$ 1.879	$6.399	$0.147	$0.428	$18.61	$12.72	0.249	0.346	2.93	3.73
2000	R$ 1.834	$7.843	$0.187	$0.492	$22.20	$13.73	0.282	0.402	3.17	3.53
2001	R$ 2.370	$4.777	$0.186	$0.405	$18.58	$12.08	0.200	0.470	3.11	4.77
2002	R$ 2.998	$6.247	$0.180	$0.387	$16.73	$9.09	0.272	0.474	2.90	4.66
2003	R$ 3.059	$6.502	$0.210	$0.473	$19.11	$12.06	0.233	0.445	2.70	5.14
2004	R$ 2.916	$6.289	$0.222	$0.511	$21.04	$17.10	0.210	0.451	2.79	6.49
2005	R$ 2.412	$7.393	$0.217	$0.559	$23.01	$18.46	0.223	0.394	2.78	5.39
2006	R$ 2.167	$8.140	$0.212	$0.531	$24.83	$14.60	0.260	0.414	3.21	4.06
2007	R$ 1.930	$12.389	$0.286	$0.813	$32.63	$20.95	0.254	0.351	2.68	3.02

Source: Source: elaborated with data collection from Jox Assessoria Agropecuário Ltda (www.jox.com.br).

[1]Animals ready for slaughtering; [2]@ = 15 kg.

TABLE 56
Prices of maize soy meal and live chickens, 1995 to 2007 (annual maximum prices)

YEAR	US$/R$ EXCHANGE RATE	CORN U$$/60 KG BAG	SOYBEAN MEAL US$/Kg	LIVE CHICKEN[1] US$/Kg	LIVE BOVINE[1] US$/@[2]	LIVE SWINE[1] US$/@[2]	Kgs of Live Chicken per kg of Corn	Kgs of Chicken per Kg soymeal	Kgs Live Chicken/ kg live bovine	Kgs Live Chicken/ kg live swine
1995	R$ 0.972	$8.954	$0.234	$0.696	$27.84	$19.81	0.348	0.493	4.42	2.60
1996	R$ 1.039	$9.653	$0.298	$0.784	$24.49	$21.55	0.264	0.483	2.75	2.00
1997	R$ 1.116	$9.367	$0.299	$0.739	$25.51	$24.80	0.268	0.606	3.53	3.47
1998	R$ 1.208	$9.128	$0.221	$0.801	$24.48	$18.42	0.263	0.278	2.97	2.49
1999	R$ 2.064	$9.115	$0.173	$0.531	$22.93	$15.94	0.290	0.441	3.65	4.13
2000	R$ 1.959	$9.492	$0.216	$0.604	$24.24	$15.64	0.531	0.727	5.63	5.42
2001	R$ 2.706	$5.340	$0.200	$0.499	$20.81	$13.42	0.239	0.594	3.64	6.72
2002	R$ 3.894	$8.733	$0.200	$0.476	$19.81	$11.79	0.365	0.605	3.17	6.23
2003	R$ 3.562	$8.085	$0.277	$0.616	$21.71	$15.58	0.328	0.564	2.95	6.05
2004	R$ 3.128	$6.964	$0.282	$0.696	$23.93	$22.53	0.281	0.683	3.28	7.48
2005	R$ 2.665	$8.086	$0.237	$0.677	$24.93	$21.83	0.267	0.505	3.27	7.18
2006	R$ 2.300	$11.311	$0.240	$0.805	$28.99	$18.04	0.355	0.520	4.17	5.48
2007	R$ 2.134	$18.790	$0.391	$0.986	$44.31	$32.48	0.338	0.431	3.39	4.11

Source: Source: elaborated with data collection from Jox Assessoria Agropecuário Ltda (www.jox.com.br).

[1]Animals ready for slaughtering; [2]@ = 15 kg.

TABLE 57
Prices of maize soy meal and live chickens, 1995 to 2007 (annual minimum prices)

YEAR	US$/R$ EXCHANGE RATE	CORN U$$/60 KG BAG	SOYBEAN MEAL US$/Kg	LIVE CHICKEN[1] US$/Kg	LIVE BOVINE[1] US$/@[2]	LIVE SWINE[1] US$/@[2]	Kgs of Live Chicken per kg of Corn	Kgs of Chicken per Kg soymeal	Kgs Live Chicken/ kg live bovine	Kgs Live Chicken/ kg live swine
1995	R$ 0.920	$7.534	$0.150	$0.416	$22.13	$16.03	0.183	0.230	2.21	1.51
1996	R$ 0.978	$7.751	$0.205	$0.590	$21.55	$12.60	0.182	0.332	1.98	1.18
1997	R$ 1.045	$7.288	$0.251	$0.470	$23.44	$18.94	0.168	0.360	2.27	1.89
1998	R$ 1.123	$7.396	$0.147	$0.548	$22.83	$15.51	0.175	0.213	2.00	1.58
1999	R$ 1.660	$4.724	$0.111	$0.348	$15.50	$10.72	0.176	0.270	2.18	3.30
2000	R$ 1.747	$5.730	$0.172	$0.249	$20.27	$11.21	0.196	0.290	2.55	2.85
2001	R$ 1.970	$4.196	$0.155	$0.333	$16.86	$9.74	0.151	0.338	2.41	3.81
2002	R$ 2.323	$4.930	$0.165	$0.292	$13.35	$6.56	0.194	0.371	2.46	3.78
2003	R$ 2.855	$5.279	$0.176	$0.411	$16.28	$9.22	0.163	0.356	2.22	4.51
2004	R$ 2.654	$5.898	$0.179	$0.413	$19.63	$13.10	0.141	0.261	2.25	5.68
2005	R$ 2.206	$6.479	$0.198	$0.469	$21.58	$14.42	0.188	0.328	2.13	4.33
2006	R$ 2.088	$5.963	$0.184	$0.368	$21.74	$10.82	0.186	0.269	2.40	2.86
2007	R$ 1.743	$9.099	$0.204	$0.541	$25.31	$13.91	0.173	0.266	2.05	2.54

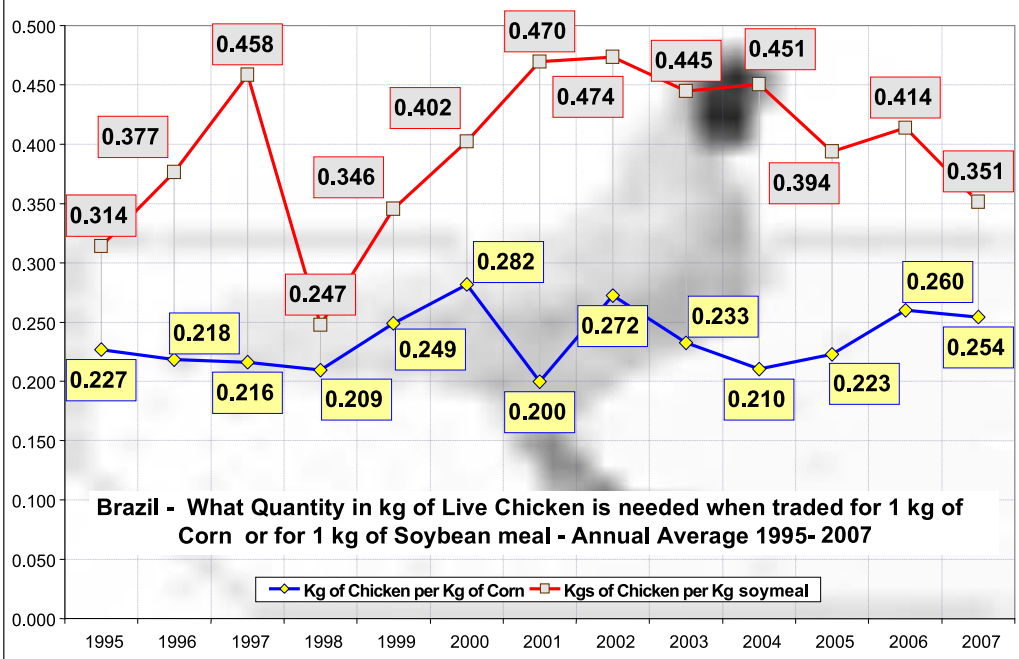
Source: Source: elaborated with data collection from Jox Assessoria Agropecuário Ltda (www.jox.com.br).

[1]Animals ready for slaughtering; [2]@ = 15 kg.

In terms of annual averages, the trade off between soybean meal and chicken ranges between the lowest and atypical value of 0.247 kg in 1998 and the highest value of 0.474 kg for 2002. The equivalent figures for maize are 0.209 kg for 1998 and 0.260 kg for 2006 (Figure 41). In terms of monthly prices for the same period, there were several peaks in which soybean meal prices surpassed 0.500 kg of chicken, with the record registered in April 2000 when it reached 0.727 kg of chicken. The record trade off for maize was in the same month, at 0.531 kg, but the figures for maize were less volatile than those for soy meal (Figure 42). Although the prices of both maize and soy meal increased during the months preceding the preparation of this paper, by the trade-off criteria they remain far from the peaks of the last decade.

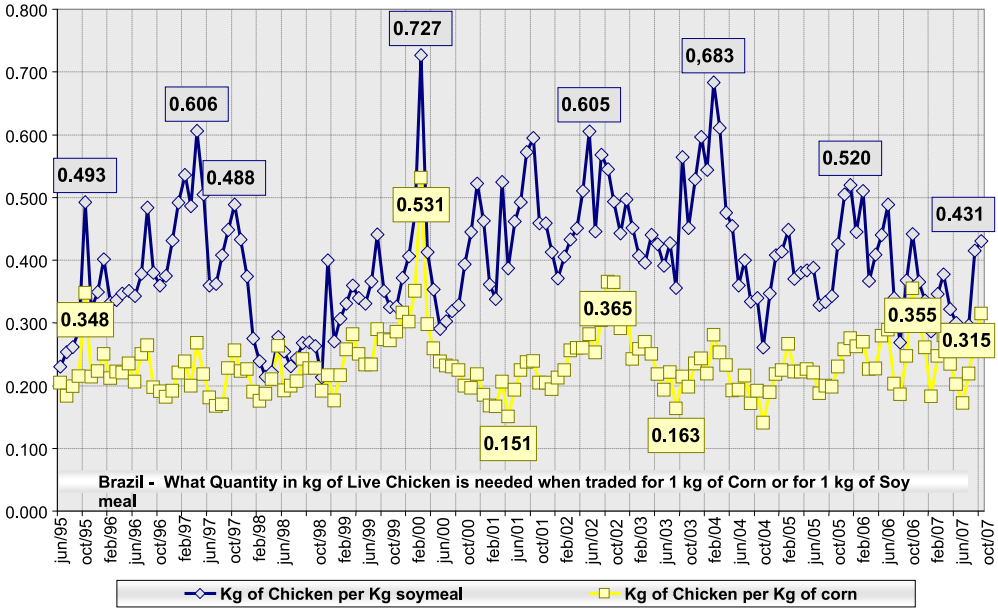
This very simple instrument of comparison used and closely watched by the Brazilian poultry producers for decades proved to be extremely useful during Brazil's periods of high inflation rates and currency-exchange oscillations.

FIGURE 41
Price of live chicken relative to maize and soy meal (annual averages, 1995 to 2007)



Source: elaborated with data from JOX (www.jox.com.br).

FIGURE 42
Price of live chicken relative to maize and soy meal (monthly averages, 1995 to 2007)



Source: elaborated with data from JOX (www.jox.com.br).

2.5.7.Land prices

It is extremely difficult to give an indication of land prices, as figures vary according to land use, the characteristics of the soils, whether the land is prepared for planting, precipitation averages in the locality, proximity to urban centres, distance to major consumer markets and ports, and countless other criteria. Nonetheless, Table 58 presents the price range for agricultural land in Brazil based on data provided by a specialized institute. The average exchange rate to the US dollar was R$2.693 in January 2005 and R$ 2.5978 in February 2005.

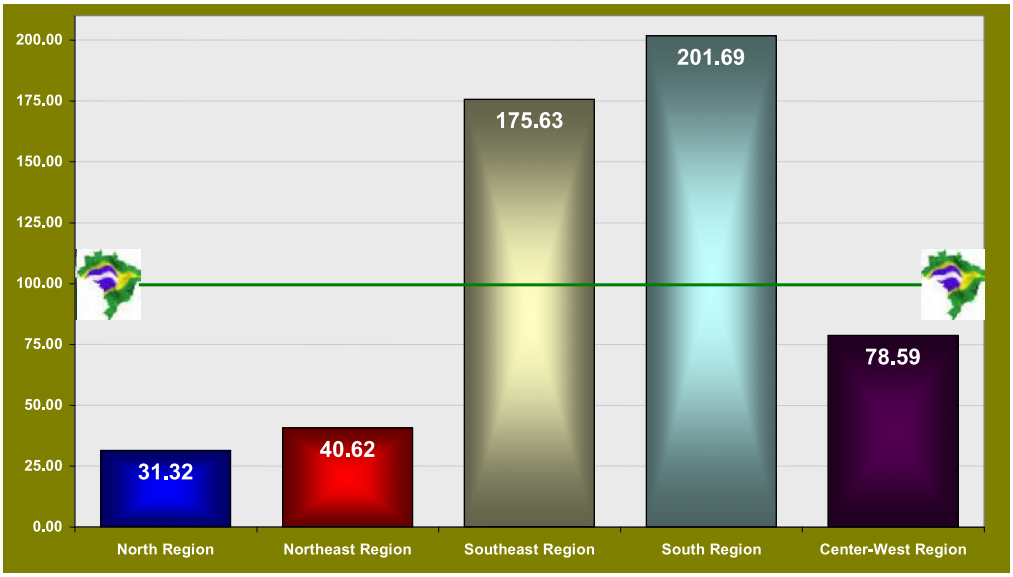
TABLE 53
Price of land in Brazil (R$/ha)

	Average	Maximum	Minimum
Brazil	**R$ 3 139.00**	**R$ 28 000.00**	**R$ 16.00**
North Region	**R$ 983.00**	**R$ 6 485.00**	**R$ 16.00**
Rondônia	R$ 2 372.00	R$ 6 485.00	R$ 186.00
Acre	R$ 433.00	R$ 1 337.00	R$ 30.00
Amazonas	R$ 220.00	R$ 918.00	R$ 34.00
Roraima	R$ 598.00	R$ 1 178.00	R$ 77.00
Pará	R$ 680.00	R$ 3 100.00	R$ 40.00
Amapá	R$ 129.00	R$ 373.00	R$ 16.00
Tocantins	R$ 1 308.00	R$ 3 500.00	R$ 145.00
Northeast Region	**R$ 1 275.00**	**R$ 12 977.00**	**R$ 30.00**
Maranhão	R$ 644.00	R$ 2 815.00	R$ 66.00
Piauí	R$ 493.00	R$ 2 111.00	R$ 45.00
Ceará	R$ 951.00	R$ 10 338.00	R$ 34.00
Rio Grande do Norte	R$ 932.00	R$ 5 439.00	R$ 44.00
Paraíba	R$ 915.00	R$ 3 625.00	R$ 124.00
Pernambuco	R$ 2 491.00	R$ 12 977.00	R$ 30.00
Alagoas	R$ 1 344.00	R$ 3 769.00	R$ 241.00
Sergipe	R$ 2 407.00	R$ 9 863.00	R$ 245.00
Bahia	R$ 1 730.00	R$ 8 575.00	R$ 69.00
Southeast Region	**R$ 5 513.00**	**R$ 21 694.00**	**R$ 72.00**
Minas Gerais	R$ 3 329.00	R$ 12 463.00	R$ 72.00
Espírito Santo	R$ 3 279.00	R$ 10 305.00	R$ 657.00
Rio de Janeiro	R$ 2 401.00	R$ 5 113.00	R$ 500.00
São Paulo	R$ 9 364.00	R$ 21 694.00	R$ 1 240.00
South Region	**R$ 6 331.00**	**R$ 28 000.00**	**R$ 369.00**
Paraná	R$ 6 709.00	R$ 16 116.00	R$ 369.00
Santa Catarina	R$ 6 373.00	R$ 28 000.00	R$ 1 428.00
Rio Grande do Sul	R$ 5 610.00	R$ 14 560.00	R$ 2 295.00
Center-West Region	**R$ 2 467.00**	**R$ 9 229.00**	**R$ 89.00**
Mato Grosso do Sul	R$ 1 967.00	R$ 7 205.00	R$ 158.00
Mato Grosso	R$ 2 864.00	R$ 9 229.00	R$ 89.00
Goiás e Distrito Federal	R$ 2 806.00	R$ 6 723.00	R$ 580.00

Sources: Instituto FNP (http://www.fnp.com.br/prodserv/relatorios/pdf/29.pdf).

Transforming the average prices in Table 58 into an index in which the national average represents 100, we can understand the migration of grain production towards the Centre-West Region. The lowest land prices are found in parts of the North Region, as a large part of it is covered by the Amazon Forest. The Northeast Region comes next in terms of low land prices, but it has a vast area with a semi-arid climate, shallow and stony soil, and erratic rainfall, which severely limit agriculture.

FIGURE 43
Land price index – geographical regions and states



Source: Instituto FNP (http://www.fnp.com.br/prodserv/relatorios/pdf/29.pdf).

The South Region has a strong agriculture, and this is reflected in land prices, although São Paulo State in the Southeast Region has the highest land prices in Brazil because of the strong presence of sugarcane, coffee and citrus-fruit plantations.

It is mostly from the South Region that farmers migrated to the Centre-West Region. The motor was not only the difference in land prices, but also the fact that yields were comparable to those obtained in the South. Tables 59 and 60 show the productivity levels of maize and soybeans in the different Brazilian regions.

TABLE 59
Regional comparison of maize production

	AREA (in thousand ha)		PRODUCTIVITY (in kg/ha)		PRODUCTION (in thousand t)	
	CROP 06/07 (a)	CROP 07/08 (b)	CROP 06/07 (c)	CROP 07/08 (d)	CROP 06/07 (e)	CROP 07/08 (f)
NORTH	564.5	575.5	2 202.0	2136.0	1 243.0	1 229.4
NORTHEAST	2 961.60	3 005.00	1 049.00	1 263.00	3 106.20	3 795.60
CENTRE-WEST	3 259.70	3 373.20	3 986.00	4 057.00	12 994.10	13 685.80
SOUTHEAST	2 404.60	2 332.70	4 306.00	4 431.00	10 353.20	10 336.60
SOUTH	4 864.50	4 983.30	4 867.00	4 670.00	23 673.40	23 272.60
NORTH/NORTHEAST	3 526.10	3 580.50	1 233.00	1 403.00	4 349.20	5 025.00
CENTRE-SOUTH	10 528.80	10 689.20	4 466.00	4 425.00	47 020.70	47 295.00
BRAZIL	14 054.90	14 269.70	3 655.00	3 667.00	51 369.90	52 320.00

Source: Conab.

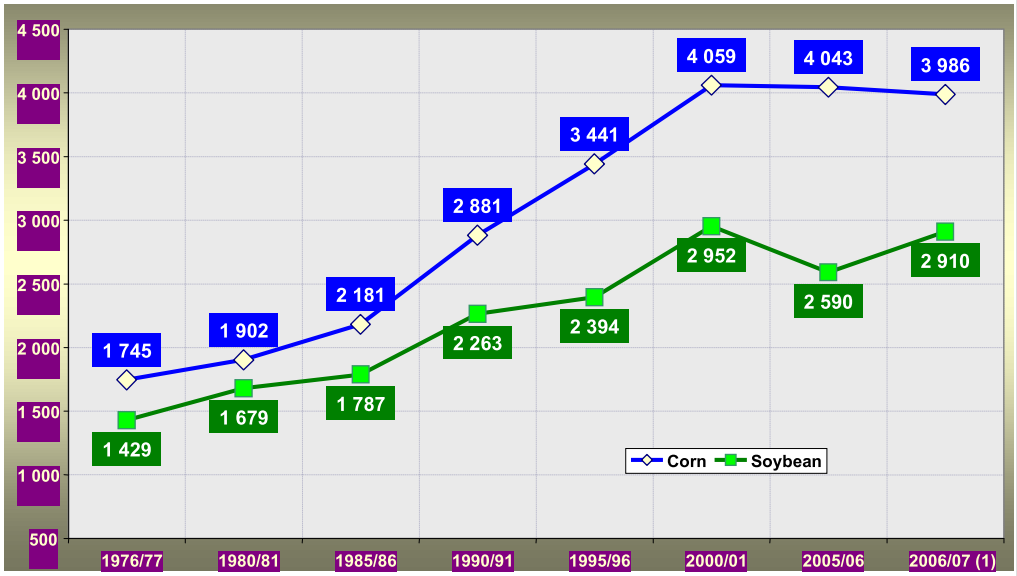
TABLE 60
Regional comparison of soybean production

	AREA (in thousand ha)			PRODUCTIVITY (in kg/ha)			PRODUCTION (in thousand t)		
	CROP 06/07 (a)	CROP 07/08 (b)	VAR. % (b/a)	CROP 06/07 (c)	CROP 07/08 (d)	VAR. % (d/e)	CROP 06/07 (e)	CROP 07/08 (f)	VAR. % (f/e)
NORTH	410.6	430.2	4.77%	2 630.0	2637.0	0.27%	1 079.9	1 134.6	5.07%
NORTHEAST	1 454.90	1 553.10	6.75%	2 658.00	2 740.00	3.09%	3 867.20	4 256.00	10.05%
CENTRE-WEST	9 105.10	9 368.00	2.89%	2 910.00	2 954.00	1.51%	26 494.80	27 673.10	4.45%
SOUTHEAST	1 468.80	1 495.70	1.83%	2 727.00	2 727.00	0.00%	4 005.40	4 078.00	1.81%
SOUTH	8 247.40	8 111.60	-1.65%	2 782.00	2 585.00	-7.08%	22 944.50	20 968.90	-8.61%
NORTH/N.EAST	1 865.50	1 983.30	6.31%	2 652.00	2 150.00	-18.93%	4 947.10	5 390.60	8.96%
CENTRE-SOUTH	18 821.30	18 975.30	0.82%	2 840.00	2 778.00	-2.18%	53 444.70	52 720.00	-1.36%
BRAZIL	20 686.80	20 958.60	1.31%	2 823.00	2 773.00	-1.77%	58 391.80	58 110.60	-0.48%

Source: Conab.

The Centre-West Region has rising rates of productivity in maize and soybeans, as the "direct planting" or "zero-tillage" system, which enhances productivity as organic matter accumulates in the soil, is widely used. As the Centre-West accounts for most of Brazil's reserves of agricultural land, the movement of agricultural production towards the centre should continue in the coming decades.

FIGURE 44
Maize and soybean productivity in the Centre-West Region



Source: Conab.

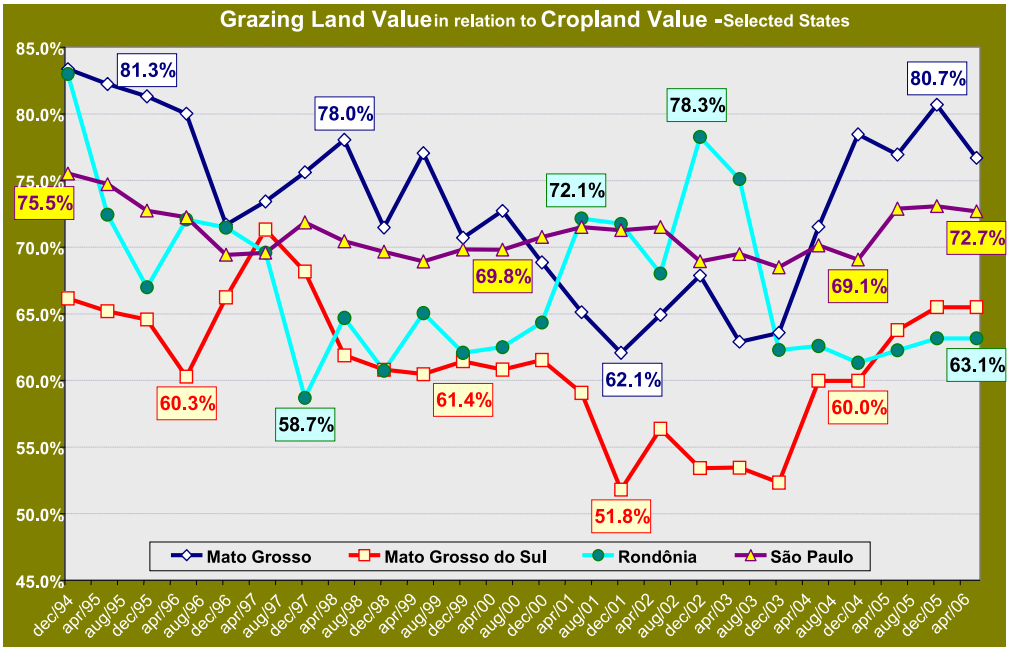
Table 61 presents the average prices of cropland in Brazil and in selected states from June 1995 to December 2005. Figure 45 presents a comparison of the price of cropland to that of grazing land in the same states during the period January 1994 to December 2006; it can be seen that grazing land is worth 50 percent to 80 percent of the value of cropland.

TABLE 61
Value of cropland – selected states

	Brasil R$/HA	Mato Grosso R$/HA	Mato Grosso do Sul R$/HA	Pará R$/HA	Rondônia R$/HA	São Paulo R$/HA	Average Monthly Rate R$/US$
Jun-95	1 742.00	698.00	1 628.00	369.00	562.00	3 935.00	R$ 0.913
Dec-95	1 477.00	610.00	1 281.00	298.00	648.00	3 440.00	R$ 0.968
Jun-96	1 345.08	574.48	1 228.58	364.51	456.69	2 799.82	R$ 1.00
Dec-97	1 289.37	582.90	1 053.26	268.14	405.93	2 625.96	R$ 1.113
Jun-00	1 575.09	680.99	1 322.71	364.05	589.17	2 983.81	R$ 1.808
Dec-00	1 667.46	796.12	1 407.32	366.89	645.72	3 268.30	R$ 1.963
Jun-01	1 893.29	1 050.82	1 848.73	350.70	741.54	3 710.87	R$ 2.376
Dec-02	2 774.86	1 523.45	2 964.05	402.84	810.29	5 397.04	R$ 3.626
Jun-03	3 354.86	1 925.98	3 633.65	428.75	873.48	6 520.32	R$ 2.883
Dec-03	3 886.59	2 183.71	4 504.86	406.85	1 058.29	7 446.98	R$ 2.925
Jun-05	4 604.53	2 517.31	4 456.34	554.25	1 413.00	8 998.46	R$ 2.414
Dec-05	4 687.84	2 563.93	4 456.34	557.21	1 393.00	9 332.50	R$ 2.286

Source: FGV.

FIGURE 45
Value of grazing land vs. cropland



Source: FGV.

Employment and wages in the poultry sector

Available statistics on labour and agriculture do not allow extent of the transfer of wages and labour to other sectors to be established. IBGE keeps several statistics on employment, such as: PPE (Monthly Research on Employment)[34] which monitors urban employment in the main metropolitan regions of the country; and Pesquisa Industrial Mensal de Emprego e Salário (Industry Monthly Research on Employment and Salaries)[35] which provides data on employment in the category "food and beverages", but does not separate meat or meat processing.

Data on agriculture and livestock employment are available from the Agricultural and Livestock Census[36] and in IBGE's annual research "Sistema de Contas Nacionais – Brasil 2000–2005" (System of National Accounts)[37]. Both provide information on the numbers employed in agriculture and livestock production; the latter also includes average incomes, but the occupation categories are not detailed.

TABLE 62
Employment and incomes in agriculture and the food industry)

Categories and activities	Total Number of People Occupied					
	2000	2001	2002	2003	2004	2005
Total	**78 972 347**	**79 544 414**	**82 629 067**	**84 034 981**	**88 252 473**	**90 905 673**
Agriculture and Livestock	***17 610 940***	***16 902 498***	***17 353 605***	***17 660 548***	***18 873 744***	***18 980 620***
- Agriculture, silviculture, forestry	12 160 942	11 680 935	11 997 589	12 251 005	13 040 725	13 094 054
- Livestock & Fishing	5 449 998	5 221 563	5 356 016	5 409 543	5 833 019	5 886 566
Industry	***15 401 694***	***15 302 635***	***15 850 088***	***16 002 247***	***17 067 388***	***18 194 779***
- Food & Beverages	1 639 696	1 675 455	1 695 397	1 836 412	2 031 041	2 203 042

Categories and activities	Average Income (R$) (Salaries + other remunerations or income/occupation)					
	2000	2001	2002	2003	2004	2005
Total	**R$ 6 489**	**R$ 7 014**	**R$ 7 478**	**R$ 8 428**	**R$ 8 914**	**R$ 9 702**
Agriculture and Livestock	***R$ 2 502***	***R$ 2 942***	***R$ 3 422***	***R$ 4 296***	***R$ 4 452***	***R$ 4 436***
- Agriculture, silviculture, forestry	R$ 2 182	R$ 2 600	R$ 3 202	R$ 4 066	R$ 4 219	R$ 3 957
- Livestock & Fishing	R$ 3 215	R$ 3 708	R$ 3 913	R$ 4 817	R$ 4 974	R$ 5 503
Industry	***R$ 7 450***	***R$ 7 978***	***R$ 8 506***	***R$ 9 555***	***R$ 10 336***	***R$ 11 109***
- Food & Beverages	R$ 6 530	R$ 6 782	R$ 7 322	R$ 8 217	R$ 8 867	R$ 9 382

Source: IBGE's annual research "Sistema de Contas Nacionais – Brasil 2000-2005" (System of National Accounts).

[34] Available at http://www.ibge.gov.br/home/estatistica/indicadores/trabalhoerendimento/pme_nova/default.shtm

[35] Available at http://www.ibge.gov.br/home/estatistica/indicadores/industria/pimes/default.shtm
(http://www.ipea.gov.br/default.jsp) IPEADATA, Sinopse macroeconômica (Macroeconomic synopsis).

[36] Preliminary results for the 2006 Census are available at http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/2006/default.shtm
Complete results for the 1995/1996 Census are available at http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/1995_1996/default.shtm

[37] http://www.ibge.gov.br/home/estatistica/economia/contasnacionais/referencia2000/2005/default.shtm

Another difficulty is that of all people working on farms, 75.9 percent in 1996 and 78.3 percent in 2006 had family bonds with the rural producer. In addition, agricultural censuses in Brazil only reveal the number of rural properties were poultry was present, without clarifying whether other agricultural activities or other livestock are also present, which is the majority of cases. It is thus not possible to establish how much poultry contributed to the income generated by the farm.

TABLE 63
Number of farms and farm population

Brazil		1996	2006
# of Agricultural and Livestock Establishments	(units)	4 859 864	5 204 130
People occupied at Agricultural and Livestock Establishments	(persons)	17 930 853	16 367 633
With family bonds with the rural producer	(persons)	13 607 876	12 810 591
	(%)	75.9%	78.3%
Without family bonds with the rural producer	(persons)	4 322 977	3 557 042
	(%)	24.1%	21.7%

Sources: Instituto FNP (http://www.fnp.com.br/prodserv/relatorios/pdf/29.pdf).

3 THE FUTURE

MAPA has just issued its forecast for Brazilian agriculture up to 2017/2018. It is based on projections by OECD-FAO and the Food and Agricultural Policy Research Institute (FAPRI) for the world economic outlook and the prospects for food and agriculture. As far as quantity is concerned, compared to FAPRI's figures, MAPA is more optimistic in its projections for maize, but extremely conservative for soy.

For the meat segment, MAPA figures surpass both OECD-FAO and FAPRI figures for bovine and broiler meats and are more moderate for pork. MAPA's projections[38] are shown in Tables 64 to 68.

TABLE 64
Brazil – maize projections to 2018

Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Production	51.06	48.32	49.90	51.48	53.06	54.64	56.22	57.80	59.38	60.96	62.54	64.12
Exports	7.50	6.27	6.85	7.43	8.00	8.58	9.16	9.74	10.31	10.89	11.47	12.04
Domestic Consumption	39.50	40.38	40.88	41.96	42.71	43.57	44.43	45.25	46.11	46.95	47.79	48.64

TABLE 65
Brazil – soybean projections to 2018

Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Production	57.55	59.17	60.79	62.40	64.02	65.64	67.26	68.88	70.49	72.11	73.73	75.35
Exports	25.20	26.11	27.03	27.94	28.85	29.77	30.68	31.59	32.51	33.42	34.33	35.25
Domestic Consumption	31.70	32.36	33.02	33.67	34.33	34.99	35.65	36.30	36.96	37.62	38.28	38.94

[38] MAPA – Projeções do Agronegócio Mundial e Brasil 2006/07 a 2017/06, Brasília, January 2008.

TABLE 66
Brazil – bovine meat projections to 2018

Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Production	10.63	10.93	11.24	11.54	11.85	12.15	12.46	12.76	13.06	13.37	13.67	13.98
Exports	2.27	2.44	2.65	2.85	3.05	3.25	3.46	3.66	3.86	4.07	4.27	4.47
Domestic Consumption	8.39	8.61	8.84	9.06	9.28	9.50	9.73	9.95	10.17	10.40	10.62	10.84

TABLE 67
Brazil – pork projections to 2018

Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Production	2.97	3.08	3.16	3.23	3.30	3.36	3.42	3.48	3.54	3.60	3.66	3.72
Exports	0.50	0.60	0.64	0.68	0.71	0.75	0.79	0.82	0.86	0.90	0.93	0.97
Domestic Consumption	2.48	2.49	2.56	2.62	2.68	2.75	2.81	2.88	2.94	3.01	3.07	3.14

TABLE 68
Brazil – broiler meat projections to 2018

Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Production	9.82	10.47	10.86	11.25	11.69	12.11	12.51	12.90	13.29	13.67	14.05	14.41
Exports	2.98	3.15	3.31	3.46	3.60	3.73	3.87	3.99	4.11	4.23	4.35	4.47
Domestic Consumption	6.84	7.17	7.45	7.72	8.00	8.27	8.55	8.82	9.10	9.38	9.65	9.93

Projections are not meant to be precise to the gram or the cent, but are useful to identify tendencies. From this point of view, MAPA's projections coincide with our view that:

- Both agricultural and livestock production in Brazil will continue to grow in the coming decade. Brazil has the land, the water, the photosynthesis, the grains, the tradition of livestock production, and the know-how. It is an important international player; livestock products are one of the sources of wealth in this country.
- Feed grains will show particular dynamism even though sugarcane production will advance at the expense of grain in the Centre-West Region. Sugarcane is today the most profitable crop in Brazil, and consequently the price of land in the State of São Paulo, the major sugarcane producer, is skyrocketing. It is, thus, inevitable that sugarcane entrepreneurs expand the plantations into neighbouring states that have more affordable land, such as those in Centre-West Region. This is the natural direction of expansion for the São Paulo alcohol and sugar industry.
- Export will continue to be one of the main drivers of growth in meat production, but domestic demand will keep pace, thanks to the increasing purchasing power of the Brazilian population and the reduction of income disparity.
- Chicken will be the meat most consumed in the domestic market, but poultry will continue to depend on the international market to absorb 30 percent of production. As a consequence, the concerns of developed-country consumers – food safety, ethics, environmental and social impacts, and animal welfare – cannot be ignored. It is up to the industry to ensure that requirements emanating from Northern Hemisphere countries are adapted to local conditions.
- Animal health is the major challenge.
- The sustainability tripod – economic value, social value and environmental value – is the roadmap to the future. Otherwise, the road leads to extinction.
- Climate change is no longer a hypothesis. It is a fact today, and has huge potential to affect agriculture and human life all over the planet. A 3 °C average increase in the world temperature would be enough to change the geography the world's agricultural production.

Of course, there are reasons for prudence and concern about the future. Although in the short term, there is a preoccupation with the grain situation, we believe that animal diseases and climate change are greater challenges for the future.

Animal disease outbreaks affect poultry meat demand and the normal course of trade, as demonstrated during the HPAI episodes of 2004 and 2006. On the positive side, demand recovered rapidly in the following years.

Climate change is more worrying because it is actually occurring. However, its potential impact on agriculture and livestock has not yet been fully studied. Researchers are ringing alarm bells and warning that it may change the geography world of production, but as yet studies are do not permit global conclusions or the forecasting of quantified scenarios.

Under the conditions existing today, we would affirm that photosynthesis-, water- and land-rich countries should prevail as poultry-meat exporters in the future. Brazil is among them and there are not that many.

3.1 SWOT analysis

On the basis of the facts presented above, we offer an assessment of the future perspectives for the agribusiness sector, of which the poultry industry is an increasingly important segment. We have opted for a SWOT (strengths, weaknesses, opportunities, threats) analysis with the intention that the assessment be as neutral as possible.

Strengths

We expect the progress of Brazil's agricultural and livestock production sectors to continue. Agriculture is photosynthesis + water + arable land, and Brazil has them in abundance. Most of the countries that will be the centres of future demand do not have enough water, or arable land, to support a shift from economic vegetarianism to increased meat intake. Brazil is in position to continuously increase its exportable poultry-meat surplus. It develops science and technology adapted to local production conditions. The country has aggressive entrepreneurs and reinvestments are the rule.

Weaknesses

Inflation control and economic stability reduce the level of public investments and create problems, such as:

- lack of investment in infrastructure, above all in logistics (warehousing, transport and ports) and energy;
- insufficient investment in technology and tropical agricultural research to match the country's agribusiness growth and potential;
- insufficient investment in the plant and animal health services needed to constantly improve official veterinary inspection and ensure products and production systems that meet the safety demands of both domestic and international markets; and
- the low bargain power of the country at international level.

Opportunities

The country's natural conditions for livestock production will attract more and more foreign poultry companies, whose global competitiveness will require production platforms in Brazil and a presence in the fourth largest chicken-meat market in the world, which has the capacity to complement exports by absorbing all the parts of the chicken. Consequently, foreign investments are to be expected in the Brazilian poultry sector in the future, generating additional value for the industry and creating new potential for expansion.

Brazilian poultry companies will have to excel to survive, because in the coming decades the concentration of the poultry industry will be in the hands of global food companies and not merely poultry companies. Nothing, however, precludes Brazilian companies from challenging as global players.

Threats

Developing countries' exports bear the brunt of developed-country protectionism, which includes pseudo-sanitary barriers, rapid closing of borders in the event of disease episodes, intentional slowness in re-opening markets even when the World Organisation of Animal

Health (OIE) declares the episode closed, and other forms of protectionism based on sanitary claims.

Another major threat is animal disease and the spread of HPAI, resulting in closed borders if Brazil is directly affected or falls in demand due to health fears about poultry products among consumers in affected countries. If Brazil experiences an episode of HPAI, it will immediately lose 60 percent of its exports and production will undoubtedly be reduced. Protectionists will seek to postpone indefinitely the return of Brazilian exports to their territories. In such circumstances, world poultry supply would, however, be severely affected, perhaps meaning that the length of import bans would be based on science rather than protectionism.

Climate change may affect the geography of food production. A 4 °C increase in temperature would be mean that most of agricultural Brazil would no longer lie within the zone of agriculturally friendly temperatures that now predominate in the country. Changes in rainfall frequency would threaten Brazil's largely rainfed grain production and the country's wealth of renewable water resources.

A poultry industry that relies on the international market for 30 percent of its output would inevitably be affected by an international economic crisis affecting demand and growth in several of the world's new centres of demand.

3.2 Homework[39]

The Brazilian poultry industry has very good production coefficients. The figures shown in Table 69 represent the average for the country and not the benchmarks, some of which are already monitoring "age to slaughtering" in terms of days and hours.

TABLE 69
Evolution of chicken production coefficients in Brazil

Year	Live bird weight (g)	Feed Conversion	Age to slaughtering - weeks/days
1930	1 500	3.50	15 weeks
1940	1 550	3.00	14 weeks
1950	1 580	2.50	10 weeks
1960	1 600	2.25	8 weeks
1970	1 700	2.15	7 weeks
1980	1 800	2.05	7 weeks
1984	1 860	2.00	47 days
1988	1 940	2.00	47 days
1994	2 050	1.98	45 days
1998	2 150	1.95	45 days
2000	2 250	1.88	43 days
2001	2 300	1.85	42 days
2002	2 300	1.83	42 days
2003	2 350	1.88	43 days
2004	2 390	1.83	43 days
2005	2 300	1.82	42 days
2006	2 340	1.85	43 days
2007	2 450	1.85	44 days

Sources: MAPA – Projeções do Agronegócio Mundial e Brasil 2006/07 a 2017/06, Brasília, January 2008.

[38] Things, tasks, missions, points, etc, that require work, attention or priority from the Brazilian poultry sector or from the Brazilian authorities. "Homework" refers to the fact that it is up to the Brazilians to do it.

Progress will continue. In the coming 20 years or less, feed conversion rate should be around 1.40 for a bird that reaches 2 450 grams in less than 39 days. Nonetheless, even in the distant future, birds will not eat zero grams and be ready in 24 hours. To keep its benchmark competitiveness in the coming 20 years, the Brazilian poultry industry will have to monitor new coefficients, such as "water conversion", "kilometres travelled per kg of meat or dozen eggs", "energy self-sufficiency index", "percent of live weight commercially used, besides meat", "income from by-products and waste" and "ZERI (Zero Emissions Research and Initiatives) index". In an industry marked by progressive margin reduction, entrepreneurial Darwinism still prevails.

Ongoing support to neutral and professionally managed associations – ensuring the "hunt in a pack" and "defend in a pack" approach – will be essential. Otherwise, protectionism by developed countries, either in its crude form or in the guise of noble purposes, will take its toll. It will be the task of associations to scientifically debate the issue of animal welfare adapted to local conditions, as breeding a bird in a European environment and climate is totally different of doing it under tropical conditions. The associations have to ensure that public budget cuts do not jeopardize official or joint animal health and sanitary protection programmes. Strong and professional associations are able to promote cooperation between farmers, researchers, university lecturers and professors, private corporations, and public agents to ensure poultry science and technology adapted to the country's environment.

4 SMALLHOLDERS

According to the preliminary results of the 2006 Agricultural and Livestock Census, rural properties in Brazil numbered 5.2 million and occupied 354.9 million hectares – an average size of 68.2 ha per property.

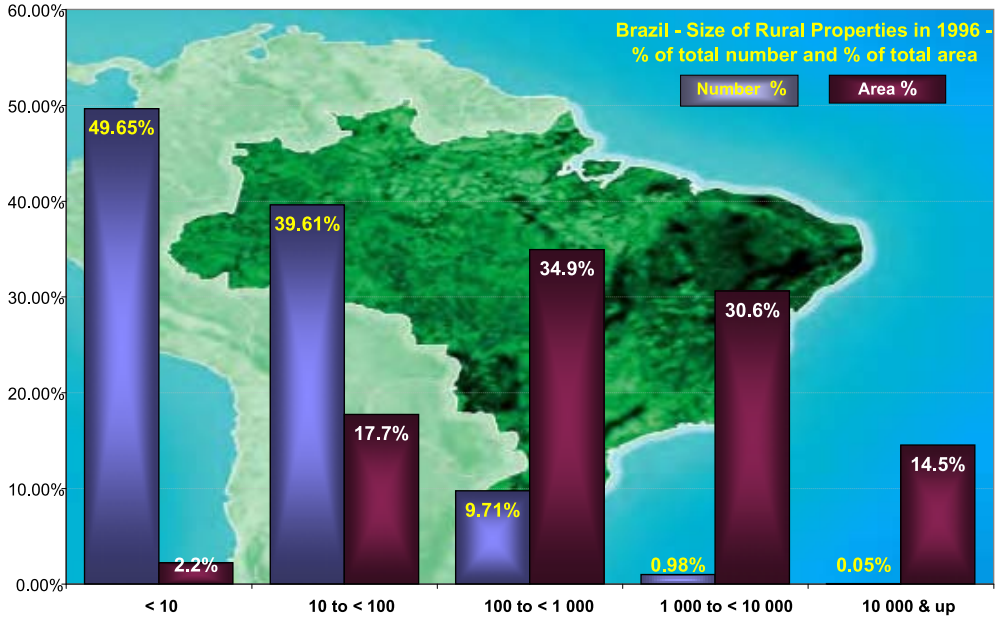
TABLE 70
Number and area of rural properties (1970 to 2006 censuses)

Structural Data	Agriculture and Livestock Census					
	1970	1975	1980	1985	1995	2006
Properties	4 924 019	4 993 252	5 159 851	5 801 809	4 859 865	5 204 130
Total area (ha)	294 145 466	323 896 082	364 854 421	37 4924 929	35 361 1246	354 865 534
Average area (ha)	59.74	64.87	70.71	64.62	72.76	68.19

Source: IBGE Agriculture and Livestock Censuses (http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/2006/default.shtm).

Data from the 1995/1996 census revealed that 49.6 percent of the rural properties in Brazil were below 10 ha. Although numerous, these properties occupied a mere 2.2 percent of the total agricultural area. Figure 46 details these percentages for each size category of rural property.

FIGURE 46
Number and area of rural properties (1996 census)



Source: IBGE Agriculture and Livestock Censuses (http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/2006/default.shtm)

Smallholders participate in the poultry sector as integrated farmers, who account for 85 percent of Brazilian chicken-meat production and 100 percent of turkey-meat production. In the South and Southeast Regions, smallholders with properties of less than 100 ha (in some areas less than 20 ha) made up the majority of integrated poultry farmers. In the Centre-West, bigger properties are involved in the vertical integration, many with several broiler houses, built with biosecurity measures that in the past were restricted to parent-stock farms. In commercial production of chickens for meat there is little space for independent smallholders. Table-egg production in Brazil is also carried out by companies or commercial operations.

Backyard production of both birds for meat and layers for eggs does exist, mainly in the interior and in regions where subsistence agriculture is strong, either because of their unsuitability for agriculture or remoteness. Brazil is promoting a policy of settling landless farmers, and not long ago one official agency distributed live birds so that the settlements could produce eggs and chicken meat for subsistence. Brazilian poultry associations alerted the authorities to the sanitary risk involved in such a policy of promoting backyard production. Concerns for the have-nots are not always the best allies of sanitary protection.

In countries where self-sufficiency or self-supply have not yet been achieved, smallholders play a fundamental role and will continue to do so. Ideally, they should organize themselves around cooperatives, associations, producers clubs or some other common structure, which would perform tasks that are difficult or unaffordable for the individual. Experience has shown that this is an extremely difficult task, as individualism is very hard to overcome and most farmers have had negative experiences with interactions outside their immediate circle of relations; they thus become suspicious and reserved with respect to collective organizations. Cases of mismanagement of cooperatives do not help to promote collective activities. Brazil has had its share of such stories, but many cooperatives from the South Region are, today, strong and efficient players in chicken meat production. Among the 30 largest chicken producers in Brazil, six are cooperatives, all of which operate under the vertical integration system. Apart from the cooperatives, there are a few successful "associations" for purchasing feed, but examples that go beyond this are the exception rather than the rule.

In the early days of Brazilian chicken-meat exports, five Brazilian companies formed a professionally managed "union" to handle exports, which lasted for a decade. More recently, small- and medium-scale chicken producers in the State of Paraná have organized a similar structure to handle their exports.

In countries where modern poultry industries prevail, the space left for smallholders to act independently is minimal and in those where exports are crucial, the possibility for the survival of the independent smallholder is almost negligible. Supplying sophisticated markets implies controls and procedures that any smallholder would find impossible to implement without the support of an integrator or a major company.

A current saying in the industry is that GMP nowadays means "give more paper". Auditors representing the clients or consumer organizations will not even inspect a production facility if the paper audit on procedures and controls is not satisfactory. How can an independent smallholder possibly provide full traceability on the grains and micro-elements used for feed or the full background of the parent stock that generated the day-old chicks

that he or she is rearing? How can it realistically be expected that a smallholder would have the knowledge and the means to implement a HACCP programme? Or to keep up with the multitude of new regulations and impositions, which reproduce at a higher rate than the chickens?

Even medium-sized poultry companies sometimes quit exporting to particular markets because of the impossibility of coping with the rules, legal requirements and assurances demanded. Other companies, however, welcome such requirements because they reduce competition.

Official rules and market requirements will continue to multiply. During the 1960s and the 1970s, the poultry industry regarded the animal husbandry people as the masters of the trade, for it was they who could guarantee the hatching and survival of the birds. During the 1980s, nutrition and slaughterhouse professionals were to the fore. In the 1990s, the industry would look to marketing to reinvent the chicken on a daily basis, and to processing experts to transform dreams in products. By the late 1990s and early 2000s, it was quality assurance and regulatory affairs that were guiding the industry. Livestock managers will do what the rules and demands permit them to do; nutrition experts will formulate in accordance with the latest prohibition or market requirements; production will simply obey and marketing will no be longer chasing the consumer, but trying to anticipate the next demand the consumer will make.

Smallholders spend their lives monitoring the weather, their debts with the banks, the high prices of inputs and low prices of output, the latest production technique that extension personnel brought to their attention, or the modern equipment they have seen in a trade show and cannot afford. They will adapt their production procedures to what the integrator informs them is the new rule or market requirement. They have done this in the past and they will do so in the future, provided they are provided with the relevant information.

Farmers love to farm and to produce, and that this is what they do best. They have to be paid not to do so, as many examples from North Hemisphere have taught us. Integrated into a poultry chain, most of them will be able to continue farming rather than having to migrate to the city. In good years, they will dream about buying the property of a neighbour or a larger farmer in the new agricultural frontier. In bad years, they will accept that they have to hand back the financed tractor. However, unless someone explains to them, they will have a hard time understanding why clients are so worried about animal welfare. Are the farmers in the importing countries cruel to their animals? Do they not know that an ill-treated animal becomes stressed, does not eat properly and fails to gain weight?[40]

In countries favouring self-supply, smallholders will continue to play a part in poultry production. Nonetheless, poultry production is not only becoming "paper complex", it is an activity that increasingly depends on science and technology for increasing its efficiency and its competitiveness. Human resources and knowledge are as essential to poultry production

[40] Free reproduction of a conversation with a number of integrated farmers during a conference on international markets in the south of Brazil.

as good feed and good genetic material. Add to that the teachings of Professor Vicente Falconi[41] that "international market includes the street where you live". In a global market, countries favouring self-supply are prone to have their markets disputed by international or global poultry companies. "Hunt in a pack" and "defend in a pack" for smallholders is not a philosophical option. It is a matter of survival.

[41] Professor Vicente Falconi Campos is the father of the total quality management revolution in Brazil in the late 1980s and early 1990s. Author of six books on management that have sold over one million copies, he is presently consultant to several of the largest Brazilian corporations. President Lula and five state governors belonging to four different political parties have drawn on his services. Called in by Minas Gerais State governor to manage the state finances in 2003, he took his native state from a budget deficit of 12 percent to a surplus of R$3 billion in 2006. He has a Ph.D. from the Colorado School of Mines (United States of America), and is professor emeritus of the Federal University of Minas Gerais, he was elected by the American Society for Quality as "One of the 21 voices for the 21st Century".

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ACRONYMS

ABEF – Associação Brasileira dos Produtores e Exportadores de Frango (Brazilian Chicken Producers and Exporters Association) – www.abef.com.br

ABIEC – Associação Brasileira das Indústrias Exportadoras de Carnes (Brazilian Association of Beef Meat Industry Exporters) – www.abiec.com.br

ABIPECS – Associação Brasileira da Indústria Produtora e Exportadora de Carne Suína (Brazilian Association of the Pork Meat Producer and Exporter Industry) – www.abipecs.org.br

ACAV – Associação de Criadores de Avestruzes (Ostrich Breeders Association)

AGE – Assessoria de Gestão Estratégica (Strategic Management Assessorship) – www.agricultura.gov.br

ALICE-WEB or simply ALICE – Análise das Informações de Comércio Exterior (Foreign Trade Information Analysis) – http://aliceweb.desenvolvimento.gov.br/default.asp

ANAB – Associação Nacional dos Abatedouros Avícolas (National Association of Poultry Slaughterhouses)

APA – Associação Paulista de Avicultura (São Paulo State Poultry Association) –www.apa.com.br

ApexBrasil – Brazilian Trade and Investment Promotion Agency – www.apexbrasil.com.br

APINCO – Associação Brasileira dos Produtores de Pinto de Corte (Association of One-Day Chicks Producers)

ASGAV – Associação Gaúcha de Avicultura (Rio Grande do Sul State Poultry Association)

BACEN – Banco Central do Brasil (Central Bank of Brazil) – www.bcb.gov.br

CGOE – Coordenação Geral de Organização para Exportação (General Coordination of Export Organization)

CNA – Confederação da Agricultura e Pecuária do Brasil (Brazilian Agricultural Confederation) – www.cna.org.br

CNPC – Conselho Nacional da Pecuária de Corte (National Beef Cattle Council) – www.cnpc.org.br

CONAB – Companhia Nacional de Abastecimento (National Company of Food Supply) – www.conab.gov.br

DDA – Departamento de Defesa Animal (Department of Animal Health)

DIPOA – Departamento de Inspeção de Produtos de Origem Animal (Department of Inspection of Products of Animal Origin)

DPI– Departamento de Promoção Internacional do Agronegocio (Agribusiness International Promotion Department)

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária (Brazilian Enterprise of Research on Agriculture and Livestock) – www.embrapa.br

EU – European Union

FAO – Food and Agriculture Organization of the United Nations

FAPRI – Food and Agricultural Policy Research Institute

FAS – Foreign Agriculture Service (of the USDA)

FGV – Fundação Getúlio Vargas (Getulio Vargas Foundation) – www.fgvdados.fgv.br

FOB – free on board

GMO – genetically modified organism

GMP – good management practices

GNP – gross national product

GPP – good production practices
HACCP – hazard analysis and critical control points
HDI – Human Development Index
HPAI – highly pathogenic avian influenza
IAA – Instituto do Açúcar e do Álcool (Sugar and Alcohol Institute)
IBGE - Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics) – www.ibge.gov.br
IBPT – Instituto Brasileira de Planejamento Tributário (Brazilian Institute for Fiscal Planning) – www.ibpt.com.br
IBRE – Instituto Brasileiro de Economia (Brazilian Institute of Economics) – www.ibre.fgv.br
ICMS – State-level tax on circulation of goods and services
IEA – Istituto di Econmia Agrícola (Agricultural Economy Institute) –http://www.iea.sp.gov.br/out/banco/menu.php
INPC – Índice Nacional De Preços Ao Consumidor (Consumer Price Index)
IPEA – Instituto de Pesquisa Econômica Aplicada (Research Institute of Applied Economics) – www.ipea.gov.br/default.jsp
MAPA – Ministério da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock and Food Supply) – www.agricultura.gov.br/
MDIC – Ministério do Desenvolvimento, Indústria e Comércio Exterior (Brazilian Ministry of Economic Development, Industry and Foreign Trade) – www.mdic.gov.br
PNAD – Pesquisa Nacional por Amostra de Domicílios (National Survey by Home Samples) – www.mpas.gov.br/docs/pdf/pnad.pdf
PNSA – Plano Nacional de Sanidade Avícola (National Plan of Poultry Animal Health)
POF – Pesquisa de Orçamentos Familiares (Family Budget Research) 2002–2003 conducted by IBGE
PPM – Pesquisa Pecuária Municipal (Municipal Livestock Research)
PSD – Production Supply and Distribution (database of USDA FAS)
OECD – Organisation for Economic Co-operation and Development
OIE – World Organisation for Animal Health
SDA – Secretaria de Defesa Agropecuária (Secretariat of Agricultural and Livestock Defense)
SECEX – Secretaria de Comércio Exterior (Secretary of Foreign Trade)
SIDRA – Sistema IBGE de Recuperação Automática (IBGE Automatic Data Recuperation System) – www.sidra.ibge.gov.br
SIF – Serviço de Inspeção Federal (Federal Inspection Service of the Ministry of Agriculture, Livestock and Food Supply)
SINDIRAÇÕES – Sindicato Nacional da Indústria de Alimentação Animal (Animal Feed Industry National Syndicate), www.sindiracoes.org.br
SISCOMEX – Sistema Integrado de Comércio Exterior (Foreign Trade Integrated System) – www.receita.fazenda.gov.br/legislacao/LegisAssunto/Siscomex
SOP – standard operating procedures
SRFMF – Secretaria da Receita Federal do Ministério da Fazenda (Secretary of Federal Income, Ministry of Finance) – www.fazenda.gov.br
SRI – Secretaria de Relações Internacionais do Agronegócio (Agribusiness International Relations Secretariat)

SWOT – strengths, weaknesses, opportunities, threats
UBA – União Brasileira de Avicultura (Brazilian Poultry Union) – www.uba.org.br
USDA – United States Department of Agriculture – www.usda.gov
ZERI – Zero Emissions Research and Initiatives

APPENDIX 1 - BRAZILIAN CHICKEN-MEAT BALANCE, ESTIMATED PER CAPITA CONSUMPTION AND WHOLESALE PRICES - 2005 TO 2007[1]

TABLE 1
Brazil's chicken/broiler-meat balance, 2005

Date	Brazilian Population persons	Per capita Consumption kg/inhabitant	Production (+) tonnes	Import (+) tonnes	Exports (+) tonnes	Domestic Availability tonnes	Average Domestic Monthly Price US$ p.kg Minimum	Average	Maximum	Estimated Total Value of Brazilian Domestic Market
Jan-05	182 722 318	3.05	745 388	154.0	187 916	557 626	$0.63	$0.66	$0.75	USD 367 931.52
Feb-05	182 936 346	2.92	749 577	22.0	215 646	533 953	$0.63	$0.67	$0.70	USD 357 733.77
Mar-05	183 150 455	2.69	724 312	47.0	231 871	492 488	$0.63	$0.65	$0.70	USD 320 086.65
Apr-05	183 364 645	2.73	733 864	37.0	232 916	500 985	$0.63	$0.66	$0.67	USD 330 625.68
May-05	183 578 916	2.81	755 295	26.0	239 144	516 177	$0.70	$0.72	$0.77	USD 371 628.72
Jun-05	183 793 267	2.91	778 370	18.0	244 421	533 967	$0.71	$0.72	$0.73	USD 384 443.28
Jul-05	184 007 699	2.84	784 176	46.0	261 558	522 664	$0.70	$0.73	$0.74	USD 381 511.14
Aug-05	184 222 212	2.89	797 926	24.0	265 442	532 508	$0.73	$0.79	$0.83	USD 420 662.36
Sep-05	184 436 805	3.05	817 582	48.0	255 028	562 602	$0.83	$0.88	$0.93	USD 495 047.52
Oct-05	184 651 478	3.04	821 715	47.0	259 764	561 998	$0.81	$0.86	$0.92	USD 483 277.86
Nov-05	184 866 232	3.37	830 220	24.0	206 589	623 655	$0.77	$0.84	$0.90	USD 523 850.04
Dec-05	185 081 066	3.23	842 705	57.0	245 650	597 112	$0.67	$0.76	$0.82	USD 453 761.80
Annual Total		35.53	9 381 130	550.0	2 845 945	6 535 735		Year Average		USD 4 890 560.34
Monthly Average		2.96	781 761	45.83	237 162	544 645		USD 0.75		USD 407 546.70
Growth % previous year		6.2%	10.4%	72.4%	17.4%	7.7%		19.20%		28.8%
			% over Production		0.006%	30.3%	69.7%			

[1] Production are data from UBA; export data from ABEF; import data from SECEX, ALICE, Ministry of Development, Industry and Foreign Trade (http://aliceweb.desenvolvimento.gov.br/); and price data from JOX Assessoria Agropecuária (http://www.jox.com.br).

TABLE 2
Brazil's chicken/broiler-meat balance, 2006

Date	Brazilian Population persons	Per capita Consumption kg/inhabitant	Production (+) tonnes	Import (+) tonnes	Exports (+) tonnes	Domestic Availability tonnes	Average Domestic Monthly Price US$ p.kg			Estimated Total Value of Brazilian Domestic Market
							Minimum	Average	Maximum	
Jan-06	185 295 981	3.42	847 700	24.0	213 722	634 002	$0.59	$0.62	$0.66	USD 393 066.36
Feb-06	185 510 976	3.47	842 298	50.0	198 887	643 461	$0.61	$0.63	$0.64	USD 405 348.93
Mar-06	185 726 052	2.96	774 605	24.0	225 510	549 119	$0.46	$0.55	$0.64	USD 302 002.25
Apr-06	185 941 208	2.68	709 282	25.0	211 526	497 781	$0.53	$0.66	$0.74	USD 328 518.96
May-06	186 156 444	2.65	690 211	50.0	196 475	493 786	$0.57	$0.69	$0.80	USD 340 677.84
Jun-06	186 371 760	2.85	725 606	57.0	194 883	530 780	$0.59	$0.65	$0.71	USD 344 969.95
Jul-06	186 587 157	3.18	779 471	24.0	186 188	593 307	$0.54	$0.58	$0.62	USD 344 104.14
Aug-06	186 802 633	2.40	748 067	46.0	300 650	447 463	$0.59	$0.72	$0.78	USD 322 140.24
Sep-06	187 018 190	3.17	804 150	45.0	210 560	593 635	$0.77	$0.85	$0.89	USD 504 551.50
Oct-06	187 233 827	2.86	792 054	122.0	256 934	535 242	$0.87	$0.96	$1.08	USD 513 715.20
Nov-06	187 449 544	2.79	806 910	59.5	284 070	522 900	$0.78	$0.86	$0.92	USD 449 642.40
Dec-06	187 665 341	3.10	819 766	25.0	238 128	581 663	$0.78	$0.85	$0.94	USD 494 392.30
Annual Total		35.52	9 340 120	551.5	2 717 533	6 623 139		Year Average		USD 4 743 130.07
Monthly Average		2.96	778 343	46.0	226 461	551 928		USD 0.72		USD 395 260.84
Growth % previous year		-0.03%	-0.4%	0.3%	-4.5%	1.3%		-3.58%		-3.0%
			% over Production	0,006%	29,1%	70,9%				

TABLE 3
Brazil's chicken/broiler-meat balance, 2007

Date	Brazilian Population persons	Per capita Consumption kg/inhabitant	Production (+) tonnes	Import (+) tonnes	Exports (+) tonnes	Domestic Availability tonnes	Average Domestic Monthly Price US$ p.kg			Estimated Total Value of Brazilian Domestic Market
							Minimum	Average	Maximum	
Jan-07	187 881 218	3.14	798 553	73.0	209 206	589 420	$0.75	$0.81	$0.94	USD 477 371.07
Feb-07	188 097 175	3.25	843 673	49.0	232 372	611 350	$0.89	$1.00	$1.03	USD 611 301.00
Mar-07	188 313 212	2.74	819 161	43.0	303 568	515 636	$0.77	$0.88	$0.99	USD 453 721.84
Apr-07	188 529 329	3.00	829 731	49.2	264 028	565 752	$0.88	$0.87	$0.98	USD 492 161.61
May-07	188 745 526	2.93	829 025	59.0	275 195	553 889	$0.81	$0.91	$1.04	USD 503 985.30
Jun-07	188 961 803	3.15	854 860	43.0	259 319	595 584	$0.89	$1.00	$1.06	USD 595 541.00
Jul-07	189 178 159	2.93	837 967	71.0	284 002	554 036	$1.00	$1.06	$1.14	USD 587 202.90
Aug-07	189 394 595	2.88	850 181	83.0	304 735	545 529	$0.99	$1.08	$1.15	USD 589 081.68
Sep-07	189 611 111	3.36	879 143	66.0	242 146	637 063	$1.06	$1.21	$1.23	USD 770 766.37
Oct-07	189 827 707	2.94	871 096	105.0	313 372	557 829	$1.12	$1.19	$1.26	USD 663 691.56
Nov-07	190 044 383	3.30	926 824	62.0	298 902	627 984	$1.23	$1.30	$1.38	USD 816 298.60
Dec-07	190 261 138	3.19	906 053	122.8	299 929	606 247	$1.25	$1.30	$1.39	USD 787 961.20
Annual Total		36.54	10 246 267	826.1	3 286 774	6 960 319		Year Average		USD 7 349 084.13
Monthly Average		3.05	853 856	69	273 898	580 027		USD 1.05		USD 612 423.68
Growth % previous year		2.9%	9.70%	49.78%	20.95%	5.09%		46.29%		54.9%
			% over Production		0,008%	32,1%	67,9%			

APPENDIX 2. BRAZILIAN REGIONS
North Region

FIGURE 1
North Region
Population: 14 750 385= 08.0% of Brazil (2005)
Total Area: 3 853 327 km²

State	Code	Area (Km2)	POPULATION
Rondônia	RO	152 581	1 538 831
Acre	AC	142 815	648 235
Amazonas	AM	1 570 746	3 269 876
Roraima	RR	1 247 690	393 253
Pará	PA	237 576	6 992 067
Amapá	AP	224 299	598 089
Tocantins	TO	277 621	1 310 034

Source: official area is from IBGE's Geosciences. Population from the Pesquisa Nacional por Amostra de Domicílios – PNAD (Domicile Sample National Research) 2005–2006.

TABLE 1
Monthly average income of working people aged above 10 years in North Region and its federal States, 2005

	Reais - R$	US$	Euro - €
Brazil	**R$ 800.80**	**$ 328.84**	**266.64**
North Region	R$ 642.40	$ 263.80	213.90
Rondônia	R$ 831.40	$ 341.41	276.83
Acre	R$ 680.70	$ 279.53	226.65
Amazonas	R$ 659.70	$ 270.90	219.66
Roraima	R$ 642.40	$ 263.80	213.90
Pará	R$ 581.80	$ 238.91	193.72
Belém Metropolitan Region	R$ 651.20	$ 267.41	216.83
Amapá	R$ 818.00	$ 335.91	272.37
Tocantins	R$ 601.00	$ 246.80	200.12

Sources: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 2
Active population and its distribution (percentage) by type of economic activity – North Region and its federal states, 2005

2005 – Active Population and Occupation per Group of Activity %	Total Active Population	Agriculture	Industry	Civil Construction	Trade	Services	Other
Brazil	**87 089 976**	**20.5**	**14.9**	**6.5**	**17.8**	**33.3**	**6.8**
North Region	6 585 422	23.4	14.9	6.7	18.1	32.4	3.8
Rondônia	768 226	37.9	11.7	4.8	14.2	28.4	2.9
Acre	277 562	31.3	8.2	5.0	15.0	37.5	3.1
Amazonas	1 367 312	20.4	14.2	6.4	19.3	34.9	4.7
Roraima	174 583	29.2	6.6	7.0	15.6	38.2	3.5
Pará	3 114 063	18.4	19.1	7.4	19.5	30.7	3.5
Amapá	230 994	9.2	8.4	9.0	21.3	45.7	6.1
Tocantins	652 682	36.4	6.9	6.5	14.6	31.8	3.8%

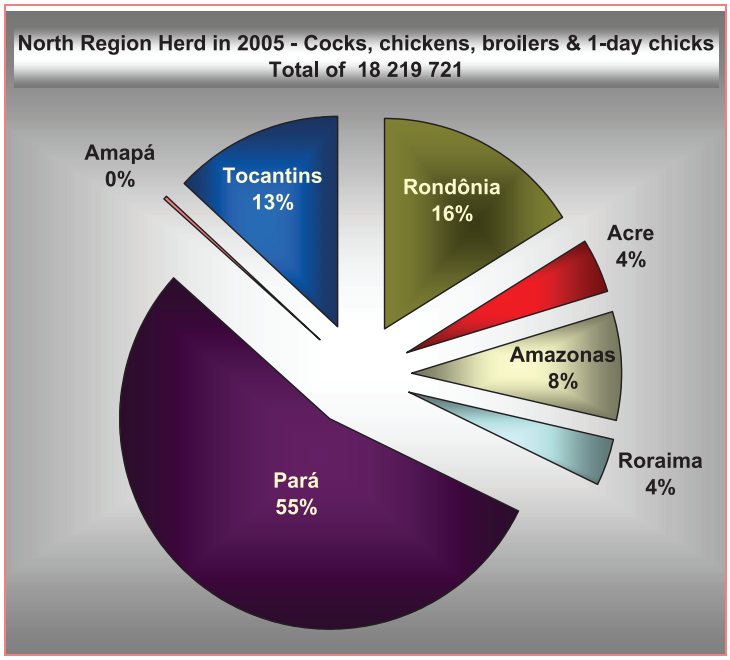
Source: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 3
Herd size – North Region and its federal states, 2005

Year 2005	Bovine	Swine	Layers Hens	Cocks, chickens, broilers & 1-day chicks	Buffaloes	Ovine & Caprine	Horses & Asses Mules	Other
Brazil	**207 156 696**	**34 063 934**	**186 573 334**	**812 467 900**	**1 173 629**	**25 894 763**	**8 367 447**	**7 141 407**
North Region	41 489 001	2 100 033	9 255 563	18 219 721	728 004	636 206	903 677	85 772
% of the Region/Brazil	20.0%	6.2%	5.0%	2.2%	62.0%	2.5%	10.8%	1.2%
Rondônia	11 349 452	308 406	1 442 062	2 954 770	6 457	115 706	177 852	0
Acre	2 313 185	151 073	427 903	722 181	2 421	53 932	40 675	8 846
Amazonas	1 197 171	290 410	2 406 616	1 527 537	49 891	81 937	13 188	17 097
Roraima	507 000	88 000	560 000	648 000	280	9 930	28 100	0
Pará	18 063 669	1 015 415	3 215 121	9 918 115	466 210	283 338	415 826	44 796
Amapá	96 599	22 248	3 222	46 515	193 485	2 938	6 083	0
Tocantins	7 961 926	224 481	1 200 639	2 402 603	9 260	88 425	221 953	15 033

Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

FIGURE 2
North region chicken flock in 2005 by state



Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

Northeast Region

FIGURE 3
Northeast Region
Population: 51 114 218= 27.7% of Brazil (2005)
Total Area: 1 554 257 km²

State	Code	Area (Km2)	POPULATION
Maranhão	MA	331 983	6 116 424
Piauí	PI	251 529	3 011 627
Ceará	CE	148 826	8 116 599
Rio Grande do Norte	RN	52 797	3 009 648
Paraíba	PB	56 440	3 600 290
Pernambuco	PE	98 312	8 427 944
Alagoas	AL	27 768	3 021 515
Sergipe	SE	21 910	1 973 103
Bahia	BA	564 693	13 837 068

Source: official area is from IBGE's Geosciences. Population from the Pesquisa Nacional por Amostra de Domicílios – PNAD (Domicile Sample National Research) 2005–2006.

TABLE 4
Monthly average income of working people aged above 10 years in Northeast Region and its federal states, 2005

	Reais - R$	US$	Euro - €
Brazil	**R$ 800.80**	**$ 328.84**	**266.64**
Northeast Region	R$ 490.40	$ 201.38	163.29
Maranhão	R$ 396.80	$ 162.94	132.12
Piauí	R$ 412.50	$ 169.39	137.35
Ceará	R$ 467.50	$ 191.98	155.66
Fortaleza Metropolitan Region	R$ 659.30	$ 270.74	219.53
Rio Grande Do Norte	R$ 607.00	$ 249.26	202.11
Paraíba	R$ 524.40	$ 215.34	174.61
Pernambuco	R$ 543.90	$ 223.35	181.10
Recife Metropolitan Region	R$ 751.60	$ 308.64	250.26
Alagoas	R$ 474.40	$ 194.81	157.96
Sergipe	R$ 541.10	$ 222.20	180.17
Bahia	R$ 492.30	$ 202.16	163.92
Salvador Metropolitan Region	R$ 728.30	$ 299.07	242.50

Sources: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 5
Active population and its distribution (percentage) by type of economic activity – Northeast Region and its federal states, 2005

2005 – Active Population and Occupation per Group of Activity %	Total Active Population	Agriculture	Industry	Civil Construction	Trade	Services	Other
Brazil	**87 089 976**	**20.5**	**14.9**	**6.5**	**17.8**	**33.3**	**6.8**
North Region	23 182 157	36.1	9.7	5.4	15.8	28.7	4.0
Maranhão	2 852 853	42.9	6.9	5.7	17.9	24.0	2.4
Piauí	1 543 303	50.0	7.2	3.8	12.2	24.9	1.8
Ceará	3 772 695	32.0	15.6	5.1	16.1	26.6	4.4
Rio Grande Do Norte	1 257 866	23.2	12.0	7.0	19.4	34.5	3.7
Paraíba	1 608 670	31.6	10.7	4.2	15.7	33.1	4.0
Pernambuco	3 622 900	31.3	9.7	5.2	17.1	30.6	5.4
Alagoas	1 211 169	43.0	6.4	5.1	14.6	28.1	2.7
Sergipe	898 801	26.2	10.4	5.0	19.9	33.1	5.3
Bahia	6 413 900	38.4	8.1	5.9	13.9	29.2	4.3

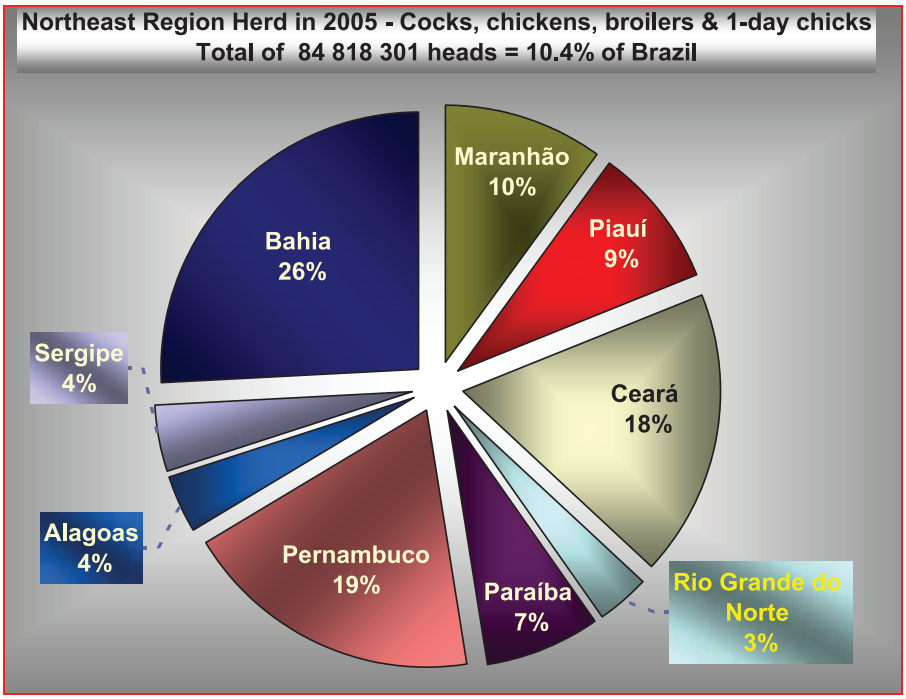
Source: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 6
Herd size – Northeast Region and its federal states, 2005

Year 2005	Bovine	Swine	Layers Hens	Cocks, chickens, broilers & 1-day chicks	Buffaloes	Ovine & Caprine	Horses & Asses Mules	Other
Brazil	**207 156 696**	**34 063 934**	**186 573 334**	**812 467 900**	**1 173 629**	**25 894 763**	**8 367 447**	**7 141 407**
North Region	26 969 286	7 090 085	39 883 815	84 818 301	121 662	18 652 578	3 199 435	1 176 363
% of the Region/Brazil	13.0%	20.8%	21.4%	10.4%	10.4%	72.0%	38.2%	16.5%
Maranhão	6 448 948	1 666 063	3 096 996	8 368 394	79 915	621 496	408 110	25 689
Piauí	1 826 833	1 355 070	2 540 529	7 599 507	542	2 901 229	395 944	22 900
Ceará	2 299 233	1 089 530	6 751 617	15 367 090	1 186	2 840 816	422 173	66 904
RioGrande Do Norte	978 494	169 100	2 247 523	2 906 662	485	929 710	126 413	56 555
Paraíba	1 052 613	144 501	2 104 899	6 146 814	1 637	1 068 893	127 340	60 234
Pernambuco	1 909 468	436 857	7 681 443	15 882 854	17 353	2 668 625	280 501	462 938
Alagoas	985 422	127 781	1 650 123	3 038 943	1 818	271 183	88 113	117 972
Sergipe	1 005 177	107 722	1 460 918	3 536 628	387	170 345	97 766	19 225
Bahia	10 463 098	1 993 461	12 349 767	21 971 407	18 339	7 180 281	1 253 076	343 946

Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

FIGURE 4
Northeast Region chicken flock in 2005, by state



Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

Southeast Region

FIGURE 5
Southeast Region Population: 78 647 648= 42.6% of Brazil (2005)
Total Area: 924 511 km²

State	Code	Area (Km2)	POPULATION
Minas Gerais	MG	586 528	19 276 468
Espírito Santo	ES	46 078	3 417 382
Rio de Janeiro	RJ	43 696	15 412 167
São Paulo	SP	248 209	40 541 631

Source: official area is from IBGE's Geosciences. Population from the Pesquisa Nacional por Amostra de Domicílios – PNAD (Domicile Sample National Research) 2005–2006.

TABLE 7
Monthly average income of working people aged above 10 years in Southeast Region and its federal states, 2005

	Reais - R$	US$	Euro - €
Brazil	**R$ 800.80**	**$ 328.84**	**266.64**
Southeast Region	R$ 935.90	$ 384.32	311.63
Minas Gerais	R$ 693.50	$ 284.68	230.92
Belo Horizonte Metropolitan Region	R$ 902.80	$ 370.73	300.61
Espírito Santo	R$ 735.30	$ 301.95	244.83
Rio de Janeiro	R$ 940.00	$ 389.70	315.99
Rio de Janeiro Metropolitan Region	R$ 1 011.30	$ 415.29	336.74
São Paulo	R$ 1 060.00	$ 435.20	352.95
São Paulo Metropolitan Region	R$ 1 178.80	$ 484.07	392.51

Sources: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 8
Active population and its distribution (percentage) by type of economic activity – Southeast Region and its federal states, 2005

2005 – Active Population and Occupation per Group of Activity %	Total Active Population	Agriculture	Industry	Civil Construction	Trade	Services	Other
Brazil	**87 089 970**	**20.5**	**14.9**	**6.5**	**17.8**	**33.3**	**6.8**
Southeast Region	36 863 614	10.0	17.5	7.2	18.8	37.1	9.2
Minas Gerais	9 510 847	22.1	15.4	6.9	16.8	33.4	5.1
Espírito Santo	1 677 058	22.2	13.3	6.3	18.1	33.1	6.8
Rio de Janeiro	6 657 034	2.4	12.7	8.3	19.3	45.2	11.5
São Paulo	19 018 675	5.5	20.7	7.1	19.6	36.5	10.6

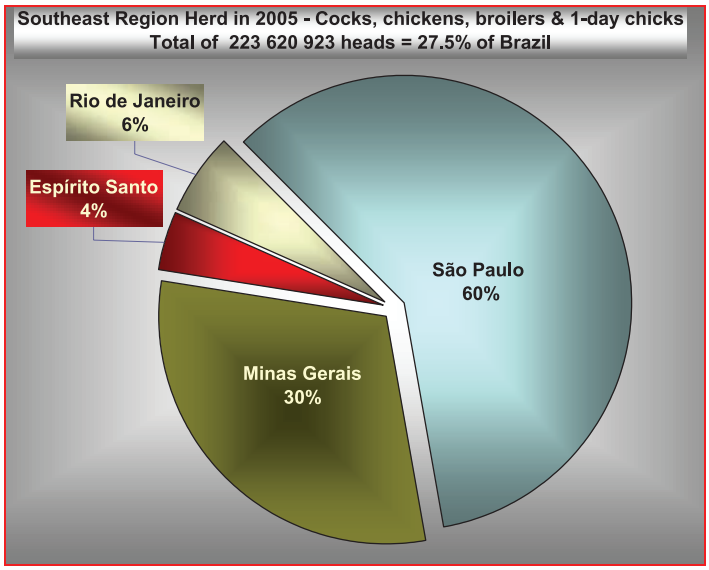
Source: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 9
Herd size – Southeast Region and its federal states, 2005

Year 2005	Bovine	Swine	Layers Hens	Cocks, chickens, broilers & 1-day chicks	Buffaloes	Ovine & Caprine	Horses & Asses Mules	Other
Brazil	**207 156 696**	**34 063 934**	**186 573 334**	**812 467 900**	**1 173 629**	**25 894 763**	**8 367 447**	**7 141 407**
Southeast Region	38 943 898	5 956 328	67 546 200	223 620 923	113 862	859 058	1 858 396	4 247 744
% of the Region/Brazil	18.8%	17.5%	36.2%	27.5%	9.7%	3.3%	22.2%	59.5%
Minas Gerais	21 403 680	3 792 958	21 599 818	67 618 845	36 158	315 529	1 064 852	629 017
Espírito Santo	2 026 690	292 405	5 868 492	9 593 088	669	49 324	89 710	690 750
Rio de Janeiro	2 092 748	164 103	898 776	12 737 252	5 299	73 961	126 907	348 454
São Paulo	13 420 780	1 706 862	39 178 664	133 671 738	71 736	420 244	576 927	2 579 523

Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

FIGURE 6
Southeast Region chicken flock in 2005, by state



Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

South Region

FIGURE 7
South Region Population: 27 027 601= 14.6% of Brazil (2005)
Total Area: 576 410 km²

State	Code	Area (Km2)	POPULATION
Paraná	PR	199 315	10 282 099
Santa Catarina	SC	95 346	5 881 352
Rio Grande do Sul	RS	281 749	10 864 150

Source: official area is from IBGE's Geosciences. Population from the Pesquisa Nacional por Amostra de Domicílios – PNAD (Domicile Sample National Research) 2005–2006.

TABLE 10
Monthly average income of working people aged above 10 years in South Region and its federal states, 2005

	Reais - R$	US$	Euro - €
Brazil	**R$ 800.80**	**$ 328.84**	**266.64**
South Region	R$ 901.40	$ 370.16	300.14
Paraná	R$ 898.80	$ 369.09	299.28
Curitiba Metropolitan Region	R$ 1 079.80	$ 443.41	359.54
Santa Catarina	R$ 961.50	$ 394.84	320.15
Rio Grande do Sul	R$ 870.30	$ 357.38	289.79
Porto Alegre Metropolitan Region	R$ 1 085.70	$ 445.84	361.51

Sources: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 11
Active population and its distribution (percentage) by type of economic activity – South Region and its federal states, 2005

2005 – Active Population and Occupation per Group of Activity %	Total Active Population	Agriculture	Industry	Civil Construction	Trade	Services	Other
Brazil	**87 089 976**	**20.5**	**14.9**	**6.5**	**17.8**	**33.3**	**6.8**
South Region	14 213 774	22.1	18.5	6.0	17.5	29.4	6.3
Paraná	5 246 954	20.5	15.9	6.5	19.0	31.8	6.3
Santa Catarina	3 168 780	20.8	22.8	5.5	17.9	26.6	6.5
Rio Grande do Sul	5 798 040	24.2	18.6	5.9	15.9	28.8	6.3

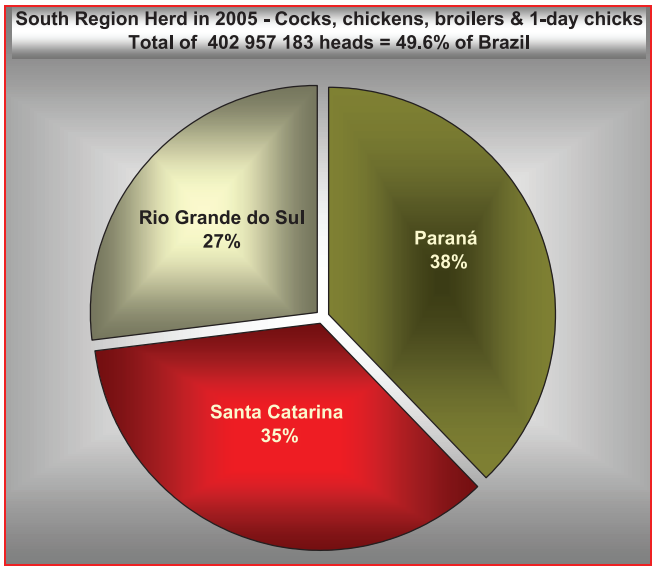
Source: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 12
Herd size – South Region and its federal states, 2005

Year 2005	Bovine	Swine	Layers Hens	Cocks, chickens, broilers & 1-day chicks	Buffaloes	Ovine & Caprine	Horses & Asses Mules	Other
Brazil	**207 156 696**	**34 063 934**	**186 573 334**	**812 467 900**	**1 173 629**	**25 894 763**	**8 367 447**	**7 141 404**
South Region	27 770 006	15 090 727	52 179 376	402 957 183	144 531	4 695 211	1 099 378	1 321 290
% of the Region/Brazil	13.4%	44.3%	28.0%	49.6%	12.3%	18.1%	13.1%	18.5%
Paraná	10 153 375	4 547 895	19 839 533	151 814 509	40 187	626 597	483 067	529 146
Santa Catarina	3 376 725	6 309 041	13 927 620	142 411 820	22 185	249 077	132 277	335 334
Rio Grande do Sul	14 239 906	4 233 791	18 412 223	108 730 854	82 159	3 819 537	484 034	456 810

Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

FIGURE 8
Southeast Region chicken flock in 2005, by state



Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

Center-West Region

FIGURE 9
Center-West Region Population: 13 060 882= 7.1 % of Brazil (2005)
Total Area: 1 606 372 km²

State	Code	Area (Km2)	POPULATION
Mato Grosso do Sul	MS	357 125	2 269 871
Mato Grosso	MT	903 358	2 811 942
Goiás	GO	340 087	5 637 792
Distrito Federal	DF	5 802	2 341 277

Source: official area is from IBGE's Geosciences. Population from the Pesquisa Nacional por Amostra de Domicílios – PNAD (Domicile Sample National Research) 2005–2006.

TABLE 13
Monthly average income of working people aged above 10 years in North Region and its federal States, 2005

	Reais - R$	US$	Euro - €
Brazil	**R$ 800.80**	**$ 328.84**	**266.64**
Center-West Region	R$ 931.70	$ 382.60	310.23
Mato Grosso do Sul	R$ 784.70	$ 322.23	261.28
Mato Grosso	R$ 816.80	$ 335.42	271.97
Goiás	R$ 802.10	$ 329.38	267.08
Distrito Federal	R$ 1 515.70	$ 622.42	504.69

Sources: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 14
Active population and its distribution (percentage) by type of economic activity – Centre-West Region and its federal states, 2005

2005 – Active Population and Occupation per Group of Activity %	Total Active Population	Agriculture	Industry	Civil Construction	Trade	Services	Other
Brazil	**87 089 976**	**20.5**	**14.9**	**6.5**	**17.8**	**33.3**	**6.8**
Center-West Region	6 245 099	17.6	10.6	7.0	19.5	37.8	7.5
Mato Grosso do Sul	1 096 553	19.0	10.4	7.0	20.7	36.8	5.9
Mato Grosso	1 400 269	31.1	9.4	5.9	18.9	29.9	4.8
Goiás	2 674 504	16.5	13.1	7.9	19.8	37.1	5.6
Distrito Federal	1 073 683	1.6	6.0	6.1	18.4	50.6	17.3

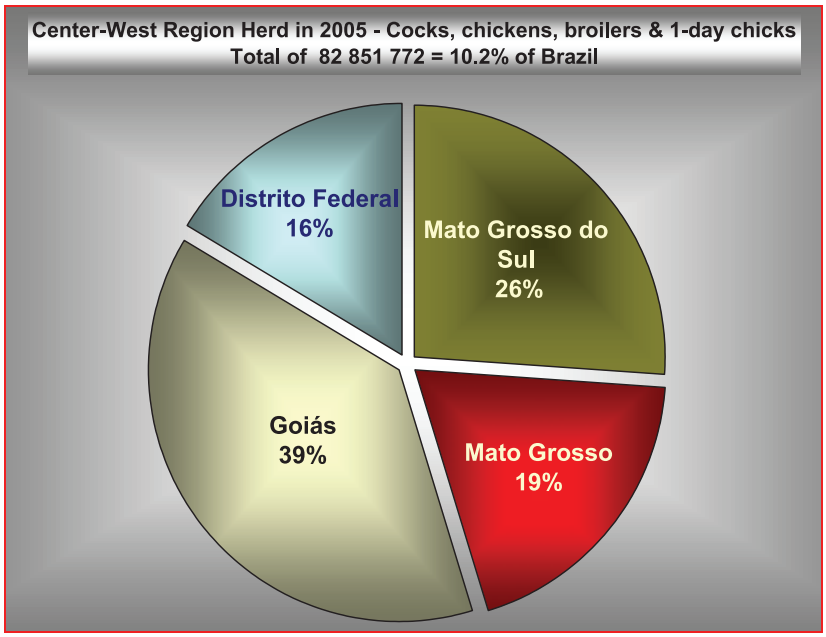
Source: IBGE, Pesquisa Nacional por Amostra de Domicílios 2005 (Domicile Sample National Research, 2005).

TABLE 12
Herd size – Centre-West Region and its federal states, 2005

Year 2005	Bovine	Swine	Layers Hens	Cocks, chickens, broilers & 1-day chicks	Buffaloes	Ovine & Caprine	Horses & Asses Mules	Other
Brazil	**207 156 696**	**34 063 934**	**186 573 334**	**812 467 900**	**1 173 629**	**25 894 763**	**8 367 447**	**7 141 407**
Center-West Region	71 984 504	3 826 761	17 708 380	82 851 772	65 570	1 051 710	1 306 560	310 238
% of the Region/Brazil	34.7%	11.2%	9.5%	10.2%	5.6%	4.1%	15.6%	4.3%
Mato Grosso do Sul	24 504 098	855 080	2 592 615	21 585 870	19 051	471 380	420 031	34 507
Mato Grosso	26 651 500	1 359 824	5 156 301	15 959 146	14 297	368 085	390 038	27 896
Goiás	20 726 586	1 499 138	8 029 921	31 801 276	31 268	193 685	490 545	111 295
Distrito Federal	102 320	112 719	1 929 543	13 505 480	954	18 560	5 946	136 540

Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

FIGURE 10
Southeast Region and Federal District chicken flock in 2005, by state



Source: IBGE (http://www.sidra.ibge.gov.br) Produção da pecuária municipal 2005 v.33 (Municipal Livestock Production 2005).

APPENDIX 3. INTEGRATION – A PARTNERSHIP THAT PROVED RIGHT[1]

In its early stages the system was based on informal agreements between the rural producer and the industry. As it enlarged and became more complex, several formal mechanisms were developed including contracts between the integrated farmers and the integrator company. The system is adopted by both private companies and cooperatives, which have a strong presence in poultry and pork production in Brazil.

The agricultural producer, regardless whether small, medium or large, is a rural entrepreneur who has a business to be managed for maximum productivity at the lowest possible cost. The integrator company supplies both resources (feed, seeds, day-old chicks, etc) and technical assistance, thus reducing the farmer's needs for working capital and enhancing his productivity. The integrated farmer contributes the installations, labour and costs such as electrical energy and water.

There is, in practice, just one model in "poultry partnership". The "industry"[2] has the capacity to produce day-old chicks, a complex structure that demands technical expertise and control, mainly of a sanitary nature. The day-old chicks are transferred at zero cost to the property of the "integrado", along with the feed required for the process of raising the birds until they are ready for slaughtering, at which point they are removed by the industry.

The remuneration of the integrated farmer is linked to productivity and efficiency, as he is responsible for managing the resources that have been allocated. It is always the objective that the "integrado" covers his basic costs, while the level of profitability depends on the efficiency of his production and management.

The industry bears the risk associated with the process and is not always able to pass the costs on via its sales price. The supply of feed involves huge financial resources on the part of the industry, as in Brazil there are rarely sufficient credit lines and financing for the rural producer.

The industry does not aim to obtain profits from the supply of resources. The goal is to facilitate and ensure the continuity of the production process and to guarantee the supply of raw-materials at the lowest possible cost in the production chain.

The integrated farmers have full liberty to act as independent poultry producers and run the risk of market prices. They are free to break their ties to an industry or cooperative at any time, and they are free to move from one integration to another, which does happen.

Integrated farmers complement their income by producing grains, milk, bovines for meat, fruits, tobacco, reforestation and other cultures. Many of their products (maize, soy, wood, etc) are bought by the industry a client.

The system has its imperfections, but when analysed without bias it proves to have prevailed over independent poultry production. It has been in place for over 45 years and has the preference of thousands of small and medium-sized rural producers, many of them situated in areas of difficult topography, that are partially inadequate for agriculture, where soils are stony and where holdings are of insufficient size to provide a good income.

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[1] Text extracted from UBA. 2001. *Integration – a partnership that proved right.* Brasilia, União Brasileira de Avicultura (Brazilian Poultry Union) (available at http://www.uba.org.br/integracao.html).

[2] As the vertically integrated farmers are known in the poultry segment as "integrados", the company that acts as the integrator is always known generically as "the industry". An integrated farmer will always introduce himself as "integrado of … *name of the company…*" and will refer to the industry by the name.

APPENDIX 4. PRICES OF MAIZE, SOY MEAL AND LIVE CHICKENS – KG. OF LIVE CHICKEN NEEDED TO PURCHASE 1 KG OF MAIZE AND SOY MEAL AND COMPARISON WITH LIVE BOVINES AND PIGS[1]

TABLE 1
Prices of maize, soy meal and live chickens – 2005

Mounth	US$/R$ Exchange Rate	Corn US$/60 Kg Bag	Soybean Meal US$/Kg	Live Chicken US$/Kg	Live Bovine US$/@	Live Swine US$/@	Kgs of live chicken per Kg of Corn	Soymeal	live bovine	live swine
January	R$ 2.624	$6.479	$0.202	$0.495	$22.48	$19.63	0.218	0.408	3.03	6.93
February	R$ 2.594	$6.746	$0.207	$0.501	$23.13	$20.24	0.224	0.414	3.08	6.98
March	R$ 2.665	$7.504	$0.210	$0.469	$21.76	$18.95	0.267	0.448	3.09	7.18
April	R$ 2.531	$7.113	$0.198	$0.533	$22.13	$14.42	0.222	0.370	2.77	4.56
May	R$ 2.403	$7.491	$0.213	$0.562	$22.89	$15.19	0.222	0.380	2.72	4.33
June	R$ 2.350	$8.086	$0.229	$0.596	$22.98	$18.09	0.226	0.384	2.57	4.76
July	R$ 2.390	$7.742	$0.227	$0.586	$21.97	$18.20	0.220	0.388	2.50	4.95
August	R$ 2.363	$7.618	$0.222	$0.677	$21.58	$19.68	0.188	0.328	2.13	4.58
September	R$ 2.221	$8.080	$0.225	$0.675	$24.31	$21.83	0.199	0.333	2.40	4.79
October	R$ 2.254	$7.389	$0.213	$0.621	$24.85	$18.42	0.198	0.343	2.67	4.45
November	R$ 2.206	$7.207	$0.222	$0.521	$24.93	$19.94	0.230	0.426	3.19	5.63
December	R$ 2.340	$7.265	$0.237	$0.470	$23.08	$16.88	0.258	0.505	3.27	5.60
Year Average	R$ 2.412	$7.393	$0.217	$0.559	$23.01	$18.46	0.223	0.394	2.78	5.39
Year Maxim.	R$ 2.665	$8.086	$0.237	$0.677	$24.93	$21.83	0.267	0.505	3.27	7.18
Year Minim.	R$ 2.206	$6.479	$0.198	$0.469	$21.58	$14.42	0.188	0.328	2.13	4.33

[1] Animals ready for slaughtering; [2]@ = 15 kg.

[1] Elaborated with data collection from Jox Assessoria Agropecuário Ltda (www.jox.com.br) .

TABLE 2
Prices of maize, soy meal and live chickens – 2006

Mounth	US$/R$ Exchange Rate	Corn US$/60 Kg Bag	Soybean Meal US$/Kg	Live Chicken US$/Kg	Live Bovine US$/@	Live Swine US$/@	Kgs of live chicken per Kg of			
							Corn	Soymeal	live bovine	live swine
January	R$ 2.215	$7.449	$0.235	$0.451	$22.57	$12.41	0.275	0.520	3.33	4.06
February	R$ 2.135	$7.378	$0.208	$0.468	$23.89	$18.04	0.263	0.445	3.40	5.48
March	R$ 2.172	$5.963	$0.188	$0.368	$23.02	$10.82	0.270	0.510	4.17	4.25
April	R$ 2.088	$6.823	$0.184	$0.503	$24.90	$13.65	0.226	0.367	3.30	3.78
May	R$ 2.300	$6.523	$0.196	$0.478	$21.74	$11.52	0.227	0.409	3.03	3.69
June	R$ 2.164	$7.742	$0.203	$0.462	$23.11	$12.25	0.279	0.440	3.33	3.82
July	R$ 2.175	$7.171	$0.202	$0.414	$25.28	$14.48	0.289	0.489	4.07	5.08
August	R$ 2.138	$7.671	$0.214	$0.631	$27.13	$15.20	0.202	0.339	2.86	3.43
September	R$ 2.173	$8.972	$0.216	$0.805	$28.99	$15.87	0.186	0.269	2.40	2.86
October	R$ 2.142	$9.686	$0.240	$0.654	$28.01	$16.57	0.247	0.368	2.86	3.62
November	R$ 2.166	$11.311	$0.235	$0.531	$24.47	$16.39	0.355	0.442	3.07	4.46
December	R$ 2.137	$10.996	$0.222	$0.608	$24.80	$18.01	0.301	0.365	2.72	4.22
Year Average	R$ 2.167	$8.140	$0.212	$0.531	$24.83	$14.60	0.260	0.414	3.21	4.06
Year Maxim.	R$ 2.300	$11.311	$0.240	$0.805	$28.99	$18.04	0.355	0.520	4.17	5.48
Year Minim.	R$ 2.088	$5.963	$0.184	$0.368	$21.74	$10.82	0.186	0.269	2.40	2.86

[1] Animals ready for slaughtering; [2]@ = 15 kg.

TABLE 3
Prices of maize, soy meal and live chickens – 2007

Mounth	US$/R$ Exchange Rate	Corn US$/60 Kg Bag	Soybean Meal US$/Kg	Live Chicken US$/Kg	Live Bovine US$/@	Live Swine US$/@	Kgs of live chicken per Kg of			
							Corn	Soymeal	live bovine	live swine
January	R$ 2.134	$11.013	$0.236	$0.703	$25.31	$18.51	0.261	0.335	2.40	3.75
February	R$ 2.117	$9.564	$0.250	$0.874	$26.92	$16.29	0.182	0.286	2.05	2.63
March	R$ 2.050	$9.392	$0.220	$0.634	$27.81	$13.91	0.247	0.346	2.92	3.00
April	R$ 2.033	$9.099	$0.204	$0.541	$27.54	$15.49	0.280	0.377	3.39	3.88
May	R$ 1.928	$9.854	$0.226	$0.700	$29.04	$16.86	0.235	0.322	2.77	3.09
June	R$ 1.925	$9.427	$0.234	$0.779	$31.68	$17.40	0.202	0.300	2.71	2.87
July	R$ 1.877	$10.204	$0.263	$0.986	$34.10	$19.98	0.173	0.266	2.31	2.54
August	R$ 1.961	$12.059	$0.272	$0.918	$32.63	$20.14	0.219	0.296	2.37	2.87
September	R$ 1.838	$14.417	$0.362	$0.870	$33.73	$23.67	0.276	0.416	2.58	3.33
October	R$ 1.743	$16.779	$0.383	$0.889	$38.44	$27.25	0.315	0.431	2.88	3.56
November	R$ 1.783	$18.790	$0.387	$0.925	$44.31	$29.45	0.338	0.418	3.19	3.78
December	R$ 1.771	$18.074	$0.391	$0.932	$40.10	$32.48	0.323	0.420	2.87	4.11
Year Average	R$ 1.930	$12.389	$0.286	$0.813	$32.63	$20.95	0.254	0.351	2.68	3.02
Year Maxim.	R$ 2.134	$18.790	$0.391	$0.986	$44.31	$32.48	0.338	0.431	3.39	4.11
Year Minim.	R$ 1.743	$9.099	$0.204	$0.541	$25.31	$13.91	0.173	0.266	2.05	2.54

[1] Animals ready for slaughtering; [2]@ = 15 kg.

Agenda

MONDAY, 5 NOVEMBER 2007

08:00 – 09:30	Registration	
09:30 – 09:45	Welcome and opening	Chanchui He, Regional Representative / Assistant Director-General, FAO Regional Office for Asia and the Pacific
09:45 – 10:00	Setting the scene for the Conference	Anni McLeod

Session I: Sector Trends and Impacts (Chair: Samuel Jutzi)

10:00 – 10:30	Global poultry sector trends and external drivers for structural change	Clare Narrod
10:30 – 10:45	BREAK	
10:45 – 11:30	Country case studies:	
	China	Han Yijun
	Thailand	Viroj NaRanong
	India	Rajesh Mehta
	Egypt	Ali Ibrahim
11:30 – 12:00	Assessment of inter-country differences in structural changes and expected trends	Martin Upton
12:00 – 12:30	Future trends and developments in poultry nutrition	Stephen Chadd
12:30 – 13:00	Future trends for poultry genetic resources	Badi Besbes
13:00 – 14:30	LUNCH	
14:30 – 14:45	Perspectives of the global markets for poultry products	Dave Harlan
14:45 – 15:00	Challenges for global feed industries	Andreas Kocher

15:00 – 15:15	Feed production inducing structural change in the poultry sector	Jan Hinrichs
15:15 – 15:30	Social impacts of structural change	Anni McLeod
15:30 – 15:45	BREAK	
15:45 – 17:15	Podium discussion, Sector Trends and Impacts	Facilitator Simon Mack

TUESDAY, 6 NOVEMBER 2007

Session II: Risks and Challenges for Poultry Production (Chair: Jimmy Smith)

08:30 – 09:00	Risks associated with poultry production systems	Les Sims
09:00 – 09:30	Poultry production and the environment – a review	Carolyn Opio
09:30 – 10:00	Long-term impacts of HPAI on poultry production system	Jan Slingenbergh
10:00 – 10:15	BREAK	
10:15 – 10:30	OIE standards related to trade and poultry diseases	Christianne Bruschke
10:30 – 11:00	Animal welfare in poultry production systems: Impact of EU standards on world trade	Peter van Horne
11:00 – 11:15	Health and socioeconomic impacts of contract poultry growing for rural communities: a review of the US experience	Jessica Leibler
11:15 – 11:30	The importance of poultry products in human nutrition Response of the Thai poultry industry to HPAI	Anan Sirimongkolkasem
11:30 – 11:45	Cambodia HPAI video clip	
12:00 – 12:30	Poster sessions	
12:30 – 14:00	LUNCH	
14:00 – 14:20	The importance of poultry products in human nutrition	Simon Mack
14:20 – 14:40	Risks caused by bioaerosols of poultry houses	Jörg Hartung

14:40 – 15:00	Veterinary services for poultry production	Karin Schwabenbauer
15:15 – 15:45	BREAK	
15:45 – 17:15	Podium discussion, Risks and Challenges for Poultry Production	Facilitator Simon Mack
17:30 – 19:00	Round table discussions	
	Large poultry production	Facilitator Nancy Morgan
	Small poultry production	Facilitator Antonio Rota

WEDNESDAY, 7 NOVEMBER 2007

Session III: Poultry as a Development Tool (Chair: Robert Pym)

08:30 – 09:00	Poultry production for livelihoods and poverty alleviation	Frands Dolberg
09:00 – 09:30	Poultry production as a tool for general development initiatives	E. Babafunso Sonaiya
09:30 – 10:00	Opportunities of small commercial poultry producers in the future	Vinod Ahuja
10:00 – 10:15	BREAK	
10:15 – 10:30	Experiences in transferring and adapting the BRAC model for the development of small poultry producers to other countries	Dewan Zahid Hossain
10:30 – 10:45	Impact of chicken development projects for small scale producers in Thailand	Kreingkrai Choprakarn
10:45 – 11:00	Formal and informal contract farming in poultry in Bangladesh	Mohammad A. Jabbar
11:00 – 11:15	Getting the private poultry sector involved in the development for Africa	Flavio Oliveira
11:15 – 12:45	Podium discussions, Poultry as a Development Tool	Facilitator Simon Mack
12:45 – 13:00	Summary Statement	Samuel Jutzi, FAO

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FAO ANIMAL PRODUCTION AND HEALTH PROCEEDINGS

1. Protein sources for the animal feed industry, 2004 (E)
2. Expert Consultation on Community-based Veterinary Public Health Systems, 2004 (E)
3. Towards sustainable CBPP control programmes for Africa, 2004 (E)
4. The dynamics of sanitary and technical requirements – Assisting the poor to cope, 2005 (E)
5. Lait de chamelle pour l'Afrique, 2005 (F[e])
6. A farm-to-table approach for emerging and developed dairy countries, 2005 (E)
7. Capacity building, for surveillance and control of zoonotic diseases, 2005 (E)
8. CBPP control: antibiotics to the rescue?, 2007 (E)
9. Poultry in the 21st century – Avian influenza and beyond, 2008 (E)

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R	-	Russian			
S	-	Spanish			

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The International Conference "Poultry in the 21st Century – Avian Influenza and beyond" took place in Bangkok on 5-7 November 2007. The objectives of the conference were to review the global poultry sector in its entirety, to assess past developments, the current situation as well as to explore options for its future. Special attention was given to the social, environmental and health implications of sector change and on policy adjustments required addressing such change. Thematically it was separated into three sessions: Sector trends and impacts; Risks and challenges; and Poultry as a development tool – each with plenary contributions, round-tables and working groups. All sectors of the poultry industry were represented including multinational corporations, poultry breeding companies, international agencies, as well as research, development and NGO communities. It was this unique 'coming together' of key stakeholders in the poultry sector that made this conference stimulating and valuable. The extended electronic version of this publication contains in addition to the original version the full text of all background papers that were prepared for the International Conference. This publication is intended to provide information about the global development of the poultry sector and to provide policy guidance for the future.

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