
Livestock Policy Discussion Paper No. 1

**THE ‘LIVESTOCK REVOLUTION’ –
IMPLICATIONS FOR SMALLHOLDER AGRICULTURE:
A CASE STUDY OF MILK AND POULTRY
PRODUCTION IN KENYA**

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Preface

This is the first of a series of 'Livestock Policy Discussion Papers'. The purpose of the series is to provide up-to-date reviews of topics relating to the livestock sector and its development in various regions of the world. A strong emphasis is placed on the compilation of quantitative information, methodological aspects and on the development of policy recommendations for the topic at hand.

This paper is divided into two sections. In the first section, the author reviews the relationship between livestock production and smallholder development, with a particular view to predicted demand growth for livestock products fuelling the global 'Livestock Revolution'. In the second section, the author explores the prospects for increasing domestic livestock production in response to the fast growing demands in developing countries using a case-study approach. Kenya is selected as a suitable case study of a Low-Income Country, with a fast-growing population and consequent expanding demand for animal products. As milk and eggs are among the major products of the livestock sub-sector, the case study concentrates on a review of the development of dairy and poultry production. Based on his analysis the author makes a number of policy recommendations pertaining to both, small and large scale dairy and poultry production.

It is hoped that the paper stimulates discussion and any feedback would gratefully be received by the author and the Livestock Information and Policy Branch of the Animal Production and Health Division of FAO.

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Executive Summary

Section I General

World-wide demand for food of animal origin is growing rapidly, particularly in the developing countries. This is seen as a revolution in global agriculture, the Livestock Revolution, affecting human health, livelihoods and the environment (Delgado *et al* 1999). In the face of rapid growth in human populations and consumer demand for food in the developing countries there is widespread concern regarding the capability of world agriculture to ensure adequate supplies on a sustainable basis.

The developing countries, as a group, have become net importers of livestock products and cereals, from the developed countries. Over the last 10 years net imports of all these commodities, except eggs, have grown. In the case of meat, the growth has been quite rapid, a trend which is predicted to continue. Given the strategic importance of food supplies, the economic importance of the agricultural sector in most developing countries, and the foreign exchange costs of imports, a high degree of self-sufficiency is generally a significant policy goal. Hence there is a strong case for substantial increases in investment in domestic livestock production in most developing countries.

The bulk of the food, of both plant and animal origin, consumed in developing countries is supplied by small-scale, semi-subsistence, producer-households. The majority are small-holder mixed farmers, producing both crops and livestock. It is reported that rural smallholders own over 90 percent of the livestock in developing countries.

Agricultural expansion is an essential component of the development process, not only to feed the growing population but also because most of the people in developing countries make their living from the land. Improvements in agricultural productivity contribute to the alleviation of rural poverty. Despite the high rates of rural-urban migration and urban population growth, the number of people engaged in agriculture is still rising in developing countries, while the scope for further expansion of the area under cultivation is limited.

Consequently, the intensity of agricultural production (output per hectare) must be increased simply to maintain average per capita incomes of a growing agricultural population, which includes a majority of the poor and malnourished. Livestock production, in all but the grassland-based systems, offers the prospect of increasing intensity of land-use. Options for increasing livestock productivity, include shifts from grassland-based to mixed and thence to landless production systems, and improvements in nutrition, disease control, management (including confinement of livestock), marketing and breeding. Significant improvements generally necessitate a 'package approach', i.e. a multidisciplinary strategy. Credit and other input and marketing services are likely to be essential.

Access to the necessary input services and markets are usually most favourable in peri-urban areas. Thus intensified, commercial "upgraded" systems developing in the vicinity of urban markets. In more remote areas, however,

opportunities for improvements in productivity are fewer and further marginalization rather than integration may occur unless appropriate policies are implemented.

The aim of this paper is to explore the prospects for increasing domestic livestock production in response to the fast growing demands in developing countries using a case-study approach. Kenya is selected as a suitable case study of a Low-Income Country, with a fast-growing population and consequent expanding demand for animal products. Given the numerical importance of small-scale producers, the small-holder farmers and pastoralists, and the key policy aims of raising their incomes and relieving rural poverty, the study concentrates on this sub-sector.

Section II The Kenya Case Study

a) General overview of the Kenyan livestock sector

Despite rapid population growth, self-sufficiency ratios for most animal products still remain high in Kenya (close to 100 percent for all animal products). However, although consumption *per capita* of meat, milk and eggs is above the average for African Countries, the levels appear to be falling. This may be linked with the estimated decline in per capita national income, which has occurred over recent years. Although the quantities involved are relatively small, it is worth noting that in 1977 and 1987 Kenya was a net exporter of all the main livestock products, but by 1997 the nation had become a net importer of beef, sheep and goat meat, milk and eggs. Exports of poultry meat had fallen to almost zero and the only expanding export commodity was pig-meat.

Population density is high in Kenya; the area of land per head of the agricultural population is only about half the average for the whole of Sub-Saharan Africa, while the percentage irrigated is also much lower. Thus the main livestock production systems are grassland based or mixed-rainfed. Cattle are the most important livestock species, with more animals per head of agricultural population than the average for the sub-continent. However, numbers of other types of livestock are lower than average. Although numbers of chickens are below average for all Sub-Saharan Africa, poultry production is relatively important, poultry meat production coming second only to beef. Beef production has grown at over two percent annually since 1987, while poultry meat production has grown even faster. While there has been relatively modest growth in cattle numbers the national poultry flock has grown rapidly. Cows' milk and eggs are also major products of the livestock sub-sector. The case study therefore concentrates on the development of dairy and poultry production.

Average farm family size is 10.3 persons, while the average farm size is 3.5 hectares. Off farm employment of family members contributes to farm household incomes, particularly in the Central and Coastal Provinces where there is a wider range of opportunities. Many of the households are female headed, either because males are engaged in off-farm activities, or due to bereavement. Some of the poorest households are in the latter category. The majority of smallholder farmers keep livestock. One study finds that 72 percent of all households keep cattle with an average herd size of 7.4 animals. In addition 65 percent of households raise poultry,

with an average of 13 birds per flock. Small ruminants and pigs are also raised by many families, but are generally less important than the cattle enterprise.

At independence in 1963, Kenya already had a thriving agricultural cash-crop and dairy-livestock economy, supported by a state-run infrastructure for the provision of inputs, research, extension and other services and for product marketing. Increasing debt and other macroeconomic problems, caused by deteriorating terms of trade, increased loan interest, and drought as well as deficiencies in domestic policies, have constrained growth since the early 1970s. Structural adjustment loans, negotiated in the 1980s, have been conditional on reduction in Government spending, market liberalisation and greater reliance on the private sector. Agricultural prices have benefited little from these reforms, while in recent years prices of livestock products have fallen relative to that of maize. State intervention in marketing through 15 parastatal Boards, including those for meat, cereals, and dairy produce and the “Kenya Co-operative Creameries” (KCC), previously a statutory monopsony, has been diminished, and replaced by private sector activity. Concerns over public health have arisen in view of the increasing quantities of raw milk sales. There is limited access to agricultural credit and interest rates are high.

Privatisation and cost recovery are planned to provide input services including market and warehouse development, artificial insemination and animal breeding, veterinary clinical and laboratory services, operation of agricultural laboratories, management of tractor hiring, cold stores and slaughterhouses, production of bee hives and land surveying. Progress in many of these areas is slow and delivery systems are often incomplete or lacking.

Adaptive research is required to identify small holder objectives and constraints and appropriate options for improvement. In this context a farming systems approach to research, with greater farmer participation, is considered desirable. The public sector agencies for the promotion of research and technological change, such as the Kenya Agricultural Research Institute (KARI) and the Universities, are however suffering from financial constraints, and there is little evidence of farmer participation in defining the research agenda or of the work of the National Research Centres being influenced by the findings of studies at the Regional Centres.

Agricultural extension, based on the “Training and Visit” system also suffers from lack of funding, while it is only in the last decade that attempts have been made to integrate extension advice on livestock with that on crops. The field veterinary/animal health services still operate separately. The long-established delivery of animal health services by the State was affected by budgetary cuts following structural adjustment in the 1980s, which adversely affected clinical, disease control and vaccination services. A policy of full cost recovery from farmers, with the ability to pay, was instituted in 1986 and a freeze was instituted on the appointment of new veterinary service staff, followed by a programme to encourage the spread of private veterinary practices. None the less it is recognised that the public sector must retain a role in the control of epidemic diseases, research and extension, drug and vaccine quality control and food hygiene inspection. Although animal health services are generally available, costs have escalated under privatisation. An important task is to better integrate the para-veterinarians or

veterinary auxiliaries, now working outside the government service, with the professional graduate veterinarians.

The Central Artificial Insemination Station, Nairobi has a monopoly in the production of bull semen, some of which may be sold directly to large-scale farmers but most of which is distributed through the Department of Veterinary Services. Before the onset of budgetary problems the service was subsidised and farmers paid a nominal fee per insemination. Since then, lack of funding has led to a serious deterioration in service delivery and a massive increase in the price, since full cost recovery is expected. The majority of dairy farmers have switched to using bulls for natural service associated with increased keeping of bulls by small-holders, long calving intervals and a general decline in the genetic make-up of the national dairy herd.

b) The Dairy Sector

Intensive smallholder production is concentrated in the high potential upland areas of Central Kenya. The most intensive form, promoted by the National Dairy Development Project, involves a package of two or three “grade” or crossbred cows, zero-grazing, improved cow housing, Napier Grass grown as fodder and manure recycling. Typically two or three cows are kept, fed some purchased concentrates in addition to cut and carried fodder and milked twice a day. A slightly less intensive system, operated on somewhat larger farms in similar areas, is based on paddock grazing. These intensive, smallholder dairy production systems, keep about 20 percent of all cattle but are estimated to produce well over half of the national total milk supply.

The semi-intensive smallholder system, based on larger herds of zebu cows, grazing natural pastures and milked only once per day, is found in more remote, medium potential areas, mainly in Western Kenya. Production per cow is lower than that of intensive production systems, but so too are the investment and operational costs. The Dairy Development Programme is largely aimed at introducing intensive production methods in place of these semi-intensive systems.

Large-scale systems, concentrated in the Central Upland areas, range from semi-intensive production with zebu cattle to highly intensive dairying with pure-bred exotic or cross bred cattle fed on irrigated forage and supplementary concentrates. Although large-scale dairying accounts for only 4 percent of the cattle population, it is presumed to yield a quarter of the national cows’ milk supply. Expansion of large-scale systems is unlikely given the intense and growing pressure on high and medium potential land resources. However, valuable complementarities exist between large and small-scale dairy farmers in the sale of grade heifers from the former to the latter and the sale of milk for processing and onward sale from small- to large-scale producers. The large-scale producers may face some of the constraints experienced by small-holders, but they are less affected since they benefit from internal and external economies of scale.

Differences in average milk yield are responsible for large differences in gross margins per cow; the average for intensive smallholder producers being more than twice that for the semi-intensive smallholder group, while that for large-scale

producers is more than twice that of the intensive smallholders. These estimates illustrate the potential for improvement of productivity of smallholder production. It is likely that smallholder farmers keeping grade cattle make more intensive use of land than do large-scale producers, but their labour and capital costs, per cow or per litre of milk are probably higher. Peri-urban producers now receive a much higher milk price than those in more remote areas, and thus earn higher net returns. It is widely claimed that dairying competes very favourably with cash crops such as tea, coffee and even horticulture.

Constraints on the expansion of intensive, small-scale grade-cattle production systems are (i) severe land shortage leading to shortage, and hence high cost, of fodder and concentrate feeds, (ii) limited access to and high cost of credit (iii) failure of artificial insemination delivery systems (iv) limited market opportunities, particularly in the more remote areas, (v) disease and deficiencies in animal health services (vi) management weaknesses. It is difficult to rank these in order of importance since they are closely inter-related. Furthermore while the high cost of credit limits the opportunities for new entrants to the dairy industry, the failure of Artificial Insemination delivery systems leads to a decline in the genetic potential of dairy cows on existing dairy farms. Poor animal nutrition and management are probably the primary constraints.

c) The Poultry Sector

Total numbers of poultry in Kenya have grown by nearly 3 percent annually over the last 20 years, with very limited State support. Production systems are conveniently categorised into “backyard systems” using indigenous birds and “commercial systems” of broiler or egg production based on special purpose hybrid chicks. Backyard production, found on the majority of smallholder farms accounts for three quarters of all chickens kept in Kenya. Almost all the commercial broilers are produced in Nairobi and Central Provinces, close to the capital city. Egg production is a little less centralised with significant numbers of layers in Coastal and Nyanza Provinces.

“Backyard” production is a supplementary enterprise, which does not compete with other activities for scarce resources and therefore involves very few costs. Birds feed mainly by scavenging, with very little supplementary grain fed, are rarely housed and receive no veterinary health care. Productivity is also low as a result of the few eggs laid and hatched and the high mortality rates. However, the system provides a low cost supplement to family nutrition and the incomes of women in poor households. The return on capital is quite high on average but risky. The main constraint on expansion is the limited feed available from household waste. Increased supplementary feeding and chick housing to avoid losses by predation offer the best options for improvement. Low cost methods of disease control might also increase returns.

Commercial systems range in size from small units of less than a hundred birds to large-scale hatchery and broiler production companies, such as Kenchic which produces 8 million day old chicks annually. The situation is probably similar to that for Tanzanian commercial poultry producers, dominated by a very small number of large integrated firms supplying day-old chicks and marketing the products. Other

large firms supply ready-mixed feeds. Capital and operating costs per bird are much higher than under backyard systems, so although production per bird is higher the margin over feed cost is much lower for these commercial systems. This is compensated for by the fact that commercial producers keep many more birds than the backyard poultry producers. However, variations in the price and quality of purchased feed, in the availability of day-old chicks and the random occurrence of disease outbreaks lead to significant risks of loss.

A comparison of “backyard” and commercial poultry systems suggests that both have their place in meeting the growth in demand for animal products in the Kenyan economy. In rural areas, backyard poultry production serves as a true supplementary enterprise, contributing additional household income and valuable animal protein to household members at very little resource cost. Significant increases in productivity would be achieved by simple improvements in housing, feeding (and watering) and disease control.

The more intensive, commercial egg and broiler production systems are better suited to, or indeed restricted to, peri-urban locations. There is a need for ready access to supplies of hybrid chicks, ready mixed feeds, and ideally veterinary services. Access to urban markets for eggs and poultry meat is equally important, when these perishable and not easily transported commodities are produced in relatively large batches. The main constraints on the expansion of commercial poultry keeping are capital limitations and imperfections in input and product markets. These imperfections are due to inadequacies of the rural road network and poor communication of information, resulting in poor integration of spatially dispersed markets and cyclical fluctuations in production and prices.

d) Policy Recommendations

Expansion of milk, meat and egg production is desirable to meet growing demands for these animal products and to raise incomes of agricultural households. The relative efficiency of large- and small-scale dairying and poultry production is difficult to assess. Large-scale producers benefit from economies of scale leading to lower unit costs and higher gross and net margins. However, small-scale producers probably achieve a higher intensity of land use. In any case encouraging small-scale producers best pursues the objective of rural poverty alleviation.

None the less, given the complementary and inter-dependent input and product markets for large- and small-scale producers, and the decline in Government provision of input and marketing services, large-scale producers may serve a useful function in contributing to the growth of the smallholder sector.

Policy interventions of general benefit to both dairy and poultry producers include the following;

- improvements in the road and communications network would extend the area suited to intensive production systems,
- improved collection and dissemination of national production statistics and market information would provide for better planning and co-ordination of input and product markets,
- surveillance and regulation of input and product markets to ensure the

maintenance of competitive conditions, and quality and sanitary control of concentrate feeds, milk, meat etc.

- adaptive, farmer participatory and systems oriented research and development, with a strong socio-economics budgeting and costing component, aimed at extension of improved management techniques to farmers,
- additional socio-economic research on marketing and institutional change,
- encouragement of farmer group activity to benefit from the economies of scale in product marketing and input supply,
- guidance of the privatisation of animal health service provision, by ending unfair competition from public sector employees, reducing the list (and hence capital cost) of equipment specified as necessary for establishing a private practice and better integration of para-veterinarians into the system,
- increased availability of credit for the establishment of small-scale intensive production systems.

Policies for the dairy sector, include all the above, and promoting through research and extension with increasing involvement of the private sector and non-government organisations (NGOs);

- improved cow feeding, housing and management,
- increased forage production and conservation,
- provision of concentrate feeds of appropriate quality and price,
- expansion and improvement of artificial insemination services,
- better control of endemic and epidemic disease,
- regulation (sanitary and quality assurance) of private and co-operative milk markets.

“Backyard” poultry production is the least costly and offers the highest return on investment of the livestock enterprises considered in this study. The low level of capital investment involved means that this enterprise is well suited to adoption by poor households. However, scope for expansion is strictly limited by the nutritional constraint of scavenging for feed. A major expansion would necessitate conversion to a more intensive commercial system. Options for improvement of backyard systems consist largely of adaptive research and extension in:

- simple and inexpensive housing,
- poultry nutrition, ration formulation, local feed milling, supplementation of scavenged diets, and
- disease control.

Research should be farmer-participatory, farming systems oriented and involve on farm testing. There should be a strong socio-economic component to assess the costs and benefits of the alternative measures proposed.

Policies for the commercial poultry sector should be aimed at:

- facilitating and monitoring markets for breeding stock, day-old-chicks, concentrate feeds, veterinary services, eggs, birds, and poultry meat,
- regulation of quality and sanitary assurance within these markets, and control of monopolies, and
- improving access to credit for small-scale commercial producers.

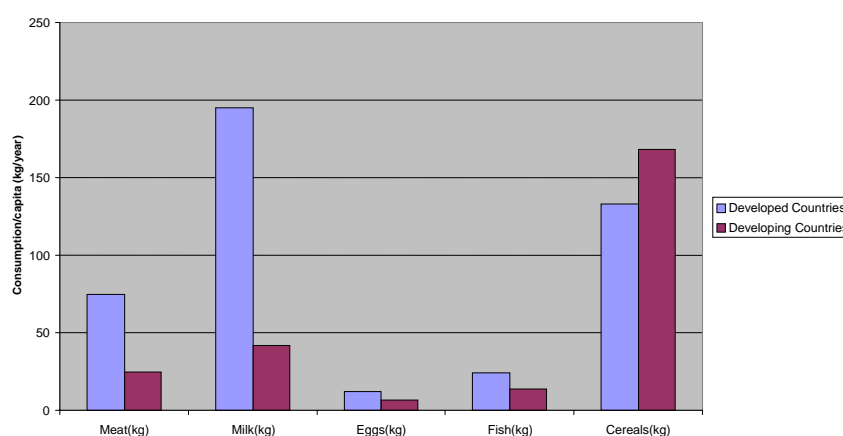
SECTION I Livestock production and small-holder development

1. Introduction

World-wide demand for food of animal origin is growing rapidly, particularly in the developing countries. This is seen as a revolution in global agriculture, the Livestock Revolution, affecting human health, livelihoods and the environment (Delgado *et al* 1999). Hitherto, overall growth in livestock production has been sufficient to meet increases in demand, without any serious price increases. However, there are considerable differences between continents and countries, and international trade between surplus and deficit producers has increased. For the developing countries, which in general are net importers of livestock products, there is concern regarding the implications of the widening gap between local consumption and production, increased exposure to and reliance on international markets, and ongoing structural changes in the livestock sector for smallholder agriculture, currently the main source of sustaining a livelihood for 650 million farmers world-wide.

Consumer demand for food, including that of animal origin, starts from a much lower base in developing countries. National income per capita in Low Income Countries was, on average, only 1.4% of that in High Income Countries; \$350 compared with \$25,700 in 1997 (World Bank 1999)¹. At purchasing parity prices the difference is less extreme (\$1400 for LICs and \$22,770 for HICs) but still huge. Such contrasting levels of income are reflected in substantial differences in levels of food consumption per capita (See Figure 1).

Figure 1: Food consumption per capita: Developed and Developing Countries



The higher income societies achieve better levels of nutrition, despite lower levels of cereal consumption, associated with intakes of animal products three or four times greater than those with much lower incomes. Although average daily intake of Calories is only 20% higher in the developed countries, intake of protein is 50% higher while intake of fats is almost twice as high. In general, as incomes rise,

¹ Low Income and High Income Countries do not correspond exactly with developing and developed countries respectively, but the distinctions are broadly comparable.

consumption of staple food-grains remains fairly stable, but consumption of preferred food commodities, such as animal products rises more rapidly. This is illustrated by comparison of the growth rates of consumption, over the period 1987-97 in developing countries, given in Table 1. While consumption of meat, milk, eggs and fish rose rapidly, intake of cereals fell slightly. However, consumption of livestock and fishery products can reach a plateau, or saturation point, beyond which growth in incomes is associated with stable or declining consumption.

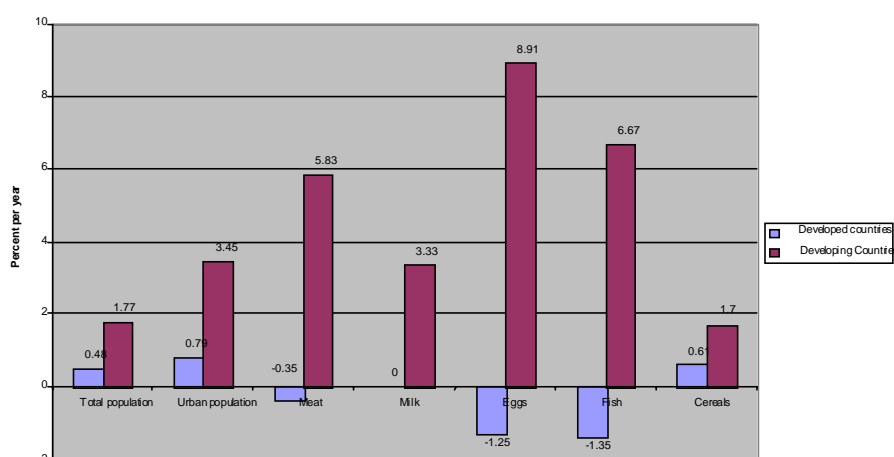
Table 1: Annual growth in food consumption per capita 1987-97 (%)

	Meat	Milk	Fish	Cereals
Developed countries	-0.87	-0.52	-1.86	0.09
Developing countries	3.95	1.49	4.77	-0.10

Source: FAOSTAT March 2000

Total consumption of livestock products in developing countries has increased more rapidly than consumption per head as a result of population growth, which for the Developing World as a whole, is nearly 2%. Consumption of all commodities of animal origin has grown very rapidly, with egg consumption growing at nearly 9% per year (see Figure 2). Urban populations were growing almost twice as fast as the total population. Urbanisation may well have influenced consumption behaviour and contributed to the increased average consumption of livestock products. It certainly creates a need for increased off-farm sales of all foodstuffs, including meat, milk and eggs, to supply the towns. Over the same 10-year period in developed countries, population growth was much slower and total consumption of livestock products declined slightly. Thus, the demand-driven “Livestock Revolution” is a particular feature of the developing countries.

Figure 2: Growth of population and total food consumption



In the face of rapid growth in human populations and consumer demand for food, there is widespread concern regarding the capability of world agriculture to ensure adequate supplies on a sustainable basis. Clearly total world production of meat milk and eggs has grown sufficiently to allow the expansion of aggregate and per capita consumption that has occurred in the developing countries. However, there has been

a slight decline in cereal consumption *per capita* (see Table 1), while large numbers of people in these countries remain undernourished and, although diminishing, the numbers are predicted to remain high through the year 2010. Furthermore, the developing countries, as a group, have become net importers of livestock products and cereals, from the developed countries (see Table 2). Over the last 10 years net imports of all these commodities, except eggs, have grown. In the case of meat, the growth has been quite rapid.

Table 2: Annual increase in net trade between developed and developing countries 1987-97 (%)

	Net imports	Net exports
Meat (developed countries)		9.95
Meat (developing countries)	5.45	
Milk (developed countries)		0.81
Milk (developing countries)	0.76	
Eggs (developed countries)		-5.61
Eggs (developing countries)	-16.08	
Cereals (developed countries)		1.79
Cereals (developing countries)	1.67	

Source: FAOSTAT March 2000

Although food security does not preclude reliance on imports for some food items it is essential that the foreign-exchange earnings from exports of other goods and services are sufficient to meet the cost and avoid growing trade deficits and foreign debt. Given the strategic importance of food supplies, the economic importance of the agricultural sector in most developing countries, and the foreign exchange costs of imports, a high degree of self-sufficiency is generally a significant policy goal. Total demand for meat in developing countries is predicted to rise from 88 million metric tons in 1993 to 188 million MT in 2020, i.e. more than double while the increase in milk consumption over the same period is predicted to approximately treble from 122 million MT to 391 million MT (Delgado *et al.* 1999).

Agricultural expansion is an essential component of the development process, not only to feed the growing population but also because most of the people in poor countries make their living from the land. Improvements in agricultural productivity contribute to the alleviation of rural poverty. In this context it should be noted that despite the high rates of rural-urban migration and urban population growth, the number of people engaged in agriculture is still rising in developing countries. This growing agricultural labour force is dependent on limited supplies of land and water. Thus, the area of cropped land per head of population dependent on agriculture in the developing countries is but a fraction of that in the developed countries (over 6 ha) and has fallen over the last 20 years from 0.37 ha to 0.35 ha (FAOSTAT 2000). The scope for further expansion of the area under cultivation is limited (Alexandratos 1995). Although the area under irrigation has grown by over two percent annually, this has failed to keep pace with population growth.

Two important implications stem from these findings: (a) the intensity of agricultural production (output per hectare) must be increased simply to maintain average per capita incomes of a growing agricultural population, which includes a

majority of the poor and malnourished, and (b) increased intensity of production imposes the threat of environmental damage and thus raises concerns as to whether the system is sustainable.

Livestock production, in all but the grassland-based systems, offers the prospect of increasing intensity of land-use. Value is added to crops by feeding them to livestock, thereby raising the value of output per hectare. Although animal husbandry can cause environmental damage, there can also be beneficial effects of improved nutrient recycling and crop-livestock interactions in mixed farming systems (Steinfeld, de Haan & Blackburn, 1997, McIntire, Bourzat & Pingali, 1992). These issues are relevant when considering the prospects for expanding livestock output from small-scale traditional household systems

The aim of this paper is to explore the prospects for increasing domestic livestock production in response to the fast growing demands in developing countries. Given the numerical importance of small-scale producers, the smallholder farmers and pastoralists, and the key policy aims of raising their incomes and relieving rural poverty, the study concentrates on this sub-sector.

Rather than model building to predict future trends (as in Delgado *et al* 1999) this assessment is based on the analysis of past change and development up to the present. Starting from a general review of smallholder livestock production in developing countries and options for improvement, the study is focussed more closely on Sub-Saharan Africa and Kenya in particular. Within this context dairying and poultry production are seen to offer the best prospects for expanding the supply of livestock products from smallholder farms. Section II of the report discusses the development of these two enterprises in Kenya.

2. Characteristics of small-scale, tropical livestock farming systems

Although small-scale producers operate in diverse farming systems, they have many features in common. First they are rural dwellers, dependent directly or indirectly, on exploiting the natural environment. Second they are family, household enterprises in which decisions regarding consumption and production are inter-dependent. Decisions about what to grow are influenced by household food requirements. Third, labour and other resources are largely provided by members of the farm household, rather than being hired in from other sources.

Tropical climates are unreliable; the inter-year variation in rainfall generally being greater the lower the annual mean. Thus smallholders and pastoralists face *large environmental risks* of drought, or floods in more humid areas, as well as pests and diseases. In addition, because producers are only partially integrated into market systems which are not well developed in rural areas, together with the uncertainties of supply and demand, there is *considerable market risk*. Smallholder households generally subsist on low incomes in cash and kind, and are therefore quite strongly risk averse. Maximising income or profit is rarely, if ever, their sole objective. Farmers and livestock keepers also avoid risk by producing as much as possible of household food requirements, by reliance on tried and trusted methods, by a cautious approach to innovations. Furthermore although changes are occurring, in traditional

societies there was a great deal of mutual and reciprocal self-help particularly in times of adversity.

Another common characteristic of many agricultural systems is that of *seasonality* of production, employment and food availability. The main exceptions are in very humid and/or irrigated regions, (e.g. in parts of Asia) where production may be continued throughout the year. Elsewhere, crop growth is largely restricted to the rainy seasons, often two per year in the humid zones but single peaked in the semi-arid areas. Grassland based systems are also affected since pasture growth is also limited to the rainy seasons. Transhumance is one response still common among pastoral people. Problems arise because food supplies, and hence the nutritional status of humans and draught-animals are at their lowest at the end of the dry season, when the greatest work peaks for cultivation and planting arise just before the start of the rains.

Differences between farming systems, the types of crops grown and livestock raised, are in part due to variation in local tastes and preferences, reflecting social history, culture and institutions. An important distinctive feature is the intensity of land use. At the lower end of the spectrum are extensive systems such as shifting cultivation or pastoralism, with low inputs of labour and purchased inputs per hectare, and correspondingly low levels of production per hectare. At the other end of the spectrum are intensive, irrigated systems with high cropping indices (ratio of total area of crops to cropped area) and landless livestock systems. Settled, rained, mixed farming systems are intermediate in intensity.

It has been argued that increases in intensity of land use, and associated changes in technology, are induced by growth in population density (Boserup, 1965). Research in the Machakos District of Kenya appears to support this hypothesis (Tiffen, Mortimore & Gichuki 1994). However, there are equally strong grounds for assuming that human population density is dependent on the natural environment and its potential productivity. Elevation and rainfall are two important ecological variables affecting the vegetation cover and the potential productive capacity of the land. Thus it may be argued that upland areas have attracted early settlement and dense populations because of the equable climate, and fertile soils. The semi-arid rangelands are sparsely populated because the natural environment is unsuited to intensive crop production, while the humid areas of South East Asia are densely populated because intensive paddy-rice growing is feasible. Dense populations in irrigated areas are often the result of immigration (e.g. the Sudan Gezira).

Linked with these effects is the importance of location and market access. The main markets for food and industrial raw materials exist in urban locations. Distance from these centres, or from their main transport routes, has an important influence on the net prices received for farm products. Similarly location in relation to urban centres affects access to markets for purchased inputs and the costs of such inputs. Because, in peri-urban areas, transport costs are low the margins between product values and input costs are high and intensive commercial agricultural production is encouraged. In more remote areas, transport costs are higher, market margins are therefore low, so less intensive semi-subsistence farming or pastoral livestock keeping is more appropriate (Uptown 1997).

Transport costs vary from one commodity to another, depending on their perishability and bulk to value ratio. Milk and eggs are relatively perishable in comparison with meat, as animals on the hoof. Hence milk and eggs are more likely to be produced intensively in peri-urban zones while ruminant meat is obtained from more distant rural areas. Furthermore, enterprises which are dependent on purchased inputs, such as concentrate feeds, are likely to be established in peri-urban zones with easy access to input markets. As a result, the development of commercial, landless systems in peri-urban locations may bear little relationship to the density of the rural population.

Institutions, or the “rules under which the economy operates”, are also associated with the intensity of land use and the technology of production. Land tenure institutions are particularly relevant in this respect. In situations where virgin, unclaimed land remains, as in parts of Sub-Saharan Africa and Latin America, the land may still be considered as a free good, with “open access”. However, once all the available land is in use for pastoral livestock-grazing or for shifting cultivation, systems of communal tenure evolve, with the land held in trust by the community, with rights allocated by the leaders. More intensive systems with continuous cultivation, especially where the establishment of permanent crops or irrigation structures are involved, are more likely to be associated with some form of payment for the use of the land, either as an annual (fixed or share) rent or as a one-off purchase price. In either case, the more intensive is the system, or the more scarce the land resource, the higher is the rental or price likely to be.

The theory of “induced innovation” suggests that changes in technology and institutions are induced by changes in resource endowments and growth in product demand (see Hayami & Ruttan 1985). In situations where land is plentiful and labour relatively scarce, the value of additional labour (strictly the marginal value product) will be high relative to that of land. This will induce the development of technology which is labour-saving, such as mechanisation, and institutions for the efficient allocation of labour. With increased population density, land-saving technology, with improved seeds and the use of agri-chemicals, becomes more appropriate and new land-tenure institutions are developed.

Since the value of the products of livestock keeping is greater than the value, or “opportunity cost” of the plant material they consume, the introduction of animals or poultry to any land use system must cause intensification of production. In all continents, intensity of production has increased through growth in livestock numbers, especially rapid in the case of chickens. In their study of “Crop-Livestock Interactions in Sub-Saharan Africa”, McIntire, Bourzat and Pingali (1992) hypothesise that “the evolution of interactions follows an inverted U form as population density increases: integration is very weak at the beginning, increases and then decreases.” This describes a process of change from grassland based systems to mixed farming systems, as human population density increases, followed at a later stage after further population growth by a switch to greater specialisation in crop production or landless livestock systems.

More intensive systems of land use generally require more sophisticated methods of production; or productive technology. Thus extensive systems, of pastoralism or shifting cultivation, require few purchased inputs other than some simple hand-tools

but continuous cultivation, or even a short-fallow system, requires the use of a plough and possibly other field equipment. Irrigated cropping requires pumps or other equipment for controlling the supply of irrigation water (Boserup 1965). The incorporation of livestock into mixed farming systems increases the technological complexity and requires the management of crop livestock interactions; adjusting the cropping pattern to provide livestock feeds, use of manure to raise soil fertility and possibly organising the use of animal draught (McIntire, Bourzat & Pingali 1992). At high levels of intensity, confinement and hand-feeding become necessary to avoid damage to crops. Confinement of animals, in turn, necessitates more careful and accurate control of their nutrition, health, and reproduction.

With mixed systems there is complementarity between crops and livestock, with animals fed on crop by-products producing manure to return nutrients to the soil. In the case of indigenous cattle there may be additional benefits in the form of draught power (Sumberg 1998). However, livestock other than cattle (and buffaloes), and indeed specialised exotic or cross-bred cattle, are unsuited to providing draught power. With intensification, livestock begin to compete with crops for land used in producing fodder and/or concentrate feeds. Furthermore increased nutrient cycling will not necessarily enlarge the total pool of nutrients, so it is questionable whether farm-yard manure is a perfect substitute for inorganic fertilizers (Powell & Williams 1995, McIntire, Bourzat & Pingali 1992). It is suggested that African farmers (and probably farmers in other parts of the world) whilst not accepting mixed farming as an overall model for agricultural development, may have adopted many of its underlying principles (Sumberg 1998).

3. Livestock and capital investment

Practically all changes in technology, whether or not they are associated with intensification, involve “capital investment”. “Capital” may be defined as anything (or any asset) which has been produced but has not yet been used up, while “investment” is an addition to the stock of capital. Increased capital investment raises the productivity of the other resources; land and labour. As suggested above, an increase in capital investment per head of the labour force, in mechanisation for example, may increase labour productivity. Livestock are a form of capital, as are buildings, equipment and stocks of feeds and medicines involved in livestock keeping.

The fact that livestock are a form of capital is often expressed in terms of their being a “store of wealth”. Like other forms of productive investment, livestock are accumulated in the expectation of the extra output that will be produced in the future to earn a return on the investment. It is also argued that the capital stock embodied in the livestock serves as a reserve or buffer against the risk of crop failure or other emergencies.

Capital investment necessitates saving, or foregoing current consumption which relates consumption and investment to total income or production over a given period. Thus, low-income households, needing to consume most of what they produce in order to survive, can only afford low rates of investment. Nevertheless, traditional

livestock owners, pastoralists in particular, accumulate quite large stocks of capital in the form of cattle or small ruminants.

Pastoral people who are entirely dependent on livestock production need relatively large herds of cattle (20 or more per household) or flocks of sheep and goats (100 or more per household) in order to generate sufficient income to meet consumption needs (Dahl & Hjort 1976). Much of the income consists of milk, mostly consumed within the household, and the rest from the sale of animals to provide for the purchase of cereals, coffee and other essentials (Cossins & Upton 1987). The accumulation of livestock is generally a slow and irregular process, involving patrimony, matrimony and parsimony. The first of these reflects inheritance from one generation to the next, matrimony may involve livestock as part of the bride price, while parsimony occurs when young stock are retained for breeding, rather than being sold or slaughtered. This method of saving and capital accumulation is feasible, even where livestock markets are incomplete or missing, since the young stock are produced within the household system. However, most options for increasing animal production and intensity, including improvements in health, nutrition, management, marketing, housing and breeding, necessitate the purchase of 'new', external, capital inputs. Thus, access to credit, in cash or in kind (e.g. heifer in trust schemes) is paramount to enable smallholders with limited resources to adopt more intensive livestock production systems.

4. General options and policies for improvement

Given a broad policy goal, such as the promotion of livestock production, Governments have three broad types of policy instrument from which to choose:

- pricing (which may be influenced by trade and exchange rate policies),
- institutional change, and
- technological change.

Price support through input or output subsidies, or by trade control, has been widely rejected as a result of debt crises and the subsequent imposition of structural adjustment regimes. Nonetheless, government intervention is needed to ensure the maintenance of competitive market conditions, to provide an appropriate legal framework and to provide a measure of quality control.

Linked with market liberalisation, the withdrawal or reduction of government provision of key input-supply, such as animal health and artificial insemination, and product-marketing services, leaves gaps in the institutional framework, which need to be filled. Although it is hoped that private enterprise and non-government organisations will expand to provide these services, policy guidance and regulation are needed for quality assurance and to ensure competitive pricing.

Although in small-scale semi-subsistence systems limited numbers of poultry and small ruminants, and even cattle, may be slaughtered for home consumption and small quantities of milk and eggs are used within the household, production of a marketable surplus necessitates the existence of an effective marketing system. In traditional areas of extensive, rangeland-grazing and mixed farming, a market usually exists for

live animals, prior to their movement to urban slaughter slabs, and for small quantities of fresh or soured milk or ghee.

Existing markets for live animals often function effectively and many ambitious projects for increasing intensity of production, by constructing stock routes, watering points and marshalling yards, have had little impact (e.g. see Williams, DeRosa & Badiane 1995). However, improved slaughter house and meat chilling facilities may be needed to comply with meat hygiene and health requirements, especially if meat exports are intended.

Intensification of milk production, on the other hand, necessitates the establishment of cooling and processing facilities. As there are economies of scale in these activities, the individual smallholder cannot afford the establishment and operating costs of a viable plant. In many cases, producer co-operatives have been formed to establish dairy facilities. Even then the supplies of milk are often insufficient to justify the capacity of the processing plants, while many have suffered from poor and ineffective management (Sumberg 1997 & 1999, Nyamrunda & Sumberg 1998, Upton *et al* 1997, R. Loader personal communication, Aneja 1993). There are major economies of scale in the processing of broiler poultry, and as a result large firms in the private sector often provide facilities.

Policies for the development and diffusion of new technologies are required since private sector activity in this area is unlikely to be adequate. There are three main reasons (Arrow 1962). First there are major economies of scale in agricultural research (in terms of both the size of research teams and the special equipment used). Second there are substantial risks of failure to achieve breakthroughs. For both these reasons, small-holder farmers cannot afford to undertake much research. The third reason affects the private sector generally and that is the difficulty of appropriating the benefits of much research. Many new technologies cannot easily be sold so there is no way of recouping the research and development cost. Many empirical studies have shown very high rates of return, ranging from 24 to 90 percent, to agricultural research which seems to indicate that there is under-investment in this activity (e.g. see Norton & Alwang 1993). A recent summary of 260 studies on the marginal rate of return to investment in agricultural research shows a median rate of 40 percent (Evenson 1998).

It should be noted that these estimates of high rates of return to investment in agricultural research relate mainly to crop research. Although returns to privately funded research on livestock may be high, several studies have shown negative rates of return for publicly funded livestock research (e.g. Huffman & Evenson 1993). However, a recent study suggests that if account is taken of the losses that would occur in the absence of research the returns to public sector investment, in both animal production and animal health research, appear more favourable (around 20 percent) (Townsend & Thirtle 2000).

However, in many instances there is little need for new basic or strategic research, rather the requirement is for a suitable institutional framework for the adaptation and delivery of the improved technology, for instance in animal health, animal breeding and livestock management techniques.

SECTION II The Evolution of the dairy and poultry sector in Kenya – a case study

5. General overview of the Kenyan livestock sector

Kenya is selected as a suitable case study of a Low-Income Country, with a fast-growing population and consequent expanding demand for animal products. There is a wide diversity of agro-ecological conditions reflecting variations in altitude, temperature, soil conditions and level and reliability of rainfall. The contrasts between the highland areas with ample rainfall and rich volcanic soils and the semi-arid areas with erratic rainfall are particularly marked. Kenya, like many other developing countries, pursues a policy of internal food self-sufficiency, in both crop and animal products. This policy has been relatively successful for most animal products, and self-sufficiency ratios remain high, despite rapid population growth. However, consumption per capita of meat, milk and eggs appears to be falling.

Consumption and production trends

Estimates of per capita national income for 1997 suggest that Kenya falls below the average for all Sub-Saharan Africa (see Table 3). The same applies when national income is recorded at “purchasing power parity”, that is after allowing for differences between countries in the relative cost of living. It was estimated that in 1992, 50 percent of the population subsisted below the poverty line of US\$1 per day income, while 78 percent earned less than US\$2 per day (World Bank 1999). In recent years, Kenya’s potential for growth has been inhibited by drought, political uncertainty and financial mismanagement. Although the economy continued to grow at over 2 percent, the population increase was greater, at nearly 3 percent, so national income per capita has declined slightly in recent years. Population growth, which was one of the highest in the world, at nearly 4 percent annually, has slowed over the last twenty five years and is predicted to continue at only 1.6 percent annually over the next 5 years, falling to just over 1 percent between 2040 and 2050 (FAOSTAT 2000).

Table 3: Populations and per capita income growth in Kenya and Sub-Saharan Africa

	Kenya	Sub-Saharan Africa
GNP per capita 1997	\$330	\$500
GNP per capita at PPP 1997	\$1,110	\$1,470
GNP growth 96-97 (%)	2.3	4.2
Population growth 87-97 (%)	2.9	2.7
GNP/capita growth 96-97 (%)	-0.1	1.2
Urban population - Total 1997 (mio.)	30	32.5
Urban popl'n growth 87-97 (%)	6.6	5.1
Agriculture value added/GDP (%)	29	25
Growth in Agric. value added (%)	0.8	4.6
Agric. popl'n/Total 1997 (mio)	77	67
Agric. popl'n growth 87-97 (%)	2.5	1.9

Sources: World Bank 1999, FAOSTAT 2000

Official statistics suggest that a very high proportion of Kenya's population is dependent on agriculture, representing considerably more than the total rural population. A crude comparison of the proportion of the population dependent on agriculture (77 percent) with the proportion of GDP produced from agriculture (29 percent) suggests a huge discrepancy in production, and income per person between the agricultural and non-agricultural sectors. This suggests that either the agricultural population has been over-estimated or that there is surplus labour and disguised unemployment in Kenyan agriculture. Although there may well be surplus labour in Kenyan agriculture, there is also a strong possibility that agricultural production is under-estimated as is suggested by some of the following analysis

Consumption of livestock products per capita is higher than the average for the whole of Sub-Saharan Africa. Milk consumption per person is estimated to be 81 kg in Kenya against only 30.4 kg for all Sub-Saharan Africa. Total calories per person per day, derived from livestock products in Kenya is 240.7 in comparison with only 143.1 for all Sub-Saharan Africa. Similarly the daily protein intake in Kenya is 15.6 gm while it is only 10.4 gm for the whole sub-continent. However, there is cause for concern in that per capita consumption of all livestock products in Kenya has been falling over the past 10 years, although milk and egg consumption had increased rapidly in the previous decade from 1977 to 1987.

The decline in consumption of animal products may, in part, have been associated with the fall in average per capita income over the 1990s. A recent study of income elasticities of demand for meat, shows them all to be positive, ranging from 0.18 for pork up to 1.53 for beef (Chantylew & Belete 1997). Thus a decline in incomes should have a negative effect on demand albeit slight. However, the fact that over the same period the trade balance for all livestock products except pigmeat deteriorated, suggests a failure of supply to meet the increasing demand (see Table 4). Although the quantities involved are relatively small, it is worth noting that in 1977 and 1987 Kenya was a net exporter of all the main livestock products, but by 1997 the nation had become a net importer of beef, sheep and goat meat, milk and eggs. Exports of

poultry meat had fallen to almost zero and the only expanding export commodity was pigmeat. Despite these changes the self-sufficiency ratios (SSRs) remain close to 100 percent for all animal products.

Table 4: Net exports of animal products from Kenya (Mt)
(Note negative values imply imports exceed exports)

	1977	1987	1997
Beef and veal	4,007	10	-504
Sheep and goat meat	122	22	-175
Pigmeat	44	3	566
Poultry	250	16	1
Milk	389	168	-341
Eggs	157	-1	-29

Source: FAOSTAT 2000

Population density is high in Kenya compared to the rest of Africa, although it varies greatly from the sparsely populated semi-arid rangelands to the densely populated high potential areas. The area of land per head of the agricultural population is only about half the average for the whole of Sub-Saharan Africa, while the percentage irrigated is also much lower (see Table 5). Thus the main livestock production systems are grassland based or mixed-rainfed. Cattle are the most important livestock species, with more animals per head of agricultural population than the average for the sub-continent. However, numbers of other types of livestock are lower than average. Pig numbers are particularly low. Although numbers of chickens are below average for all Sub-Saharan Africa, poultry production is relatively important.

Table 5: Land and livestock resources in Kenya and Sub-Saharan Africa

	Kenya	Sub-Saharan Africa
Land/100 in agriculture	261 ha	608 ha
Crops/100 in agriculture	21 ha	42 ha
Perm. Pasture/100 in agric.	98 ha	211 ha
Percentage of cropland irrigated	1.5	3.0
Cattle/100 persons	61	54
Sheep/ 100 persons	26	43
Goats/100 persons	34	49
Pigs/100 persons	0.5	7
Poultry/100 persons	132	191

Source: FAOSTAT 2000

National statistics on livestock production are given in Table 6. Cattle are the most important source of meat, followed by poultry. Small ruminants make a somewhat smaller contribution to national meat supplies. Pig production is quite limited at present. Beef production has grown at over two percent annually since 1987, while poultry meat production has grown even faster. While there has been relatively modest growth in cattle numbers the national poultry flock has grown

rapidly. Milk from cows and eggs are also major products of the livestock sub-sector. The following analysis therefore concentrates on the development of cattle and poultry production.

Table 6: Livestock production and productivity 1997
(Annual % growth rates 1987-97 in parenthesis)

	Cattle	Sheep	Goats	Pigs	Poultry
Total meat production(Mt)	270,000 (2.09)	22,800 (0.90)	29,260 (1.58)	5,525 (1.68)	55,200 (2.23)
Animal numbers (000)	13,414 (0.59)	5,600 (-0.75)	7,400 (1.31)	105 (1.15)	28,900 (2.77)
Off-take rate %	14.4 (0.78)	33.9 (1.66)	35.9 (0.27)	81.0 (0.53)	1.59 (-0.52)
Meat/head slaughtered (kg)	140 (0.71)	12 (0)	11 (0)	65 (0)	1.2 (0)
Total milk/egg production (Mt)	2,300,000 (1.14)	24,640 (-0.75)	92,500 (1.31)	-	48,480 (2.04)
Percentage in milk/lay	34 (-0.11)	22 (0)	25 (0)	-	70 (-0.70)
Yield per head (kg)	510 (0.65)	20 (0)	50 (0)	-	2.4 (0)

Source: FAOSTAT 2000

Livestock production systems

There are several different cattle production systems in Kenya ranging from grassland-based pastoral to intensive zero-grazed dairying, which will be discussed in more detail below. However, some indications of performance may be derived from the aggregated national statistics. The off-take rate, measured as the number of animals slaughtered as a percentage of the national herd, at 14.4 percent compares favourably with the average for all Sub-Saharan Africa of 9.7 percent. The off-take rate has risen over the past 20 years. However, considerably higher off-takes of 16 to 18 percent are achieved in Latin America, the Near East and East and South East Asia. The lower off-take rate in Kenya may reflect the relative importance of dairy production in this country. The statistics indicate that milking cows make up 34 percent of the total national cattle herd. This is twice the proportion of milking cows in the cattle herd for all Sub-Saharan Africa and is higher than the average for any other continent of the developing world.

Beef production per animal slaughtered, at 140 kg, is above the average of 129 kg for Sub-Saharan Africa, but is lower than the yields obtained in Latin America and East and South East Asia. Milk yield, at 510 kg per milk cow is also above the average for Sub-Saharan Africa, but is only about half the average yields obtained in most other “developing” continents. Kenyan milk yields have been increasing slowly over the past 20 years and there should be scope for further improvement.

Poultry, mainly chickens, are raised in both “backyard systems” and large-scale commercial units, for both meat and eggs. It is estimated that 159 birds are slaughtered annually per 100 birds in the national flock. This is higher than the figure, of 143, for all Sub-Saharan Africa but below the levels achieved in other

continents, for example in Latin America the figure is 319. The off-take rate has diminished slightly over the past 10 years. The meat yield per bird slaughtered is 1.2 kg, which is better than the average of 0.9 kg for Sub-Saharan Africa and similar to yields achieved in other parts of the developing world. Despite a slight decline over the last 10 years, the proportion of the national flock in lay is 70 percent, which is higher than the all continental averages for the developing world, while egg yield per laying hen, at 2.4 kg, is about average for the developing world.

Cereal-based concentrate feeds are used for dairy cattle, pigs and poultry and are manufactured locally (Gitu & Kanyua 1993). Over the past 20 years domestic production of cereals, particularly the main staple food crop, maize, fell by about 0.7 percent annually. Net trade fluctuated widely from year to year, but between 1977 and 1997 net imports increased dramatically by 23 percent per year on average. Within this context, cereal use for animal feeds declined quite rapidly between 1977 and 1987, then rose again between 1987 and 1997, although it continued to decline as a proportion of total domestic supply.

Kenya covers a wide range of topographical and climatic zones. A large part of the North and East of the country is designated as Arid and Semi-Arid Lands (ASALs). Practically the only form of land-use possible is grassland-based ruminant livestock production. Pastoral communal grazing or group ranching is practised while there are a few private ranches. Only about 20 percent of the total land area, located mainly in the South Central and Western parts of the country, is suitable for cultivation and is characterised by intensive mixed crop-livestock farming systems. A narrow strip along the East Coast is also used for mixed farming. Most of the human population is concentrated in these more fertile areas, and by association so too are most of the cattle (Wint & Bourn 1994).

Various attempts have been made to identify agro-ecological zones and associated types of farming system. An international classification devised in the late 1970s (FAO 1978) was applied to Kenya's land resources and described in the "Farm Management Handbook of Kenya" (Jaetzold & Schmidt 1982). The seven main agro-climatic zones (AEZs) identified in Kenya are listed in Table 7. Crop production is restricted to the first four zones, where cattle and small-ruminants are kept in mixed rainfed farming systems. The more arid zones 5 to 7 are suited only to grassland based systems, mainly pastoralism.

Table 7: Definition of agro-climatic zones in Kenya
(after Jaetzold & Schmidt 1982)

Agro-ecological Zone	Climatic description	Rainfall / evaporative potential (%)
1	Humid	>80
2	Sub-humid	65-80
3	Semi-humid	50-64
4	Transitional	40-49
5	Semi-arid	25-39
6	Arid	15-24
7	Very arid	<15

Subsequently Geographical Information Systems (GIS) have been used to integrate climatic, topographical and human population data to identify land-use zones or farming system domains more precisely than with conventional mapping (Norton-Griffiths 1987, Short & Gitu 1990, Wint & Rogers 1998). The latest study (Wint & Rogers *op cit*) is aimed at predicting cattle density, cultivation levels and farming systems in Kenya using GIS mapping of human population density and remotely sensed eco-climatic and topographic data (Figure 4).

Preparation of a manual of livestock production systems in Kenya (Peeler & Omoro 1997) involved the estimation of the spatial distribution of animals. This was based on livestock population statistics published, by Administrative District, in the Animal Production Annual Report for Kenya (MALDM 1993). The statistics for cattle are further subdivided by type, into indigenous zebu cattle and grade dairy cattle. Animal numbers in particular systems were estimated by assessing the spatial intersections between Administrative Districts and AEZs. Despite the growth in cattle numbers recorded in Table 6 above, more recent estimates of Kenya's livestock populations (MALDM 1996a) are closely similar to those reported in the Manual. The only exception is the Coastal Province where according to the official statistics, dairy cattle numbers rose by 32 percent, from 45,000 to 60,000, in the year 1994-95 (MALDM *op cit*).

Many studies have been made of agricultural and livestock production systems in Kenya. Those relating specifically to dairying and poultry production will be discussed below. Of particular interest are a series of farming systems studies conducted in the early 1990s and sponsored by the Swedish Funded, FAO executed, Farming Systems Programme in Eastern and Southern Africa. The Kenyan studies covered a total of 519 farms in the first five High Potential AEZs with sub-samples from Eastern, Central, Coast, Valley and Western Provinces (MALDM & KARI 1993).

Cropping patterns vary quite widely from one AEZ and Administrative District to another. Maize and beans are the staple food crops over much of the cultivated area although potatoes and other root crops are grown in upland areas, some bananas in the West, and sorghum and millets in semi-arid areas. A wide range of different cash crops are grown, including tea, coffee, pyrethrum, cotton and horticultural products. Average farm family size estimated from the Farming Systems Programme is 10.3 persons, while the average farm size is 3.5 hectares. Off farm employment of family members contributes to farm household incomes, particularly in the Central and Coastal Provinces where there is a wider range of opportunities. However 38 percent of all households in the survey earn income from off-farm employment or self-employment. Over 30 percent of the households are female headed, either because males are engaged in off-farm activities, or due to bereavement. Some of the poorest households are in the latter category.

The majority of smallholder farmers keep livestock. In the farming systems study quoted above, 72 percent of all households were found to keep cattle with an average herd size of 7.4 animals. In addition 65 percent of households raise poultry, with an average of 13 birds per flock. Small ruminants and pigs are also raised by many families, but are generally less important than the cattle enterprise.

Figure 4: Main agro-ecological Zones in Kenya

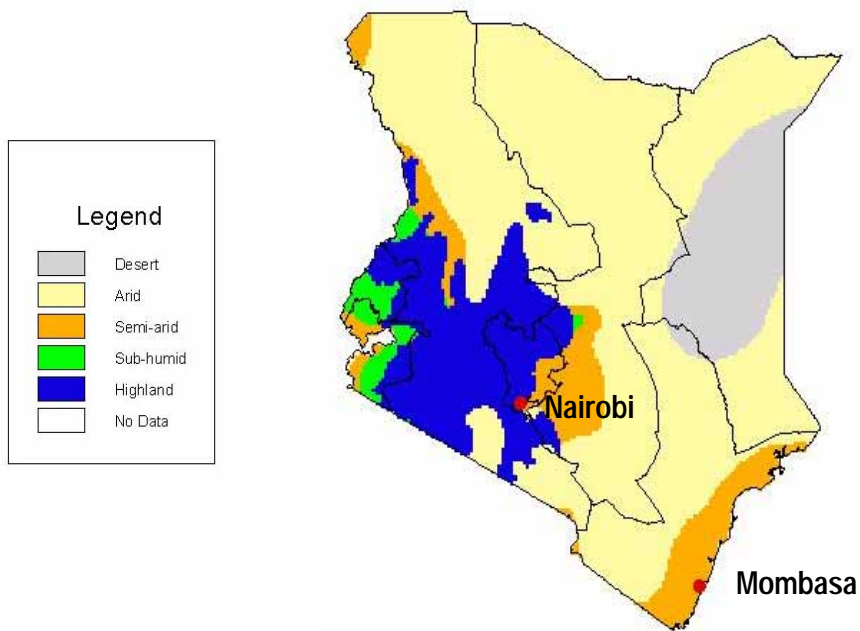
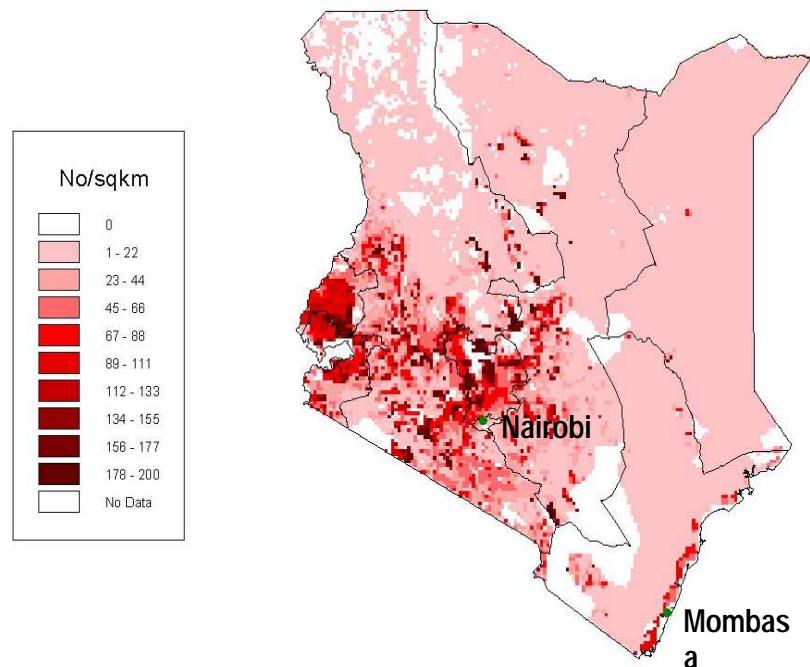


Figure 5: Map of predicted cattle distribution in Kenya



Institutional framework affecting the livestock sector

At independence in 1963, Kenya already had a thriving agricultural cash-crop and dairy-livestock economy, supported by a state-run infrastructure for the provision of inputs, research, extension and other services and for product marketing. Initially commercial production and these services were restricted to the settler population in the High Potential Upland areas. However, these opportunities were extended, particularly after adoption of the Swynnerton Plan (Kenya 1954), to a new class of African freehold farmers (Heyer 1981). The 1960s were characterised by rapid growth of marketed output from small farms, of 12.6 percent annually from 1964 to 1970, as the former “white highlands” were resettled while production, for export, of coffee, tea, pyrethrum and dairy products was promoted. The infrastructure of the road and rail network, social services, marketing boards for most of the main cash and food crops, producer co-operatives, agricultural research stations, and state funded agricultural and veterinary services was well established before independence. These institutions have endured until the economic recession and structural adjustment programmes of the 1980s led to major policy changes.

Balance-of-payments problems first arose in 1971, following rapid expansion of Government spending and a deterioration of the terms-of-trade for Kenyan products. The continuing economic crisis, suffered by many African and other developing countries, was generated in part by the world oil-price rises of the 1970s, economic recession in the industrialised High Income Countries, high interest rates on international capital and diminished demand for primary product exports. In Kenya the problems were exacerbated by several droughts over the two decades, the most severe occurring in 1984/5. Further blame is attributed to faulty domestic policies, including excessive growth of Government spending in the 1960s, maintenance of an exchange rate, which overvalued the regulation, and control of marketing and trade and an over-extended and inefficient public and parastatal sector. In the late 1970s and early 1980s agricultural output fell and the national debt rose to 10 percent of National Income (Bigsten & Ndung’u 1992).

Structural Adjustment Loans were negotiated during the 1980s, from the International Monetary Fund, the World Bank and the US Economic Fund. The usual conditions were imposed requiring currency devaluation, a rise in the interest rate, liberalization of internal and external markets, a reduction in Government spending and intervention and greater reliance on the private sector. Some success has been achieved in stabilisation of the Kenyan economy, despite the Government’s unwillingness to adopt all the recommended policies (Mosley 1991). The national debt and inflation have been reduced although the Kenyan Shilling continues to depreciate by around 5 percent annually. One area in which the Government of Kenya was unwilling or unable to adjust lies in the area of public sector employment. Throughout the last two decades public sector employment has been maintained, thereby decreasing the share of budgetary expenditure available for working capital. Salaries as a share of recurrent expenditure rose from 47 percent in 1979-80 to 60 percent in 1984-5 and have probably increased since (Bigsten & Ndung’u 1992).

By the mid-1980s the World Bank was dissatisfied with slow improvement in productivity in the main exporting sectors. Further lending was therefore

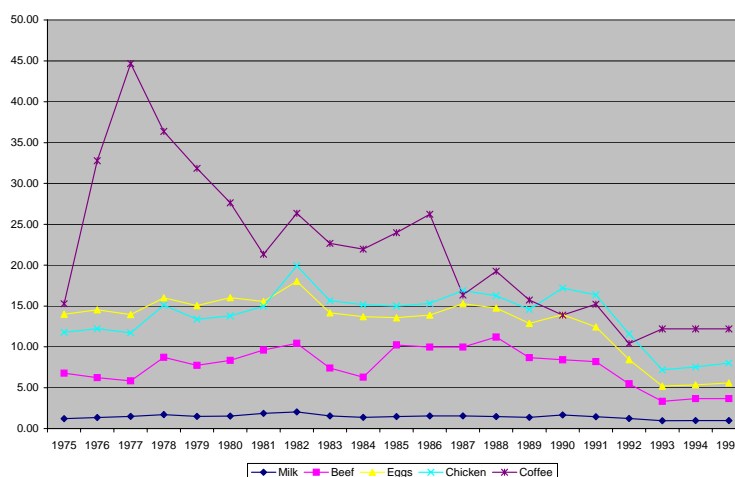
disaggregated into loans for specific sectors. The first Agricultural Sector Adjustment Loan of 1986 was aimed at improving supply of agricultural inputs, improving producer incentives and marketing, budget rationalisation, reform of agricultural parastatals and restructuring of the Agricultural Finance Corporation in order to increase the availability of credit to small farmers. These aims have only been partially achieved and agricultural output actually fell over the early 1990s. Some recovery has occurred since then.

The impacts on farmers are best considered under the headings of prices, institutions and technology. Farm prices are notoriously unstable. The marketing boards had little impact in stabilising prices, and unlike marketing boards in other African countries, did not attempt to accumulate surpluses for this purpose or for other development investment (Bigsten & Ndung'u 1992). The prices for the major export products are influenced by fluctuations in the world market, while prices of domestic food crops are affected by variations in supply. Furthermore, fluctuations in the exchange rate affect domestic prices for tradable goods. When the domestic currency is overvalued, the domestic price is depressed relative to the price of non-tradable goods; devaluation of the currency then improves the relative price of agricultural tradables. On this basis it is suggested that from 1979 to 1982 prices for exportable agricultural products were relatively depressed; between 1983 and 1988 after some economic stabilisation, prices of agricultural exports improved somewhat but from 1989 onwards they again deteriorated.

Given the inflationary situation over the last 20 years all prices were rising. However, rates of increase differed between products. A crude index of movements in real prices is given by treating the price of the staple food-crop maize as a standard for comparison. Trends in the prices of coffee, milk, beef, eggs and chicken meat, relative to that for maize are shown in Figure 5 (FAOSTAT 2000); all have fallen.

The downward trend in world coffee prices since the late 1970s, along with those of other export crops, contributed to the economic destabilisation of the period. Given the financial pressures limiting the scope for price support, the falling relative prices for livestock products, serve to emphasise the need for increased productive and marketing efficiency.

Figure 5: Commodity prices relative to that of maize



The institutional framework is influenced by the limits on Government funding and the required transfer of input supply and product marketing services to the private sector. In the latter respect the State control of agricultural marketing through 15 Marketing Boards and other agencies has been reduced. The Kenya Meat Commission, established in 1950 with a statutory monopoly on virtually all stages of the livestock marketing process, was never able to enforce its monopoly power. Gradually its share of the market declined and the two main KMC slaughterhouses deteriorated and were finally closed in 1992 (de Haan, van Ufford & Zaal 1999). The National Cereals Produce Board which was responsible for control of maize markets and for price fixing, closed 65 percent of its buying centres in 1987, and is claimed to have become fully liberalized in 1994. It remains in operation however, as a buyer of last resort (Meilink 1999).

The Kenya Dairy Board (KDB) was officially responsible for the control of marketing and pricing of dairy produce. However the price was strongly influenced by the main marketing organisation, the Kenya Co-operative Creameries (KCC), which held a virtual monopoly of milk processing and distribution until the early 1990s. In 1992 however price controls were removed and a number of private dairies have been established in competition with KCC (Staal & Shapiro 1994). Severe problems have arisen in milk marketing since the KCC, already accused of managerial inefficiency, paying low producer prices and late payment to farmers is now suffering from loss of trade and under-capacity utilisation of processing plants. The KDB has become ineffectual as informal sales of raw milk have expanded.

Local producer co-operatives have long been responsible for milk collection from members for delivery to the KCC or other official buyers. In other agricultural sub-sectors, except for coffee, farmer co-operation has had a limited impact despite promotion by the Ministry of Co-operatives. In 1983 only 10 percent of farm produce, other than coffee, was handled by co-operatives. Co-operative credit schemes suffered from poor repayment rates and high operating costs. The Agricultural Finance Corporation has been of limited assistance to smallholder producers. The increases in interest rates following structural adjustment and the elimination of subsidies have raised the costs of borrowing.

Cuts in government spending were least drastic in the area of public services. Levels of expenditure on education and health were maintained. However, the provision of agricultural services has stagnated (Bigsten & Ndung'u 1992). In addition since the retention and payment of staff was given first priority very little was left for operating expenses. Thus a whole range of agricultural services, which were previously available, free of charge or at a subsidised rate are no longer on offer. Privatisation and cost recovery are planned to provide input services including market and warehouse development, artificial insemination and animal breeding, veterinary clinical and laboratory services, operation of agricultural laboratories, management of tractor hiring, cold stores and slaughterhouses, production of bee hives and land surveying. Progress in many of these areas is slow and delivery systems are often incomplete or lacking.

Given the relatively poor productive performance of Kenyan livestock and farming systems, there should be considerable scope for improvements in technology. However, the fact that large-scale commercial producers generally achieve higher

yields than the smallholders suggests that improved technologies are already available and adoption is constrained by institutional weaknesses and limited communication of knowledge and information to farmers. Adaptive research is required to identify small holder objectives and constraints and appropriate options for improvement. In this context a farming systems approach to research, with greater farmer participation, is considered desirable.

The public sector agencies for the promotion of research and technological change are also suffering from financial constraints. The Kenya Agricultural Research Institute is a large organisation, employing about 550 full-time researchers, deployed in 21 Research Centres. In addition, a further 300 agricultural scientists are employed in the Universities and other organisations such as the Kenya Trypanosomiasis Research Institute. Furthermore several international research centres such as the International Livestock Research Institute are located in Nairobi, so there is a substantial agricultural research establishment in Kenya. Much of KARI's infrastructure of land and buildings, together with a large body of research was developed over the past century. Since 1985 activities have been split between 15 commodity- or factor-specific National Research Centres including the National Animal Husbandry Research Centre, Naivasha and the National Veterinary Research centre, Muguga, and six Regional Research Centres for the conduct of adaptive and problem-solving research for local farming systems (Roseboom & Pardey 1993).

As a result of the limited funding in recent years, 80 percent of which is spent on personnel costs, KARI has become heavily dependent on international and bilateral donor assistance. Thus, funds are generally allocated for a series of short-term projects with no assurance of resources for longer term programmes. There is also a problem of organising and co-ordinating project funded by different donors each with their own research agenda (Upton 1999). A further problem is the separation of the research and extension wings of the MOALD; indeed until recently the Kenya Agricultural Research Institute, which is the main component of the National Agricultural Research System, was located in a separate Ministry of Research, Technical Training and Technology. Farming systems teams have been established at the Regional Research Centres and these together with an officer from the MOALD were responsible for the farm level diagnostic surveys discussed earlier (MALDM & KARI 1993). However, there is little evidence of farmer participation in defining the research agenda or of the work of the National Research Centres being influenced by the findings of studies at the Regional Centres.

There are approximately 9,000 MOALD agricultural extension agents, of which about two thirds are front-line staff engaged for field-work. The "Training and Visit" system (Benor & Harrison 1977) based on fortnightly visits to contact farmers, has been adopted. Here again funding is a constraint, while it is only in the last decade that attempts have been made to integrate extension advice on livestock with that on crops. The field veterinary/animal health services still operate separately.

6. The Kenyan Dairy Industry

History of dairying and framework conditions

Cattle have been raised and milked in Kenya, by pastoralists and agro-pastoralists for many centuries. Indeed the indigenous Boran breed of zebu cattle is recognised today as a high quality beef animal. However, intensive milk production with exotic (*Bos taurus*) breeds was probably introduced by settlers about a century ago. “The National Animal Husbandry Research Centre (NAHRC) was started in 1903 with a mandate to adapt temperate technologies to fit tropical conditions. The first Friesians were bought in 1908, but almost all the animals died from tick borne diseases.” (Waithaka 1994). Cross breeding with local cattle was found to introduce a measure of disease resistance along with hybrid vigour. Research was devoted to animal health, particularly tick control through the use of acaricide dips, and the correction of dietary mineral deficiencies.

African smallholders, particularly in Central Province with reasonable access to Nairobi, had already started buying grade (or crossbred) cattle from settler farmers long before the adoption of the Swynnerton Plan (1954). However, the Veterinary Department was not prepared to provide support services to smallholders until 1955 when the controlled introduction of grade cattle to “African areas” was approved. By 1960 dairy production had become a major source of income for small farmers, despite the fact that milk sales were controlled by a quota system, favouring the large and well-established farmers from 1954 to 1970. Artificial insemination had been available for some time but was only widely adopted in the late 1960s when the cost per service had fallen, due to improvements in technology and external financial assistance. The private ownership of bulls was then proscribed by administrative decree but smallholders were already organising co-operatives for milk marketing and the delivery of input services (Cowen 1981). The support of smallholder producers was used by the KCC to resist state control of dairy marketing, which was recommended by the Kibaki Commission in 1965 (Heyer 1981).

Research: A Dairy Cattle Research Project supported by the Netherlands Government was in operation from 1969 to 1977. The research, based at NAHRC, was conducted in collaboration with the Wageningen International Agricultural Centre and the Utrecht Veterinary College. The substantial research output included studies on grass and fodder production and conservation, use of crop by-products, acclimatisation of imported exotic cattle, calf rearing and fertility management (Waithaka 1994). During this period pasture studies, including smallholder farm surveys, were also in progress at the Kitale National Agricultural Research Centre (Chudleigh 1977 and Goldson 1977). It is claimed that “milk production did not take off during that period due to low, government controlled pricing (De Jong & Zwart 1994). About this time a substantial study of small holder dairy development in Kenya was completed and used in the Farm Management Handbooks Series (Stotz 1979 and Stotz 1983).

Following the completion of the Dairy Cattle Research Project, the National Dairy Development Project (NDDP) was launched in 1980, again with assistance from the Netherlands Government. This was essentially an extension programme aimed at diffusing the findings of the Dairy Cattle Research Project presented as a

technological package including zero-grazing, improved cow housing, production of Napier Grass and recycling of manure, to smallholder farmers in high potential areas (De Jong & Zwart 1994). Initially a grant scheme was devised to help marginal farmers with the purchase of heifers, with additional finance from the Agricultural Finance Corporation (AFC). A Farm Liquidity Budget Form was devised to assist in financial planning. However the grant scheme was abandoned in the early stages of the project, while AFC loans did not materialise. The project therefore concentrated on full-time farmers with sufficient private means to invest in dairy cows.

None the less, over the period 1977 to 87 cattle numbers increased at over 3 percent annually, while nationally milk production increased by over 4 percent per year. Cross-bred, “grade” heifers were purchased, often with credit from the co-operatives, from the large commercial dairy farms, some of which specialised in breeding (Freeman, Ehui & Jabbar 1998, Oluoch-Kosura & Ackello-Oguto 1998). Various heifer-in-trust schemes were also in operation, whereby a farmer is provided with an in-calf heifer on the understanding that the first heifer calf to be produced will be returned to the scheme management for distribution to another farmer, or some similar variant (Afifi-Affat 1997). The NDDP extension agents encouraged the formation of farmer groups, or zero-grazing clubs, established demonstration farms, organised workshops, field-days and study tours and distributed Dairy Extension and Advice Forms to improve management recording.

From 1990 to 1993, the NDDP was followed by the Dairy and Poultry Research Project, again supported by the Government of the Netherlands, to strengthen research at the NAHRC. This project also adopted farming systems research techniques, with district cluster teams including both research and extension staff operating from selected Regional and National Research Centres. The resultant research recommendations were passed to the Centre Research Advisory Committee, with members from local Universities, extension, agro-industries and farmers, for approval. The approved programme included studies on forage and fodder production, calf rearing, fertility management, tick control and economics.

It may be noted that around this time the KARI Directorate conducted a research prioritisation exercise for the whole Institute. Dairying was identified as the first priority area of research, above all other forms of livestock system and the major food crops (KARI 1991). The International Service for National Agricultural Research has been assisting KARI with organisational structure and research prioritisation since the early 1980s. In 1996 an exercise was carried out, by KARI staff using a methodology devised by ISNAR personnel, to prioritise research activities within the dairy programme. (KARI 1996). On the basis of the predicted benefit-cost ratios, the four main “research thrusts” were ranked in the following order; (1) Socio-economics, (2) Feed resources and utilisation, (3) Animal health and (4) Animal breeding/ genetic improvement.

From 1991 the multi-donor funded Livestock Development Programme has been in operation. This too is essentially an extension programme, the overall objective being to improve the standards of living of the rural population, of selected areas, through increased milk production and consumption. It is aimed at relatively disadvantaged areas, such as Western Kenya where intensive dairy farming is a new activity, where much of the milk is likely to be used for home consumption and at

promoting women as dairy farmers and co-operative members. The main activities include upgrading of cattle, improved fodder production and conservation, disease control and farmer training through on-farm demonstrations, workshops, seminars and study tours. A substantial list of project outputs have been achieved, but improvements in production and the welfare of dairy producers have been hampered by the general deterioration in service provision following structural adjustment.

Marketing: The decline of the KCC and the problems of milk marketing were outlined above. Although established as a large-scale farmer co-operative in the 1940s, and long-registered as a private limited company, it is in effect a parastatal. As such it has been inhibited by the fact that transactions costs of milk marketing in Kenya, as in many other developing countries, are necessarily high (Staal, Delgado & Nicholson 1997). Rural feeder roads are relatively poorly developed and maintained and may even become impassable in the rainy season. As a result communications are difficult and transport costly. Milk is a highly perishable and bulky product (around 85 percent water), which make transactions costs greater than for other farm products. Its shelf-life may be increased by simple processing into “*mala*” or soured milk, but this adds to costs. Quality assurance is difficult without scientific milk testing and this implies potential losses by traders, processors and consumers when milk is spoiled or adulterated. Given that pan-territorial and pan-seasonal pricing was imposed on the KCC problems were inevitable. The costs of transport differ considerably between peri-urban producers and those in the more remote and marginal areas, while costs of production differ between the rainy season when surpluses occur and the dry seasons when shortages are more likely. An influential KARI study recommending the adjustment of milk prices to cover costs of production in different areas was published in 1992 (Waithaka & Nijssen 1992). With the liberalisation of the milk market substantial price differentials are emerging (Staal, Delgado & Nicholson 1997, Omore *et al* 1999).

Since the economic reforms of the early 1990s marketing channels have diversified, with increasing amounts of raw milk sold directly to consumers, although this practice has not been sanctioned by the authorities. Self-help groups, not registered as co-operatives and therefore not constrained by co-operative law, have been established to collect and sell milk. At the same time the official farmer co-operatives now sell to consumers, traders, or private dairies as well as the KCC (McDermott, Randolph & Staal 1999). The extent to which the KCC is by-passed depends upon proximity to major market centres like Nairobi. Peri-urban producers can obtain a higher price (net of transactions costs) by direct and informal sales to processors and consumers, whereas producers in more remote areas find it more attractive to accept the price, and delayed payments, offered by KCC (Staal, Delgado & Nicholson 1997). One study, in Nyeri district, has shown overall improvements in milk prices and farm household incomes resulting from liberalisation of the milk market (Staal & Shapiro 1994). However, quality and hygiene standards may deteriorate, unless some monitoring and control is re-imposed. Whatever the outcome it is clear that milk marketing has suffered a period of major change and instability, which may have had a temporary adverse impact on milk production and supply.

Transactions costs also impinge on the supply of farm inputs. The higher costs of inputs, together with the lower net returns for farm products, explain why farms in the more remote, lower-potential areas are likely to farm less intensively and to place a

higher emphasis on production for subsistence rather than for the market. This argument applies to concentrate feeds, which are likely to be more readily available, at a lower price to peri-urban livestock keepers than to others in more remote areas. Concentrate feed manufacture and marketing has always been in private hands. However, this is not the case for key input services of animal health provision and artificial insemination.

Support Services: Clinical veterinary services, provided by a mixture of government and private veterinarians, together with state-run laboratories conducting research on important animal diseases, were established long before independence. Veterinary scouts were employed by the state to assist in the control of major epidemic diseases among African smallholder livestock. Training of animal health specialists was expanded after independence at certificate, diploma and degree levels and the Government Service to smallholders was expanded. The Field Services Division of the Department of Veterinary Services dispensed treatments and drugs, at subsidised prices at divisional veterinary clinics, and on regular “clinical runs” to a series of road-side points on a fixed circuit. The government veterinary service was also responsible for the control and supervision of the use of communal dip tanks for tick-control in high-potential areas, until 1977 when it took responsibility for their operation (Leonard 1987).

The delivery of animal health services by the State was affected by financial constraints in the early 1980s as budgetary allocations to the Department of Veterinary Services fell. This adversely affected clinical, disease control and vaccination services (Umali, Feder & de Haan 1992). A policy of full cost recovery from farmers, with the ability to pay, was instituted in 1986 (Otieno-Oruko 1999) and a freeze was instituted on the appointment of new veterinary service staff. In the course of the following decade the process of privatisation was carried further. The stated policy aim was to facilitate establishment of private veterinary practice in all viable areas by providing line credit on a commercial basis, to encourage the development of co-operatives and farmers’ groups for dip tank management and other service delivery and to reduce government intervention to extension advice, control of epidemics and public health measures.

In the general debate regarding the privatisation of animal health services, a distinction has been drawn between public goods, such as the control of zoonoses or major epidemic diseases and private goods such as curative treatments. The former consists of goods or services from which potential beneficiaries are not readily excluded (non-exclusivity) and for which use by one person does not affect the benefits derived by others (non-rivalry) (Holden 1999, Leonard 1993, de Haan & Bekure 1991). Classification of many animal health services is debatable, while public goods may be provided by group activity (e.g. tsetse control) or be delivered privately with Government funding (e.g. vaccination campaigns). In either case the public sector must retain a role in the control of epidemic diseases, research and extension, drug and vaccine quality control and food hygiene inspection. An important task in Kenya, and elsewhere, is to better integrate the para-veterinarians or veterinary auxiliaries, now working outside the government service, with the professional graduate veterinarians.

In Kenya the establishment of private veterinary practices has expanded more slowly than intended, partly because of the excessive costs of credit and of the recommended equipment for a clinic, and partly because of unfair competition from Government veterinarians who continue to draw a salary and charge for clinical services (Otieno-Oruko, Upton & McLeod 2000). Although animal health services are generally available, costs have escalated under privatisation (Otieno-Oruko, Upton & McLeod *op cit*). An infection and treatment immunisation method against East Coast Fever has been developed, to reduce the need for dipping, but the cost is estimated at between US\$ 18 and US\$ 20 per head, and careful veterinary follow up is needed to identify adverse reactors (Muraguri *et al* 1998).

The delivery of improved bull semen through artificial insemination is clearly a private good. None the less, the Government Veterinary Service has been responsible for this service since the 1950s (Cowen 1981). After independence the service was heavily subsidised and is claimed to have contributed substantially to the expansion of the smallholder dairy sub-sector. The Central Artificial Insemination Station, Nairobi has a monopoly in the production of bull semen, some of which may be sold directly to large-scale farmers but most of which is distributed through the Department of Veterinary Services.

Before the onset of budgetary problems the service was subsidised and farmers paid a nominal fee per insemination. Since then lack of funding has led to a serious deterioration in service delivery and a massive increase in the price, since full cost recovery is expected (Otieno-Oruko 1999). As a result the majority of dairy farmers have switched to using bulls for natural service. It is estimated that by 1996 only 10 percent of the grade cattle population is served by AI (MALDM 1996a). The results are increased keeping of bulls by small-holder producers, long calving intervals due to problems of arranging timely service where there is no bull and a general decline in the genetic make-up of the national dairy herd (private communication by the Director NAHRC). Alternative private and co-operative group services are developing but prices vary substantially depending upon farm location and the service used.

Much of the previous discussion relates particularly to changes in the policy and market environment experienced by smallholder milk producers. The large-scale commercial producers have experienced the same changes but, because of the economies of scale, are better able to cope. Internal, technological economies mean that some of the largest scale producers can justify milk cooling and processing on the farm, to employ their own veterinarians and to select and keep high quality breeding bulls. External pecuniary economies apply more generally to large scale producers in that transactions costs may be minimised by special contractual agreements with milk processors and consumers, with private veterinarians and with the Central Artificial Insemination Station (Staal, Delgado & Nicholson 1997).

Smallholder systems

Milk production is a well established activity among smallholder farmers in the upland high-potential zones of Kenya, and represents an important commercial enterprise along with cash crops such as coffee, tea, fruits or vegetables. The dairy enterprise is integrated, as a source of manure and consumer of crop by-products, with the food and cash cropping system. Dairying has spread to the lower-lying borders of

Lake Victoria and the Kenya Coast. Smallholder producers are estimated to keep 61 percent of all cattle in Kenya, 84 percent of the grade cattle, and to produce 66 percent of the milk. It should be noted that some smallholders also keep dairy goats. Indeed the Small Ruminant CRSP programme for the introduction and promotion of a dual purpose goat has operated in Kenya for many years (Semenye *et al* 1989). In addition camel milk is produced in the pastoral areas. None the less it is estimated that cows' milk makes up 83 percent of total milk production in Kenya (MALDM 1996a).

A distinction may be drawn between two main types of smallholder milk production system;

- a) intensive, with grade (exotic or cross-bred) cattle
- b) semi-intensive, mostly indigenous zebu, multi-purpose cattle.

The most intensive systems are found within 150 km of Nairobi, the capital and largest city. This area includes all of Central Province and the central part of Rift Valley Province. Over 80 percent of smallholder-owned grade cattle are located in these two upland areas (see Table 8). The majority of cattle kept in these two areas are exotic or cross-bred grade-cattle. Although intensive smallholder dairy systems, with grade cattle, exist in other provinces, such as Eastern, Western, Nyanza and the Coast, they are in much smaller numbers. However, as noted earlier, dairy cattle numbers in Coastal Province are claimed to have increased rapidly in recent years.

Table 8: Cattle numbers by Province and by production system (1993)
(Percentage of system total in parenthesis)

	Smallholder intensive; grade cattle	Smallholder semi-intensive East African Zebu	Large-scale commercial; exotic cattle	Grassland based East African Zebu	Total cattle
Rift Valley	1,393,547 (55)	1,299,360 (24)	272,254 (54)	2,059,100 (46)	5,024,261 (39)
Central	642,500 (25)	77,530 (1)	166,500 (33)		886,530 (7)
Eastern	217,440 (9)	531,820 (10)	56,000 (11)	965,860 (22)	1,771,120 (14)
Nyanza	149,110 (6)	2,089,200 (39)			2,238,310 (17)
Western	101,830 (4)	924,960 (17)			1,026,790 (8)
Coast	40,100 (2)	531,820 (10)	5,300 (1)	648,300 (14)	1,119,330 (9)
North Eastern	150 (0)			809,310 (18)	809,460 (6)
Total	2,544,677 (100)	5,348,500 (100)	500,054 (100)	4,482,570 (100)	12,875,801 (100)
Percentage of all cattle	19.8	41.5	3.9	34.8	100

Source: Peeler & Omore 1997

Within the “intensive” sub-group, the farmers achieving the highest level of intensity practice zero-grazing. Typically the farm land amounts to about one hectare, and the dairy herd consists of few animals, usually a Holstein–Friesian or Ayrshire

cross with the local East African Zebu. Farm families are often quite large. Income is derived from milk, cash crops and off-farm work. The bimodal rainfall regime generally allows two food crop harvests per year. For example, in the farming systems survey described above, the 134 farms in the Upper and Lower Middle Zones of Murang'a District, Central Province averaged 1.85 hectares in area, with an average family size of 11.37 persons. Over 78 percent of families owned dairy cattle, with an average herd size of 2.46 animals. Maize, beans and bananas were the main food crops while tobacco, avocados and mangoes were grown for cash. Pigs and poultry were also raised. In addition, 37 percent of households received income from off-farm work (MALDM & KARI 1993). Mainly because of land shortage, many farmers reported the purchase of fodder as well as maize and other concentrate feeds. Although AI services were readily available a majority of farmers used bulls. A high proportion reported regular cattle dipping, de-worming and vaccination. Manure is a valuable by-product worth about 28 percent of the value of the milk produced on small farms (Lekasi & Tanner 1998).

Natural forage, mostly Kikuyu, Star and Rhodes grass, is cut and carried although many farmers now plant Napier grass. Some estimates of areas of natural and planted fodders, in key dairying districts, are provided in a recent report (Omore *et al* 1999). Crop residues from maize and bananas, together with cuttings of weeds and grass verges are also used. Markets have developed for Napier grass, maize stover and roadside grass. Typically 2-3 kg of concentrates are given to milking cows daily, consisting of compounded dairy meal, maize bran, cotton seed cake or other suitable products (McDermott, Randolph & Staal 1999). Cows are milked twice a day, typically by hand. Yields are low, generally 5-8 kg per day and calving intervals are long, at about 600 days (Odima, McDermott & Mutiga 1994). Calf mortalities are also high. Despite these productive inefficiencies, returns to scarce resources are acceptable because of relatively low labour and other input costs.

Along the gradient of decreasing intensity, there is an intermediate type of system, still using grade cows but employing an open grazing or paddock feeding system. The number of cattle and the land area per household are slightly larger (the latter at 1.5 to 5ha) than those under the zero-grazing system. The yields obtained and the costs of production are somewhat lower however. Otherwise the systems are quite similar (for more details see Omore *et al* 1999). These first two sub-groups are pooled in the Peeler and Omore study (1997). Production parameters are given in Table 9.

The majority of small-scale milk producers are less intensive, mostly dependent on the small East African Zebu cattle, which provide milk, meat, manure and in some cases draught power. Although these systems are present in the high potential Agro-Ecological Zones 1 to 3, they are also found in the dryer transitional and semi-arid, lowland zones 4 and 5. Nearly 60 percent of these systems are found in the west of Kenya; in Western and Nyanza Provinces (Table 7). Farm sizes may be up to 5 hectares of cultivated land but natural pasture may also be available. Cattle are grazed, herded or tethered during the day and kraaled during the night. They are generally not supplied with concentrates or mineral supplements and few disease control measures are practised. Cows are milked once a day for the first 3 to 5 months of lactation, while calves are also suckled. Milk off-take per cow per year is low. For other production parameters, see Table 9.

Table 9: Production parameters for different dairy production systems

	Smallholder intensive grade cattle	Smallholder semi-intensive East African Zebu	Large-scale commercial exotic cattle
Age at first calving (yrs)	3.4	3.0	2.5
Mature weight (kg)	300	250	400
Calving rate (% / year)	70	65	80
Pre-weaning calf mortality (% / year)	13	20	10
Age at weaning (days)	183	274	122
Adult mortality	9	9	3
Milk offtake (kg / lactation)	2,500	250	5,000

Source: Peeler & Omore 1997 (*adapted from other sources*)

Production parameters may be used, by means of a steady-state herd model, to predict the physical productivity of milk and animals per carrying capacity unit (a crude measure of feed energy requirement) per cow or per animal in the herd. The model used by Peeler and Omore (1997) was the Livestock Productivity Efficiency Calculator (James 1991). Estimates of the milk production by system and province are given in Table 10. These results support the claim that 67 percent of cow's milk is produced on small-holder mixed farms; the bulk of this (56%) from the intensive producers. The grassland-based mainly pastoral systems only contribute a small proportion of the total milk output and are therefore ignored in the remainder of this discussion.

Table 10: Milk production in Metric tons by Province and by production system (1993) (*Percentage of provincial total by system in parenthesis; last column percentage of grand total*)

	Smallholder intensive grade cattle	Smallholder semi-intensive East African Zebu	Large-scale commercial exotic cattle	Grassland based East African Zebu	Total all cattle
Rift Valley	941,491 (60)	79,752 (5)	425,931 (27)	112,989 (7)	1,560,163 (51)
Central	434,078 (62)	4,759 (1)	260,483 (37)		699,319 (23)
Eastern	146,904 (46)	32,642 (10)	87,610 (27)	53,000 (17)	320,156 (10)
Nyanza	100,740 (44)	128,231 (56)			228,971 (7)
Western	68,797 (55)	56,772 (45)			125,569 (4)
Coast	27,092 (28)	26,124 (27)	82,916 (9)	35,574 (37)	97,082 (3)
North Eastern	101 (0)			44,409 (100)	44,510 (1)
Total	1,719,203 (56)	328,281 (11)	782,315 (25)	245,972 (8)	3,097,771(100)

Source: Peeler & Omore 1997

With further information on the prices of culled animals, and of milk, estimates can be made of the financial gross margins. For the KARI/DFID manual of livestock production, stock for slaughter were valued at Ksh. 55² per kg liveweight, exotic breeding cattle at Ksh. 99 and East African zebu cattle at Ksh. 77; prices prevailing in

² In recent years the US\$ has been valued at approximately KShs 60

a Nairobi cattle market in 1997 (Peeler & Omore 1997). Milk was valued at the current price, of Ksh. 14 per kg, offered by the Kenya Co-operative Creameries. On this basis the gross margins per cow, under the three production systems small-holder intensive, small-holder semi-intensive (meat and milk) and large-scale commercial production are given in the first row of Table 11. The second row gives somewhat higher estimates for the small-holder producers, informed by more recent surveys (Omore *et al* 1999). The discrepancies between the two sets of results appear due to differences in productive performance rather than price inflation. Milk prices are slightly higher in the latter estimates but heifer prices are slightly lower. Annual milk offtake in the second set of estimates appears close to the lactation offtake in the first set, despite a calving rate of 70 percent for intensive production.

Table 11: Gross margins per cow from Kenyan dairy production systems

	Smallholder intensive zero-grazed: grade cows	Smallholder semi-intensive: grade cows	Smallholder semi-intensive: zebu cows	Large-scale commercial: exotic cows
Peeler & Omore 1997	17,633		7,567	38,677
Omore <i>et al</i> 1999	25,000	20,000	9,000	

These figures suggest that the returns to smallholder milk production are much lower than those obtained by large-scale commercial producers. This reflects the higher levels of productivity achieved on the large-scale holdings, and illustrates the potential for improvement of productivity of smallholder production. As might be expected the gross margin per cow increases with increasing intensity of production. The results should be viewed with caution since, as was shown in Figure 5, the relative prices of milk, meat and feed grain have changed over the last 10 years. Furthermore there are large inter-regional differences in the prices of milk and of cattle, especially since markets were liberalised. Farm gate and retail prices for milk range from Ksh. 11 and Ksh. 14 per litre in Central Province to Ksh. 20 and Ksh. 35 per litre at the Coast (Owango *et al* 1998, Omore *et al* 1999). The above estimates must be subject to large standard errors but the ranking of alternative systems is probably unaffected. It is also likely that the value of manure and draught power has been ignored in these calculations.

In order to estimate the net margin or profit, it is necessary to quantify the fixed costs of cattle housing and equipment, labour inputs and the opportunity costs of land and capital. For mixed crop-livestock systems, such as the smallholder dairy farms of Kenya, the accurate assessment of fixed costs for an individual enterprise is fraught with difficulty. A fairly sophisticated programming model is likely to be needed. None the less, attempts have been made. Variations in the (*full*) production costs of milk, under zero-grazing, were investigated by Waithaka and Nijssen (1992) who estimated that fixed costs of land, labour and capital, on average make up 46 percent of the total. They calculated that the price of milk offered by KCC in March 1992, of Ksh. 5.20 per litre, was inadequate to cover the costs of production in even the lowest cost NDDP districts. Their recommendations were that milk prices would have to rise and that the break-even price differs substantially between districts.

In another study, using data from Sellen *et al* (1990) for farms in Nyeri District of Central Province, net returns were estimated for open-grazed, semi-zero and zero-grazed farms, together with the impacts of market liberalisation (Staal & Shapiro 1994). The fixed costs of land, labour and capital were estimated to be many times greater than the costs of tradable inputs. None the less net returns were found to be positive even under price control, and to increase after de-control of the milk market. In this study returns per unit of milk were shown to increase with increasing intensity. This contrasts with the findings of Baltenweck *et al* (1998) which suggest that, although returns to labour per cow increase with increasing intensity, returns to labour per litre of milk decrease. These findings are interpreted as suggesting that if milk prices decrease over time, low intensity systems will remain competitive, while high intensity dairy systems may not (McDermott, Randolph & Staal 1999).

The returns to individual factors of production, land, labour and capital may be assessed qualitatively. Productivity per hectare of land is high, in comparison with most crops, given that the value of plant material growth is augmented by its conversion into animal products. It is widely claimed that dairying competes very favourably with cash crops such as tea, coffee and even horticulture (MALDM 1996a). The more intensive the livestock system, the greater is the return per hectare of land, by definition. The purchase of feeds from outside the farm, as is common practice, further increases the net returns per hectare of the farm-land.

Recent studies of smallholder intensive dairying suggest that the returns to family labour (net farm income after all other costs have been subtracted) amount to the equivalent of nearly US\$1,000 per year (Ksh 60,000 at the recently quoted exchange rate) (Baltenweck *et al* 1998). This is not a very high figure, considering that the average farm household consists of 9 or 10 persons. However, this estimate is based only on the dairy enterprise; other sources of income such as crop production and off-farm work are likely to be significant. Intensive dairy production is, by its nature, heavily labour using in daily hand-feeding, milking, calf rearing and regular hygiene and health measures. However, the opportunity costs of family labour are relatively low especially if the dairy work can be fitted around other forms of employment. Opportunity costs of labour are likely to be higher in the more densely populated high-potential zones where opportunities for alternative productive activities are greater. Returns to labour are presumably acceptable, on average, otherwise many farmers would be withdrawing from milk production. The positive net returns from dairying, after deduction of labour costs, estimated by Staal & Shapiro (1994) seem to confirm this.

The establishment of a dairy unit represents a substantial capital investment, especially if exotic or cross-bred heifers are purchased and a concrete-based and metal-roofed stall is built. The minimum price likely to be charged for a grade dairy cow is Ksh. 50,000 (MALDM 1996a). Additional capital is invested in housing and equipment. Thus, a farmer entering the industry is likely to need credit, in cash or in kind (e.g. a heifer-in-trust), but once the debt is cleared his/her wealth will have increased significantly. (It should be noted that the estimated return of Ksh 60,000 quoted above should cover the costs of the substantial labour inputs in addition to providing a return on capital.) As suggested above, credit available to smallholders is limited. A survey of peri-urban, smallholder dairy farmers in Kenya in the mid 1990s, found that only 38 percent were in receipt of loans, two thirds of which were

obtained through co-operatives and a further fifth from commercial banks. (Oluoch-Kosura & Ackello-Ogutu 1998). About half the borrowers were credit constrained, in that they wished to borrow more at current interest rates but were unable to do so. About 40 percent of the loans were used to purchase crossbred dairy cows. Econometric analysis suggested favourable returns to investment and unsatisfied demand for credit (Freeman, Ehui & Jabbar 1998).

It is estimated that over a third of the milk produced by smallholders is consumed within the household by family members and calves. The marketed surplus of a little over a million MT, is sold either:

- directly to individual or institutional consumers (55 percent) or
- to co-operatives, self-help groups and traders, including KCC (38 percent) or
- to private processors (7 percent) (Omore *et al* 1999).

In this context only 20 percent of marketed milk is delivered to KCC or other private processors. Much of the rest is sold unprocessed as raw milk.

There are large differences however, between regions. In central Kenya within easy reach of Nairobi, and along the Coast near the second city, Mombasa, and the coastal hotels there is a ready market for milk and milk products. Almost all the milk is sold directly to consumers, to co-operatives or local processors. In more remote areas marketing through KCC still dominates, with over 50 percent of marketed milk passing through the company factories.

There are very large discrepancies in the price received by farmers, varying from Ksh. 12 per litre in the more remote areas to Ksh. 36 around Mombasa. Marketing margins are estimated to vary between –3 percent up to 36 percent (Omore *et al* 1999). However, in general it has been demonstrated that farm-gate prices for milk have improved since liberalisation has led to increased market competition (Staal & Shapiro 1994).

Concerns over public health have arisen in view of the increasing quantities of raw milk sales. In the past, the policy of requiring all milk sales to be directed through the KCC for pasteurisation, was designed to minimise risks of human infection with zoonoses, such as brucellosis or tuberculosis. Studies have been launched under the MOA/KARI/ILRI Smallholder Dairy Project. However, the limited information available so far suggests that the risks are not serious (Omore *et al* 1999). Clearly such risks as do exist are likely to be greater in the peri-urban intensive milk production areas where most direct sales of untreated milk are made.

There is a widespread consensus that there is considerable potential for expansion of smallholder dairy production (MALDM 1996a & b, Omore *et al* 1999, Freeman, Ehui & Jabbar 1998). This is expected to come largely through increases in productive efficiency. It is suggested that the rapid human population growth is further reducing land available for livestock production “making it impossible to increase livestock numbers” (MALDM 1996b). In the high potential areas of the Central and Rift Valley Provinces, it appears that 75 to 100 percent of farmers keep dairy cows. However, there may be scope for some increase in numbers in lower lying areas such as parts of Western Kenya.

A comparison of estimates of production parameters and margins from smallholder dairying with those for large-scale commercial production suggest considerable scope for increase in productive efficiency by the former group. However, there are formidable constraints on increasing productivity, the most important of which is nutrition. The pressure on the land in Agro-Ecological Zones 1 to 3, means that fodder production is costly and this is reflected in high prices for purchased forage. Concentrates are expensive and credit for operating expenditure is unavailable (Oluoch-Kosura & Ackello-Ogutu 1998). In addition, the inadequate network of rural roads and poor communications create problems of marketing and input supply. These have been exacerbated by the deterioration of public sector provision of marketing, artificial insemination and veterinary facilities. However, there is evidence that private sector activity is expanding to fill the gaps with some advantages in terms of farm prices.

Large scale dairy production

The class of large-scale dairy producers includes not only private individuals but also commercial firms and parastatals such as the Agricultural Development Corporation. The majority are found in the “peri-urban” area including Central Province, the central part of Rift Valley Province and parts of Eastern Province around Mount Kenya. Practically all grade cattle, on large-scale farms, are located in these upland areas (see Table 7). It is suggested that the actual numbers may be somewhat lower than those given in the official statistics (Omore *et al* 1999).

This category of farming systems includes a wide range of farm sizes (from 20 hectares to several thousands of hectares), and levels of productive performance. Methods vary from semi-intensive low-input, low-output holdings to highly intensive enterprises, with irrigated forage production and mechanised milking. Herd sizes range from 20 cows up to 2.7 thousand on one large farm at the Coast, where over 1,000 cows are milked daily. However, most herds are of fewer than 100 animals. Friesian-Holstein is the most common breed, although there are some Ayrshires, and declining numbers of Jerseys and Guernseys. Some producers in the dryer areas such as the Kenya Coast use Sahiwal Zebus (*Bos indicus*) and their crosses with the local East African Zebu as these animals appear to be better adapted to local conditions than the temperate (*Bos taurus*) breeds.

The variety of large-scale systems is just as diverse as that of the smallholder systems. For example one case, described in Peeler and Omore (1997), is a herd of 360 Friesian, Sahiwal and crossbred cattle. No concentrates are fed, cows are milked only once per day and a high percentage are fattened for beef after just one lactation. Mean milk offtake per lactation is estimated at 1,125 kg. In contrast, a 90 cow Friesian herd at Naivasha, zero-grazed and fed a total mixed ration based on home-grown irrigated lucerne and purchased cereals and milked thrice daily achieves an average yield of 6,715 kg. At the National Sahiwal stud, Naivasha, and in milking trials with Ayrshire-Sahiwal crosses at the Coast, mean lactation yields of 7,500 kg are obtained.

With such a wide range of different production systems, specification of typical or average production parameters must be subject to large standard errors. None the less an attempt was made by Peeler and Omore (1997) and their estimates are

presented in Table 9. Although on average these production traits for the large-scale commercial farms are estimated to be better than those for small holder producers, it should be clear from the above that some of the large-scale herds perform less well than the average intensive small scale unit. On the basis of these figures it is calculated that 25 percent of the national milk supply is produced on these large-scale farms (Table 10), even though they keep less than 4 percent of the national cattle population (Table 8)

The average gross margin per cow is estimated to be 50 percent higher than that obtained by intensive smallholder producers (Table 11). However, this is strongly influenced by the average milk yield per lactation, which is assumed to be twice as high on the large farms. Fixed costs are estimated to be somewhat higher on the large farms, so that with the same level of lactation yield, the large farms would earn a lower gross margin per cow. The marginal revenue per additional kg of milk per lactation, net of concentrate feed costs, is Ksh. 7.14. Hence, under these conditions yield increase is advantageous in spreading fixed costs and raising gross margin per cow

Although the average margin per cow is higher on the large-scale farms, the return per hectare of land may well be lower since, with a larger area, a lower intensity of production is justified. Wages for hired labour per cow may exceed the opportunity costs of family labour used on smallholdings. On the other hand, large scale operation allows scope for specialisation and division of labour, which may result in greater efficiency and labour productivity. Capital investment, in buildings and equipment, as well as high quality livestock, is likely to be higher per cow on large farms. None the less the high yields and gross margins are likely to yield a satisfactory rate of return.

Since the liberalisation of the dairy industry in 1992, when the Kenyan Government revoked KCC's monopoly of urban milk sales, many large-scale producers have established their own milk processing facilities. Most of these processing plants have been established in the vicinity of the major cities, Nairobi and Mombasa and are registered with the Kenya Dairy Board. Apart from processing their own milk many of these enterprises also buy in milk from local smallholder producers. Pasteurised milk, *mala*, yoghurt and some cream and cheese are sold directly to supermarkets, public institutions and hotels. Dairy processors around Mombasa, in Coastal Province, are described in a current study in progress by the Department of Agricultural and Food Economics, The University of Reading (Henson, S.J., R.J. Loader and A. Brouder personal communication). These processors are selling their dairy products for much higher prices than those offered by the KCC. Indeed some are buying raw milk at prices above the KCC level, and are still earning a satisfactory return on the processing activity.

A few large-scale dairy farmers, in more remote areas, may have to sell to KCC. However, they have advantages of scale in dealing with KCC, in that the large farms are likely to be selected as collection points to which smallholders must bring their smaller daily deliveries. Thus all large-scale farm produced milk is processed, at least by pasteurisation, before sale. Given that animal health services are more readily provided on large-farms, fewer sanitary and quality assurance concerns are likely to apply than for smallholder milk.

The potential for expansion of numbers of large-scale commercial dairy producers is extremely limited. Given the population density in the high potential areas and the continuing rural population growth, pressures are likely to intensify for the break-up and redistribution of these large holdings. There may be some scope for increasing herd sizes if demand expands faster than supply and comparative advantage, of milk production over the main cash crops, improves.

Having estimated the average productivity of dairy cattle on large-scale farms to be considerably higher than the levels achieved on smallholdings, it would be hazardous to forecast further improvements in productive performance overall. However, the comparison of different individual large-scale farms show substantial variation in performance and there must be some scope for improvement in production and margin per cow for the least productive groups.

Constraints to expansion are akin to those affecting smallholders, but may be less restrictive. Large farmers are also faced with high opportunity costs for the high potential land, where profitable cash crops can also be grown, with poor communications, expensive purchased concentrates, declining public sector services for marketing and input supply and high interest rates charged by the official credit agencies. However, the control of a large area of land alleviates the problems of allocating this resource among competing alternative uses. Large farmers generally have better means of communication (e.g. telephones) and transport (e.g. privately owned vehicles) than most smallholders. Many have established their own processing and marketing facilities, while they are all better placed than smallholders to arrange contracts for the supply of inputs, services and credit. The largest units employ their own veterinarians, while others may establish a formal contractual agreement with a particular private practice. Some inputs, such as high quality bull semen (for artificial insemination) and production credit might be obtained from international sources.

In summary, it appears that, on average, the large-scale dairy producers may have a comparative advantage over the smallholder sector. The average gross margin per cow is much higher, as is the gross margin per unit of feed. However, this provides no assurance of greater intensity of land use. Studies from many other parts of the world suggest that productivity per hectare is negatively associated with farm size (Berry & Cline 1979, Kutcher & Scandizzo 1981, Otsuka 1988). Kenya's own Land Settlement Programme is often quoted as an example, where the subdivision of large white-owned estates into small farms redistributed to Africans led to immediate increases in incomes and productivity (Binswanger & Elgin 1998). In any case the productive performance of dairy cows varies so much between large-scale producers, it would be dangerous to conclude that large-scale production is inherently more efficient in all respects.

In fact there are important complementarities between large- and small-scale dairy producers. Historically the introduction of exotic (*Bos taurus*) cattle and the associated production technology, the establishment of a processing and marketing co-operative, the KCC, and the conduct of research and development in the field of animal health and disease control, are largely due to the settler population. Today, there is much inter-dependency. Smallholders buy their grade heifers from, and sell their milk to large-scale producer/milk processors. Thus, the latter group depend upon

smallholders to provide a market for their surplus heifers and an additional supply of milk which justifies the establishment of a high capacity processing plant. The large-scale producers may provide a sufficiently concentrated market to justify the establishment of private veterinary practices and Artificial Insemination services.

Summary and conclusions

It may be concluded that Kenya has a well-established and functional dairy industry, including both large- and small-scale producers, which continues to make an important contribution to Kenya's economic and social development:

- It makes a significant contribution to the National Income, at about 50 percent of the value of all livestock production, which in turn represents 30 percent of agricultural Gross Domestic Product.
- It comes close to meeting the growing domestic demand for dairy products resulting from rapid rural and urban population growth, and changing *per capita* incomes. Consumption levels are higher than in other countries of Africa.
- The maintenance of a national self-sufficiency ratio of near 100 percent implies a high degree of import substitution with associated savings in foreign exchange. Potential markets for Kenyan dairy exports exist in neighbouring countries.
- It provides employment and income for large numbers of rural people, in a situation where
 - (i) nearly 80 percent of the population depend on agriculture,
 - (ii) population density on the high-potential cultivable land is very high, and is still growing
 - (iii) a majority (90 percent) of the poor, which make up nearly 50 percent of the total population, live in rural areas (CBS 1998),
 - (iv) many of the poor farm households are female headed.

On these grounds a strong case can be made for Government policies aimed at facilitating the growth of the dairy industry, within the process of general economic development. If a choice had to be made between promotion of large-scale or small-scale dairying solely on the basis of relative productive efficiency, the decision would be difficult. As has already been shown, the large-scale producers probably achieve a higher level of productivity per cow and per unit of livestock feed, whilst the productivity per hectare of land, and intensity of land use may well be lower on the large-scale holdings. A comprehensive measure of "total factor productivity" requires a set of relative weights for the factor inputs based on their opportunity costs. If land is scarce and labour plentiful, then the opportunity cost weighting for the former will be high relative to that for the latter. Measurement in the context of integrated crop-livestock systems is particularly difficult. Overall, the relative productive efficiency of large-scale and small-scale production is at the moment indeterminate.

Intensive smallholder production is concentrated in the high potential upland areas of Central Kenya. The most intensive form, promoted by the National Dairy Development Project, involves a package of two or three "grade" or crossbred cows, zero-grazing, improved cow housing, Napier Grass grown as fodder and manure recycling. Typically two or three cows are kept, fed some purchased concentrates in addition to cut and carried fodder and milked twice a day. A slightly less intensive system, operated on somewhat larger farms in similar areas, is based on paddock grazing.

The semi-intensive smallholder system, based on larger herds of zebu cows, grazing natural pastures and milked only once per day, is found in more remote, medium potential areas, mainly in Western Kenya. Production per cow is lower than that of intensive production systems, but so too are the investment and operational costs. The Dairy Development Programme is largely aimed at introducing intensive production methods in place of these semi-intensive systems.

Large-scale systems, concentrated in the Central Upland areas, range from semi-intensive production with zebu cattle to highly intensive dairying with pure-bred exotic or cross bred cattle fed on irrigated forage and supplementary concentrates. Although large-scale dairying accounts for only 4 percent of the cattle population, it is presumed to yield a quarter of the national cows' milk supply. Expansion of large-scale systems is unlikely given the intense and growing pressure on high and medium potential land resources. However, valuable complementarities exist between large and small-scale dairy farmers in the sale of grade heifers from the former to the latter and the sale of milk for processing and onward sale from small- to large-scale producers. The large-scale producers may face some of the constraints experienced by small-holders, but they are less affected since they benefit from internal and external economies of scale.

Constraints on the expansion of intensive, small-scale grade-cattle production systems are (i) shortage, and hence high cost, of fodder and concentrate feeds, (ii) limited access to and high cost of credit (iii) failure of artificial insemination delivery systems (iv) limited market opportunities, particularly in the more remote areas, (v) disease and deficiencies in animal health services (vi) management weaknesses. It is difficult to rank these in order of importance since they are closely inter-related. Furthermore while the high cost of credit limits the opportunities for new entrants to the dairy industry, the failure of Artificial Insemination delivery systems leads to a decline in the genetic potential of dairy cows on existing dairy farms. Possibly poor animal nutrition and management are the primary constraints.

Given the parallel policy objective of promoting equity, concentration on the smallholder sector has obvious advantages. Intensity of production and labour employment per hectare is probably higher under small-scale production, so there will be a greater impact in rural poverty reduction, entrepreneurial activity linked with production for the market will be encouraged, while women, often among the most disadvantaged of rural people may be, and have been, drawn into small-scale dairying. So long as the rural population continues to grow employment in agriculture, and other rural pursuits, must increase to absorb these people. Small-holder production offers the best prospects for absorbing increasing numbers. However, as suggested above there are strong inter-dependencies between small-scale dairy farmers, and the now limited numbers of large-scale producers. There are some advantages to be gained, for the Kenyan dairy industry as a whole, by the continuing existence of a small number of large-scale dairy producers.

Dairying, as a form of mixed crop-livestock farming, contributes to meeting other key policy objectives of stability and sustainability. Stability is promoted by keeping animals, which serve as a form of insurance; they can be raised in years of good harvests and consumed or sold when crops fail. Even though the effect may be less

simple than this, it is likely that the total income derived from a diversified, mixed system will be more stable than that from specialisation. Sustainability is promoted because mixed crop-livestock systems, involving the feeding of crop residues and the application of manure to the soil, ensures some nutrient re-cycling, and is less likely than specialised systems to result in nutrient deficits or surpluses.

Policy instruments for promoting the development of the dairy industry fall under three main headings; prices, institutions and technology change. Prices are increasingly determined by market forces, unfettered by government controls, subsidies or taxes, following the imposition of the structural adjustment regime. Dairy farmers' margins are estimated to have improved as a result (Staal & Shapiro 1994, Owango *et al* 1998). However, market liberalisation should not imply total state disengagement. There is a continuing need for policies to maintain competitive market conditions, or to avoid the development of monopolies, to establish appropriate quality standards, to promote the spread of appropriate institutions and to provide public goods.

Rural roads and communications are public goods, the maintenance and improvement of which would lead to major improvements in the marketing of milk, and other farm products and in the availability and costs of inputs. It is estimated that 30 percent of the milk produced in two Districts of the Central Rift Valley is lost annually due to the poor state of the roads (MALDM 1996b, Omoro *et al* 1999). As discussed earlier the poor state of some rural roads accounts for the very large price differentials that currently exist between peri-urban and more remote areas.

The recently restructured Kenya Dairy Board is facing problems of quality control, given the widespread sales of raw milk, many officially licensed, which are strictly illegal. It is suggested that the situation might be rationalised by legalising sales of raw milk, provided that acceptable standards of cleanliness, non-adulteration and limited delay between production and sale are assured (Omoro *et al* 1999).

Farmers' groups have an important role in providing market power, and economies of scale in marketing and service provision, to small holder producers. Dairy co-operatives have proved very successful among small-scale dairy farmers in Nairobi's peri-urban zone, in both milk collection and the provision of credit, bulk feeds, drugs, veterinary and artificial insemination services. In parts of Central Province further from Nairobi, and at the Coast, dairy co-operatives are concerned only with milk collection and marketing. Fewer co-operatives exist in Rift Valley and Western Provinces. Nonetheless it is reported that, for all Kenya, dairy co-operative membership has risen from just over 2,000 members in 1963 to over 100,000 today. In parts of Western Kenya, Self Help Groups perform similar marketing functions to the dairy co-operatives, despite being registered with the Ministry of Culture and Social Services, rather than the Ministry of Co-operative Development. Some disillusionment with co-operatives has resulted from instances of mismanagement. Given the potential benefits to be derived from group activity, policies are needed to encourage the formation of new groups, the expansion of membership and the development of conscientious and reliable management. The Intensive Co-operative Management Assistance Programme (ICMAP) component of the Finnish assisted Livestock Development Project contributes to this objective.

Concentrate feed milling is already established, in the private sector, in high and medium potential areas. There are some concerns among farmers about feed quality, yet the only testing facilities are in Nairobi. More testing for quality control and dissemination of results is desirable.

Privatisation of animal health service delivery has had limited success. It is proposed that (a) the list of essential equipment required to establish a private practice, as specified under the Kenya Veterinary Association privatisation scheme, should be modified to reduce the capital investment cost (b) that unfair competition from public sector employed veterinarians, who currently offer their services at a fee, should be ended by persuading them to establish fully privatised practice, (c) that a residual public sector veterinary service is needed to provide public goods such as the control of major epidemic diseases and zoonoses, meat inspection and extension advice, and (d) that private practice by “para-veterinarians” (e.g. ex animal health assistants) should be legitimised and encouraged (Otieno-Oruko, Upton & McLeod 2000).

The expansion of private sector provision of animal health services is likely to be linked with the delivery of artificial insemination. Farmer access to AI services should therefore improve. Co-operative group activity is seen as a means of reducing the transaction costs of providing animal health and artificial insemination services; thus providing further justification for the encouragement of farmers’ groups. The National Livestock Recording Centre and the Dairy Recording Service of Kenya, collaborate with Central Artificial Insemination Station, the Breeders’ Societies and the Kenya Stud Book in monitoring and managing improvements in the genetic potential of the Kenyan cattle population (MALDM 1996a).

Credit is an important input in providing funds for the establishment, expansion or improvement of a dairy enterprise. It is also needed for the establishment of a processing plant, a feed mill, a private veterinary practice or an artificial insemination service. The provision of rural credit is subject to high transaction costs, moral hazard and other risks. Government intervention may be justified to improve farmer access to credit and to reduce the charges.

Promotion of technological change is an important area where government intervention is justified. This involves the whole knowledge and information system, including both research and extension/diffusion systems, since the private sector is likely to under-invest in these processes. It may be inferred, from the wide range in productive performance between smallholders and some large-scale farmers, that improved technologies are already available. Research should be oriented towards on-farm adaptive studies to identify farmers objectives, opportunities and constraints. Linked with these activities socio-economic studies should be aimed at monitoring and evaluating the impacts of the changing policy environment. Analysis of the economics of alternative methods of controlling major diseases, such as East Coast Fever, is important in this context.

The public sector agricultural extension service is failing to reach many farmers. A recent study has shown that, even in Central Province where the ratio of extension workers to farmers of 1:500 is higher than elsewhere in Kenya, fewer than 50 percent of farmers receive livestock extension advice (Staal *et al* 1997). Communication of

options for improved production and management is an important public sector activity. Government support is necessary, while extension should be better integrated with adaptive and farmer-participatory research.

7. The Kenyan poultry sector

Most rural families in Kenya keep poultry. The proportion is put at 90 percent in the Animal Production Annual Report (MALDM 1996a). Similar proportions were found in a recent study in the Western Kenyan Highlands (Okuthe 1999) although the average was 65 percent in the Farming Systems study discussed above (MALDM & KARI 1993). Chickens are estimated to make up 99 percent of the poultry population of Kenya. Some turkeys are grown commercially and it is suggested that some ducks and quail are also kept, but in quite small numbers. This analysis therefore concentrates on the chicken population.

The three main categories of chickens reported in the official statistics are indigenous birds raised under “backyard systems”, making up 76 percent of the total population, hybrid broilers, 13.4 percent, and hybrid layers 9.6 percent, as shown in Table 12 (MALDM 1996a).

Table 12: Poultry numbers by Province and production system (1996)

	Indigenous 'backyard'	Broilers 'commercial'	Layers	All poultry
Nairobi	0.4	59.5	4.3	8.8
Central	5.9	33.5	55.5	14.4
Rift Valley	20.3	0.3	4.1	16.0
Eastern	15.4	0.6	9.1	12.7
Nyanza	30.1	1.4	11.0	24.2
Western	14.3	1.1	3.3	11.5
Coast	13.8	3.6	12.8	12.4
Percent of total	100.0 (76.0)	100.0 (13.4)	100.0 (9.6)	28.65 million

Source: MALDM 1996a

The two latter groups are described as commercial systems. However, it is claimed that “Commercial poultry keeping in the country was mainly done by small-scale farmers who kept between 100-1000 birds per batch.” (MALDM 1996a). Hence the distinction between small-scale and large-scale production, used in the case of dairying, may not be entirely appropriate. None the less, a fairly clear distinction can be drawn between “backyard” and “commercial” systems. It should be noted however, that an alternative classification has been suggested, with “backyard” systems treated as being intermediate in intensity between extensive “free-range” systems and more intensive “small-scale” systems (Sonaiya 1992).

Poultry numbers have grown on average by about 2.8 percent annually over the last 20 years despite declines during the droughts of the early 1980s. The growth of the poultry industry in Kenya is largely the result of private enterprise. It was traditional practice for most rural households to keep a few chickens, scavenging for feed around the homestead. Commercial poultry and egg production began as an extension of flocks kept for home consumption. Traders collected old hens from

farms at relatively low prices and marketed them in urban areas. This has led to the growth of commercial hatcheries, in peri-urban areas, which sell hybrid broiler- or layer-chicks to small-scale market oriented poultry producers. Integrated systems have also developed whereby the hatchery supplies chicks, and possibly feeds and veterinary services to the farmer, and guarantees to buy the mature birds or eggs for onward sale to the consumer.

The main government intervention, the National Poultry Development Project which started in 1976, was concerned mainly with extension, and breed improvement through the cockerel and pullet exchange programmes. This programme ended a decade ago.

Indigenous “backyard” production

Village chicken production systems are based on scavenging flocks of the indigenous domestic fowl. The birds survive on domestic food wastes, agro-processing by-products, grass verges, and insects, occasionally supplemented with grain, at very low cost. A study in Western Kenya showed that 80 percent of rural poultry keepers gave no supplementary feeds. However in the peri-urban areas, the majority of producers fed crushed maize or grains as a supplement (Okuthe 1999).

Expenditure on disease control is strictly limited. The occasional sale of birds involves little or no additional marketing cost. The investment cost of establishment is generally slight since young or breeding stock are often provided as gifts, or on loan/entrustment and housing is limited to shutting the birds up in the household kitchen at night. Thus, capital and recurrent costs are very low. This system is therefore well suited to adoption by very poor households. Within the household women, who are otherwise particularly disadvantaged, are normally entrusted with poultry keeping and may reap the benefits.

Such low input systems are relatively unproductive in comparison with more intensive types of poultry production. Some estimates of productivity parameters are given in Table 13. The official statistics given in the first column, have been used unchanged for several years for the estimation of total poultry meat and egg production from the “traditional sector”. The second and third columns present survey results from two areas in the Western Kenyan Uplands between September 1996 and April 1997 (Okuthe 1999). Similar results from surveys in Tanzania and Ethiopia are given in columns 4 and 5 respectively. Indeed similar management practices and productive performance parameters have been observed in other parts of the world, such as Bangladesh, Sri Lanka and Thailand (Huque *et al* 1999, Gunaratne *et al* 1993, Kingston & Creswell 1982)

Table 13: Production traits for “backyard” poultry systems

	MALDM 1996a	Okuthe 1999 Rural	Okuthe 1999 Peri-urban	Tanzania ¹ 1996-98	Ethiopia (Dessie 1996)
Age at maturity (days)	225	-na-	-na-	225	195
Pullet weight at maturity (kg)	1.2	1.6	1.6	1.3	1.0
Number hens per cock	7	6.4	5.0	4.3	3 or 4
Clutches per year	3	-na-	-na-	2.7	3-4
Eggs per clutch	20 (15 ²)	34/year	52/year	13	13
Consumed or sold %	50	49	83	15	48
Hatchability %	90	62	61	84	81
Mortality 0-8 weeks %	60	56	39	40	60.8
Mortality 8-24 weeks %	20	23	23	-na-	0-100
Mortality adults %	10	33	52	-na-	0-100

¹ Sources: Katule 1998, Kitalyi 1998, Lawrence 1998, Minga *et al* 1996, Mtambo 1998, Mwalusanya 1998

² Alternative figure given by KARI/DFID (1996)

Under these “backyard systems” hens are both layers and brooders. Thus clutches of eggs are laid and brooded at intervals, two to four times per year. As a result of the practice and poor nutritional levels annual egg production is very low, estimates ranging from 30 to 60 per year. Some are consumed or sold but, in rural areas, over 50 percent are kept for hatching. Hatchability is probably lower, on average, than the 90 percent estimated by MALDM (1996a). Chick mortality rates are high, averaging between 40 and 60 percent over the first 8 weeks. A large number of these are due to predation and accidents given that the chicks are rarely confined. There are generally proportionally fewer deaths among older birds, but disease risks are high. An outbreak of Newcastle Disease, for instance, could eliminate an entire flock.

Given a typical price for local (adult) birds of Ksh.150 and for eggs of Ksh.4 each (MALDM 1996a) the total annual income per hen can be estimated as in Table 14. Figures are given, in the first column, for what is described as the standard case, which is based on the productivity data given in the first column of Table 13. The remaining columns give the results of sensitivity analysis. Certain parameters are held constant throughout; for instance that half of the eggs produced are consumed and the other half used for hatching, and the ratio of 7 hens per cock. The cost of flock depreciation is effectively eliminated by assuming that the price received for an old hen is exactly equal to the price of its replacement. Thus the only cost is that due to mortality of adult birds. Since it is assumed that no variable costs are involved, the total annual income per bird also represents the annual gross margin.

Table 14: Financial returns to “backyard” poultry (per hen, per year)

	Standard MALDM case	Egg production		Hatchability		Mortality	
		Low	High	Low	High	Low	High
Eggs produced	45	30	60	45		45	
50% consumed	22.5	15	30	22.5		22.5	
Value of eggs consumed (Ksh.)	90	60	120	90		90	
Hatchability %	80	80		65	95	80	
Chicks hatched	18	12	24	14.63	21.38	18	
Chick mortality %	60	60		60		80	40
Growers reared	7.2	4.8	9.6	5.85	8.55	3.6	10.8
Grower mortality %	20	20		20		30	10
Adults reared	5.76	3.84	7.68	4.68	6.84	2.52	9.72
Value of birds Ksh	864	579	1,152	702	1,026	378	1,458
Adult mortality %	0.10	0.10		0.10		0.15	0.05
Replacements needed	0.11	0.11		0.11		0.17	0.06
Depreciation Ksh	17	17		17		26	9
Gross output (Ksh)	937	619	1,255	775	1,099	442	1,539
Flock value per hen (Ksh)	415	415		415		453	378
Rate of return %	226	149	302	187	265	98	407

Several points may be noted:

- The main product is poultry meat rather than eggs, since few are laid and most are hatched rather than consumed.
- Other than when there is a severe disease outbreak causing very high mortalities, the reproduction rate is high compared with that of ruminant species around 600 percent (one hen rears 5.76 young per year) in the standard case. The reproduction rate for poultry could, of course, be much higher.
- Variation in productivity is huge, between flocks, between seasons and between years, ranging from zero, if all the birds are lost, up to a reproduction rate of possibly over 1000 percent (more than 10 young reared per hen).

These findings suggest that the estimates of indigenous birds slaughtered, namely 40 percent of the bird population, given in the official statistics are wildly inaccurate. If the population statistics only include adult birds, then the actual off-take rate should be at least 10 times greater. Even if chicks are included in the population data, the net off-take should surely be more than 100 percent. A much higher return is earned, on average, by hatching and rearing, rather than by consuming eggs. However, the risks of losses are increased by hatching and rearing, because mortalities are highly unpredictable.

Even at these very low levels of technical efficiency, or productivity per bird, this system, on average, yields a very favourable rate of return on scarce resources. Backyard poultry keeping is a good example of a supplementary enterprise, which provides some additional income whilst not competing for resources with the principal productive activities. Since land and labour inputs are minimal the return per hectare of land or per day of labour must be very high. The return on capital, embodied in the “backyard flock”, is also high, generally over 100 percent, given the large number of offspring produced annually per laying female.

Most of the eggs not used for hatching are consumed within the household. Few are sold. Many of the chickens produced are retained as replacements, eaten by household members, exchanged as gifts or entrusted to neighbours. Some are also sold locally to neighbours or in village markets. Traders may buy in these markets to transport and sell on in urban areas. In either case the marketing channels for both eggs and birds are very simple, with few costs and small marketing margins. No processing is involved other than plucking, drawing and cooking within the home.

Within the limited context of production mainly for subsistence, with a low level of sales in local markets, sanitary and quality assurance problems do not arise. However, control of infectious diseases, such as Newcastle Disease, is much more difficult among widely dispersed smallholder “backyard chicken” producers than where there are a limited number of larger scale commercial producers. Indeed the survey in the Western Kenyan Highlands revealed that many smallholder producers do not appreciate the possibility of veterinary treatment for poultry (Okuthe 1999).

Despite the high returns yielded by low input-low output poultry production, the scope for expansion is strictly limited. Most farmers already keep chickens, so there is little scope for spreading the practice to new producers. At the same time existing producers are already keeping more chickens than can be adequately fed with the meagre nutrient supply from the “scavenging food resource base” (Wood 2000, Roberts & Gunaratne 1992). Calculations for backyard poultry keepers in Asia suggest that between 200 and 500 kg of dry matter are produced annually in the form of waste food materials from a single household. This should provide sufficient nutrients to maintain between two and five hens (Wood *op cit*). If these figures are applicable to Kenyan farm households, then the typical flock of around 13 birds must be under-nourished.

These calculations suggest that the first priority option for improvement in productivity is to improve nutrition by hand feeding of grain or poultry mash. Other interventions, such as disease control or the introduction of high yielding hybrids, are unlikely to raise productivity without improvements in nutrition. Provision of adequate water ranks alongside nutritional improvements as being of high priority.

Hand feeding must raise the costs of production in terms of the opportunity cost of home-grown grain or the purchase price of poultry mash. The latter source may be too expensive, especially in the rural areas. Kenyan farmers complain of the high costs and poor quality of purchased feeds (MALDM 1996a). Prices quoted in this report by the main feed mills in Nairobi range from Ksh.12 to Ksh. 21 per kg, while the price of a 40 g egg is Ksh. 4 and of a 1.3 kg bird is Ksh. 150. Given approximate conversion rates for indigenous birds, of 4.5 kg feed per kg bodyweight and 8.8 kg feed per kg egg mass (Barua & Yoshimura 1997), marginal costs and revenues may be estimated. Feed costs per kg liveweight range from Ksh. 54 to Ksh. 94.5 to yield a marginal revenue of Ksh. 115. However, feed costs per kg of eggs range from Ksh.105.6 to Ksh. 184.8 to yield a return of only Ksh. 100. Given that the main purpose of backyard production is hatching and rearing, the latter finding is not too serious. Furthermore home grown supplements and feed mixes from minor feed mills are substantially cheaper than those quoted above.

The potential benefits of improved nutrition are more likely to be achieved if birds are confined in pens or poultry sheds. Food can be rationed more accurately and wastage is reduced. At the same time losses due to predation or theft of birds are less likely. As a part of the study in the Western Highlands of Kenya (Okuthe 1999), a trial was conducted on the confinement of chicks in simple pens. The reduction in losses was more than sufficient to cover the costs of constructing and using the pens, so the practice was found to be financially viable. Other local farmers adopted the innovation voluntarily.

Disease is widely recognised as a constraint on smallholder poultry production (Smith 1990, Say 1987, Kitalyi 1998). The observed high mortality rates are, in part, due to health problems. Newcastle Disease is reported to be the most prevalent and most damaging disease of poultry in Kenya (MALDM 1996a). However, this may reflect the fact that this is a List A, notifiable, disease while most other poultry ailments are not. Control is possible, by vaccination, and vaccines are available from District and Divisional Veterinary Offices and from local chemists (Ondwassy *et al* 2000). Very few smallholder producers of indigenous chickens do vaccinate their poultry. Indeed many are unaware of this option.

The survey in the Western Kenyan Highlands showed Newcastle Disease to be a minor cause of loss in the rural study area but the main cause of loss of adult birds among peri-urban producers. A vaccination trial was conducted, but difficulties were met in ensuring that all the birds in a free range flock were treated. In the event, the incidence of Newcastle Disease in unvaccinated flocks was so low that no significant benefits were observed. None the less farmers were convinced of the potential benefits and hoped that the service could be continued by para-vets delivering vaccine, for Newcastle Disease, fowl typhoid and fowl pox, to “vaccination clusters” or groups of farms (Okuthe 1999). Trials of heat stable vaccine, for Newcastle Disease, as a feed additive in Zimbabwe were not encouraging (Rushton 1996, Oakeley 1998).

Breed improvement, for instance through the cockerel and pullet exchange programmes, should be seen as a means of transforming the system to commercial egg or broiler production, rather than of improving the existing system. Hybrid birds are probably less suited than indigenous hens to the activities of incubating and brooding chicks, which are at the core of backyard systems of poultry keeping.

Commercial systems

Estimates of the provincial populations of broilers and layers are given in Table 12. These two types of birds are estimated to make up 23 percent of the total Kenyan chicken population, with the number of broilers (13.4 %) exceeding the number of layers (9.6 %). It is clear from these statistics that these intensive, commercial systems are concentrated in peri-urban areas. Practically all the broilers (93 %) are located in Nairobi and Central Provinces, while over half the layers are raised within the same area. A substantial number of layers are raised in Nyanza Province, in Western Kenya where human population density is also high. Significant numbers of broilers and layers are raised in Coastal Province near the second main city of Mombassa.

These two main production systems include a very wide range of scales of operation. In a survey of 100 farms within 15 km of Nairobi, 20 farms had fewer than 100 birds, 50 farms had between 100 and 1000, while the remaining 30 farms had between 1000 and 10 000 birds, all supplying poultry products to Nairobi (Gitao 1996). Even larger scale firms are involved in this sector; for instance, the largest hatchery reportedly produces over 8 million day-old chicks (6.4 million broilers and 1.7 million layers) annually (MALDM 1996a).

Apart from the above survey (Gitao *op cit*) which was aimed at investigating the main health problems of poultry in peri-urban areas, and the official statistics, which are a little difficult to interpret (MALDM *op cit*), there is very little published information on these production systems. However, a detailed study of poultry production in and around Dar es Salaam was conducted in 1995-96 (Sumberg 1998). It may be assumed that poultry production systems in peri-urban areas of Kenya are not very different from those in Tanzania, so the findings of this study may be relevant.

A key finding, of the Dar es Salaam study, is that the whole system is dominated by a very small number of large, integrated firms, which may also serve as suppliers of day-old chicks and poultry feed and providers of marketing services to small-scale egg and broiler producers. That this situation applies in Kenya is borne out by the announcement of plans for expansion by Kenchic Kenya Ltd. an integrated broiler and day-old chick producing company. Expansion would require increased involvement of smallholder producers who would be encouraged to invest in utility poultry houses (African Farming 1988). Alongside these large firms, small-scale producers also make use of modern technology for poultry production. Some of these expand into input supply activities, such as feed milling.

Capital investment requirements for this system are high, including durable capital in the form of purpose built poultry houses, battery cages etc. (utility houses could be constructed for Ksh 24 per bird for broilers or Ksh 60 per layer at 1988 prices, African farming *op cit*) and working capital for chicks, feed and veterinary treatments. Cash flow problems are avoided by buying small quantities of feed on a weekly or even daily basis (Sumberg 1998). Risks, associated with disease losses, uncertainty of supplies of day-old chicks and feeds, in both quantity and quality, and un-assured markets, are also high. Thus it is concluded, at least for intensive poultry production around Dar es Salaam, that (a) even small-scale producers “are far removed from the poorest residents of the region”, rather they are often wives of middle-class urban residents, and (b) financial losses are made by a significant proportion of intensive small-scale producers of both broilers and eggs (Sumberg 1998).

It is difficult to interpret the official statistics on productivity. The number of broilers slaughtered in 1996 is reported to be 3.83 million, which is identical to the number of broilers reported in the population statistics. Yet estimation of these statistics is based on the assumption that broilers are slaughtered at 7 or 8 weeks of age, which would seem to imply that 4 or 5 batches can be raised each year, even after allowing two to three weeks between batches for cleaning and disinfecting the broiler house. It is possible that only one batch is raised per year. Around Dar es Salaam the average number of batches of broilers per flock is only 1.6 (Sumberg

1998). If this is the situation it suggests enormous scope for improvements in efficiency of the system.

However, in 1996 the three largest hatcheries alone supplied 7.2 million broiler chicks. Given that there are other unrecorded hatcheries producing chicks, this must be an underestimate of the total number hatched. If this figure is accepted as the total number of chicks supplied and if the population of broilers, at any one time, is 3.83 million, then nearly two batches per year can be produced. Even allowing for 25 percent mortality, more than 1.5 batches would be produced per year.

In the case of layers, 2.6 million chicks are supplied as replacements for 2.7 million hens, each laying 200 eggs per year. Given that the number of chicks is an underestimate, there are probably sufficient numbers to replace the entire laying flock each year. However, the off-take of culls is assumed to be only 30 percent of the adult flock. Hence there remains 70 percent of the flock to be accounted for by losses or flock growth.

The above discussion is aimed at demonstrating the difficulty of estimating the productive performance of the commercial poultry sector in Kenya. Undoubtedly there is great variation in performance between different producers, as was shown in the Tanzanian study and between years. Production, supply and markets are quite volatile. In 1986 there was a surplus of day old chicks but by 1988 chicks were only being sold in response to orders from the previous year. Requests for immediate delivery could not be met. At the same time feed costs were rising rapidly thereby acting as a constraint on planned expansion (African Farming 1988). Cyclical fluctuations in prices and supply were reported with a six month lag between them. "Every time the price is good, people come to us for chicks. Six months later there are too many eggs and the price collapses. People cancel their orders and the supply goes down again." (R. Houghton, General Manager of Kenchic Hatchery, quoted in African Farming 1988).

Estimates of the gross margin from broiler production are given in Table 15. Prices of chicks, feed and broiler meat are given by MALDM (1996a). Considerable uncertainty surrounds the estimation of feed intake and costs. Feed costs are based on an assumed requirement of 2.5 kg of feed, broiler's mash, per kg of liveweight gain, which for a 2.3 kg broiler, killing out at 1.5 kg amounts to 5.25 kg of broilers' mash (Say 1987). However, the same authority also suggests that the feed consumption over the life of a broiler chicken may amount to 7.7 kg so considerable uncertainty surrounds the estimated feed requirement. The situation is exacerbated by the fact of considerable variation in feed quality and inadequacy of the feed inspectorate service (MALDM 1996b, African Farming 1988).

Table 15: Financial returns to broiler production (per bird)

	Average feed cost Ksh 18 per kg	High feed cost Ksh 21.5 per kg	Low feed cost Ksh 14.5 per kg
Sale price 1.5 kg carcass @ Ksh 130 per kg	195	195	195
Cost of broiler chick Ksh	39	39	39
Feed cost: 2.5 kg per kg x 2.3 kg liveweight	104	124	83
Losses @ 10 % Ksh	16	18	14
Margin per bird Ksh	36	14	59

Note: loss rates adopted from Sumberg 1998, calculated as percentage of total cost (1 + loss rate)

Feed prices quoted for the main Kenyan feed-miller are generally lower in Nairobi than in more remote areas, because of the variation in transport costs. However other feed millers in other locations sell for up to Ksh 2.9 less per kg.

The calculations in Table 15 suggest that on average a reasonable margin per bird is earned; sufficient to cover costs of disease control and the overhead costs of labour and housing. However, sensitivity analysis, allowing only for the observed variation in the price of feeds, shows that margins may fall to a non-sustainable level. Given that the feed costs rise with increasing distance from the main urban centres, it appears that intensive poultry production is more likely to be financially viable in the peri-urban areas. The margin per bird is much lower than that for “backyard systems”, but whereas the latter is produced over a whole year, the production of a broiler takes only 7 or 8 weeks. With more or less continuous production the margin per year should be five or six times that recorded in Table 15. Even then the margin per bird for commercial production is lower than that from “backyard” production.

Disease incidence is another source of uncertainty and risk. Newcastle Disease and Infectious Bursal (Gumboro) Disease are claimed to be important but both are controllable by vaccination. Vaccines for the former are available from District and Divisional Veterinary Offices and from local chemists, although in rather large packs of 100 to 200 doses. Vaccine for Gomboro Disease must be imported in even larger consignments, while a cold chain is needed for delivery (MALDM 1996a). There are obvious economies of scale in the delivery of animal health treatments. A recent survey (Gitao 1996) showed that in addition to these major diseases coccidiosis affects 35 percent of the flocks studied. Chronic respiratory disease, ascites, malnutrition and vitamin deficiency are also important.

Estimates of the returns from egg production are given in Table 16, again based on prices given by the Kenyan Ministry of Agriculture, Livestock Development and Marketing (MALDM 1996a). On average the margin per bird is considerably higher than for broiler production, but this refers to the annual output per layer. As already remarked, it should be possible to raise five or six batches of broilers over the period of a year, while only one batch of layers would be kept. Furthermore the costs of replacements, housing, labour and health care are generally substantially higher for layers than for broilers. Egg producers face similar risks to broiler producers. Returns on average appear lower than those obtained from “backyard production”.

However, commercial egg production is not subject to the same constraints on the scale of operation.

Table 16: Financial returns to egg production, per layer per year (Ksh)

	Growers' and layers' mash @ Ksh 14/kg	Growers' and layers' mash @ Ksh 17/kg	Growers' and layers' mash @ Ksh 12/kg
Day old chick	65	65	65
Feed cost to point of lay 10 kg	140	170	120
Losses @ 25 %	68	78	62
Cost to point of lay	256	313	247
Feed cost 200 x 0.2 kg	560	680	480
Losses of layers @ 10%	93	110	81
Sale of eggs 200 @ Ksh 50	1,000	1,000	1,000
Sale of culled bird	150	150	150
Gross margin	224	47	342

Note: loss rates adopted from Sumberg 1998, calculated as percentage of total cost (1 + loss rate)

Returns to land, for both broilers and layers, are very high since these “factory farming” systems require very little space. Feeds are imported into the system from other farming areas and systems. Labour inputs per bird are higher than under “backyard” scavenging systems, but there is considerable scope for economies of scale in automation, specialisation and division of labour, leading to substantial cost saving. Returns to labour are likely to be high for the large-scale production units. As already discussed, the capital costs of intensive poultry production are likely to be high. However, returns are generally sufficient to persuade companies and individual producers to invest in broiler and egg production.

Marketing of live and processed poultry and of eggs is almost entirely conducted in the private sector. It is suggested that small-scale commercial poultry producers may suffer from the lack of a marketing organisation and be exploited by middlemen (MALDM 1996a). Many producers are integrated with large-scale poultry processing and egg packing companies, which provide an assured marketing channel. However, even the large-scale producers complain of poor communications and lack of market integration resulting in the co-existence of gluts in some markets and shortages in others (African Farming 1988). The situation is unlikely to have changed significantly over the past decade. Market volatility also results from fluctuations in the availability and price of competing products, such as beef, pork and Nile Perch and dried fish. Poultry meat is viewed as a relatively expensive alternative in Kenya.

The Ministry of Agriculture now provides market price data for poultry products in key towns throughout Kenya. These data are published in local newspapers, and go some way towards alleviating the problem of poor communications and market failure. Apart from this, very little poultry husbandry or veterinary extension advice is provided by the public sector. However, some of the larger hatcheries provide advice on housing and production methods.

There are some large-scale processing plants producing frozen chickens, on the outskirts of Nairobi and some other major towns. Small-scale poultry processing also takes place in peri-urban locations (Silverside & Jones 1992). However, many birds are slaughtered and processed within the household of either the producer or the consumer. Formal meat inspection should be possible at the large-scale processing plants but not for smaller-scale operations.

Sanitary and quality assurance measures are largely limited to those imposed by large-scale processing companies. However, the importation of day old chicks is subject to statutory control, with the twin objectives of disease control and encouragement of local hatcheries. Limited imports of hatching eggs and day old chicks of parent or grandparent stock are allowed for breed improvement purposes.

There are no obvious limits to expansion other than those imposed by input and product markets. Clearly these systems are restricted to peri-urban areas by the high transactions costs of input delivery and product marketing. Furthermore, periodical shortages and corresponding high prices of key feed ingredients, such as oilseeds and fishmeal, together with moderate levels of productive efficiency result in high costs of production and prices for eggs and poultry meat. As a result poultry products face stiff competition from other sources of animal protein, so the quantities demanded are limited. None the less, as urban demand for all animal products grows, it should be possible for the sub-sector to expand poultry numbers sufficiently to keep pace.

Domestic producers face competition from imported poultry meat and eggs. Given the absence of quota or tariff restrictions on trade, domestic producers must keep unit costs of production below border parity prices in order to compete. In fact official statistics suggest self-sufficiency ratios for poultry meat and eggs very close to 100 percent, which suggests that domestic production is reasonably competitive. Indeed the Ministry of Agriculture in the Sector Strategy Plan (MALDM 1996b) proposes increased exports of poultry meat to neighbouring countries.

There is considerable scope for improvements in market efficiency. A reduction in transactions costs leads to a rise in the producer price, a fall in the consumer price and increases in quantities both supplied and demanded. Improvements in the rural infrastructure of roads, transport and communications would extend the area suited to intensive poultry production. It would also lead to closer integration of different urban markets, a reduction of price discrepancies between market places and welfare gains for both producers and consumers. Improvements in data gathering, on numbers of poultry, production levels and prices, by system and by district, are needed for planning purposes by both the Government and private producers. Regular publication of up-to-date market data, for communication to potential and active poultry producers, would yield major improvements in the efficiency of production and marketing and reduce cyclical inter-year fluctuations in supply and prices.

Improvements in productive efficiency would reduce costs of production, improve farm incomes, reduce product prices and thereby increase the quantities demanded. Productive efficiency would be improved by better co-ordination of the day-old chick markets, linked with planning for continuous occupation of poultry housing. Tighter control of feed quality should improve efficiency of food conversion and greater overall productivity. Health improvement offers prospects for greater

productivity through reduction in bird mortality and higher rates of growth and egg production. Some improvements would be achieved through better hygiene, nutrition and management on the farm, but regular vaccination and other disease control measures would also yield benefits. However, in some cases the costs of treatment may exceed the benefits. Research studies are desirable to assess the relative costs and benefits of alternative disease control measures.

Summary and conclusions

Poultry production in Kenya is conveniently categorised into “backyard systems” using indigenous birds and “commercial systems” of broiler or egg production based on special purpose hybrid chicks. The former system, employed by the majority of farm households accounts for three quarters of all chickens kept in Kenya. Almost all the commercial broilers are produced in Nairobi and Central Provinces, close to the capital city. Egg production is a little less centralised with significant numbers of layers in Coastal and Nyanza Provinces.

“Backyard” production is a supplementary enterprise, which does not compete with other activities for scarce resources and therefore involves very few costs. Birds feed mainly by scavenging, there is very little supplementation with feed grain, are rarely housed and receive no veterinary health care. Productivity is also low as a result of the few eggs laid and hatched and the high mortality rates. However, the system provides a low cost supplement to family nutrition and the incomes of women in poor households. The main constraint on expansion is the limited feed available from household waste. Increased supplementary feeding and chick housing to avoid losses by predation offer the best options for improvement. Low cost methods of disease control might also increase returns.

Commercial systems range in size from small units of less than a hundred birds to large-scale hatchery and broiler production companies, such as Kenchic, which produces 8 million day old chicks annually. The situation is probably similar to that for Tanzanian commercial poultry producers, dominated by a very small number of large integrated firms supplying day-old chicks and marketing the products. Other large firms supply ready-mixed feeds.

Capital and operating costs per bird are much higher than under backyard systems, so although production per bird is higher the margin over feed cost is much lower for these commercial systems. This is compensated for by the fact that commercial producers keep many more birds than the backyard poultry producers. However, variations in the price and quality of purchased feed and the random occurrence of disease outbreaks lead to significant risks of loss.

A comparison of “backyard” and commercial poultry systems suggests that both have their place in meeting the growth in demand for animal products in the Kenyan economy. In rural areas, backyard poultry production serves as a true supplementary enterprise, contributing additional household income and valuable animal protein to household members at very little resource cost. The opportunities offered for intensification are particularly important given the high and increasing agricultural population density in the high potential areas of Kenya. Significant increases in

productivity would be achieved by simple improvements in housing, feeding (and watering) and disease control.

The more intensive, commercial egg and broiler production systems are better suited to, or indeed restricted to, peri-urban locations. There is a need for ready access to supplies of hybrid chicks, ready mixed feeds, and ideally veterinary services. Access to urban markets for eggs and poultry meat is equally important, when these perishable and not easily transported commodities are produced in relatively large batches. These commercial production systems are likely to expand in response to the rapid growth of the urban population and the corresponding demand for livestock products.

As already remarked, all types of poultry production system have developed on the basis of private enterprise, with very little Government intervention. However, there is a clear need to increase production of eggs and poultry meat, in order to meet growing consumer demand for these products, and to raise household incomes of the producers. Backyard production systems in particular provide an important source of protein to young children and supplementary income to often cash-starved households, especially the women within these households. Thus a case can be made for policy interventions aimed at facilitating the operation of input and output markets for all systems of poultry production, with the aim of promoting efficient development and growth. Further encouragement of smallholder, backyard production systems is warranted as a means of rural poverty alleviation.

The main constraints on the expansion of commercial poultry keeping are capital limitations and imperfections in input and product markets. These imperfections are due to inadequacies of the rural road network and poor communication of information, resulting in poor integration of spatially dispersed markets and cyclical fluctuations in production and prices.

Policy options for development of the “backyard” system consist largely of adaptive research and extension. This should concentrate on the areas of simple and inexpensive housing, poultry nutrition, ration formulation, local feed milling, supplementation of scavenged diets and disease control. Research should be farmer-participatory, farming systems oriented and involve on farm testing. There should be a strong socio-economic component to assess the costs and benefits of the alternative measures proposed.

Policies for the commercial poultry sector should be aimed at facilitating and monitoring the markets for breeding stock, day-old chicks, concentrate feeds, veterinary services, eggs, birds and poultry meat. National recording systems are needed of the quantities and prices of all these items in the main market places, to identify patterns of production and consumption and their changes over time. The information should be made available as soon and as widely as possible to allow better planning by private sector producers. Monitoring and control of feed quality, by strengthening the Feed Inspectorate Service, is highly desirable, as is the general surveillance of market conditions to avoid the growth of monopolistic practices by the large scale hatcheries, feed mills and processors. Export of poultry products may be facilitated by appropriate trade policies.

Public sector intervention is required to increase the availability of credit for the development of poultry production, feed milling and poultry processing and packaging enterprises, to fund research and to promote the establishment of private veterinary and para-veterinary practices in the main production areas.

8. Livestock Sector Policy Recommendations

Expansion of milk, meat and egg production is desirable to meet growing demands for these animal products and to raise incomes of agricultural households. The relative efficiency of large- and small-scale dairying and poultry production is difficult to assess. Large-scale producers benefit from economies of scale leading to lower unit costs or higher gross and net margins. However, small-scale producers probably achieve a higher intensity of land use. In any case the objective of rural poverty alleviation is best pursued by encouraging small-scale producers.

Given the complementary and inter-dependent input and product markets for large- and small-scale producers, and the decline in Government provision of input and marketing services, it is inadvisable to adopt policies discriminating against large-scale producers.

Policy interventions of general benefit to both dairy and poultry producers include the following;

- improvements in the road and communications network, would extend the area suited to intensive production systems,
- improved collection and dissemination of national production statistics and market information would provide for better planning and co-ordination of input and product markets,
- surveillance and regulation of input and product markets, to ensure the maintenance of competitive conditions, and quality and sanitary control of concentrate feeds, milk, meat etc.
- adaptive, farmer participatory and systems oriented research and development, with a strong socio-economics budgeting and costing component, aimed at extension of improved management techniques to farmers,
- additional socio-economic research on marketing and institutional change,
- encouragement of farmer group activity, to benefit from the economies of scale in product marketing and input supply,
- guidance of the privatisation of animal health service provision, by ending unfair competition from public sector employees, reducing the list (and hence capital cost) of equipment specified as necessary for establishing a private practice and better integration of para-veterinarians into the system,
- increased availability of credit for the establishment of small-scale intensive production systems.

Policies for the dairy sector, include all the above, and promoting through research and extension with increasing involvement of the private sector and non-government organisations (NGOs);

- improved cow feeding, housing and management,
- increased forage production and conservation,

- provision of concentrate feeds of appropriate quality and price,
- expansion and improvement of artificial insemination services,
- better control of endemic and epidemic disease
- regulation (sanitary and quality assurance) of private and co-operative milk markets

“Backyard” poultry production is the least costly and offers the highest return on investment of the livestock enterprises considered in this study. The low level of capital investment involved means that this enterprise is well suited to adoption by poor households. However, scope for expansion is strictly limited by the nutritional constraint of scavenging for feed. A major expansion would necessitate conversion to a more intensive commercial system. Options for improvement of backyard systems consist largely of adaptive research and extension.

Policies for the commercial poultry sector should be aimed at:

- facilitating and monitoring markets for breeding stock, day-old-chicks, concentrate feeds, veterinary services, eggs, birds, and poultry meat,
- regulation of quality and sanitary assurance within these markets, and control of monopolies,
- improved access to credit for small-scale producers.

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