PART

1

Major challenges to food security in the 21st century

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CHAPTER 1

Population dynamics and hunger

Hunger: taking stock of the global situation

When addressing the challenge of eradicating chronic hunger and malnutrition in the decades to come, it is critically important to understand the full dimension of the problem. It is not just a question of producing more food, but of understanding population dynamics and changes in food consumption. These are the fundamentals that inform all related policy decisions.

The world produces enough food to feed everyone, yet nearly 1 billion people remain hungry. Hunger affects certain populations in all continents, in both developed and developing countries and in urban and rural areas. Without a doubt, the challenge of eradicating hunger is daunting, and attempts at both national and international levels have not proved very successful. As data reported in this chapter clearly demonstrate, world food security remains an uncertain prospect.

During global crises, debate about how to reduce hunger figures high on the international agenda, as it did during the world food crisis of 1974 and as it has since

BOX 1

FAO keeps hunger on the global agenda

FAO launched Freedom from Hunger, its first public awareness campaign in 1963. In 1992, together with the World Health Organization (WHO) and in collaboration with the United Nations Children's Fund (UNICEF) and the World Food Programme (WFP), FAO convened the landmark International Conference on Nutrition. It then invited heads of state to the 1996 World Food Summit (WFS), and called them back for the World Food Summit: *five years later*. In 2008, with the sudden increase in food and fuel prices, FAO responded by organizing a High-Level Conference on World Food Security, which provided a global arena for discussion of the challenges these developments posed. In October 2009, when the situation had been compounded by the impact of the global financial crisis and the number of the hungry rose to more than 1 billion, FAO responded by organizing the High-Level Expert Forum on How to Feed the World in 2050. A month later, FAO hosted the World Summit on Food Security, where it opened a petition for signature as part of its *1billionhungry* campaign. So far, the petition has been signed by nearly 3.5 million people. Currently, together with WHO and other members of the United Nations Standing Committee on Nutrition (UNSCN), FAO is preparing for the second International Conference on Nutrition, or ICN+20.

2007, with the onset of the food, fuel and financial (triple F) crisis. Yet, for more than 65 years now, the Food and Agriculture Organization of the United Nations (FAO) has made a concerted effort to keep the hunger issue constantly high on the international agenda. With the expertise of its technical divisions in the areas of agriculture, forestry, fisheries, natural resources and economics and trade, FAO has gathered, analysed and disseminated information to specific audiences with the goal of raising and maintaining awareness of the challenges hundreds of millions of people face each day in obtaining enough food to sustain healthy lives.

Identifying the hungry

It is well understood that extreme poverty is at the root of chronic hunger and malnutrition: the hungry, as defined by FAO in terms of food security, are those people who do not have "physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" at all times (FAO, 1996a).

While the hungry can be found in rural and urban areas of all countries, they are more likely to live in the rural areas of developing countries, as that is where nearly three-quarters of the world's poor live. Even the hungry in the urban areas of developing countries are likely to be recent migrants from rural areas, forced to move because of lack of livelihood opportunities.

The hungry in rural areas are mostly from households engaged in subsistence farming or they work for others, selling their labour as agricultural workers. They lack the livelihood assets as well as physical, natural and financial resources needed to generate sufficient income to ensure family food security. They often also lack the expertise, training and education needed to improve their productivity and incomes or to find alternative employment opportunities. While a lot depends on people's socio-economic, political, cultural and natural environments, there are a host of other external factors that affect the poverty and food security of rural and other food-insecure households. These include rural infrastructure, such as roads, communication or electrical systems; and institutional set-ups, such as markets, social safety networks, research and development, education and training, and health, legal, finance and credit systems as well as existing policy environments and political systems. Figure 1 summarizes the multitude of factors and complexity of the processes that underpin food security status at the household level.

In addition to these external factors, there are certain "care factors" that affect the nutrition security of household members. These include childcare, eating habits and practices, nutritional education, food preparation, and the social and cultural norms that determine how food is distributed and utilized within a household (IFAD, FAO and WFP, 2000).

Estimating the number of hungry

Although defining who the hungry are is conceptually straightforward, determining the number of hungry with any degree of precision is a more difficult process.

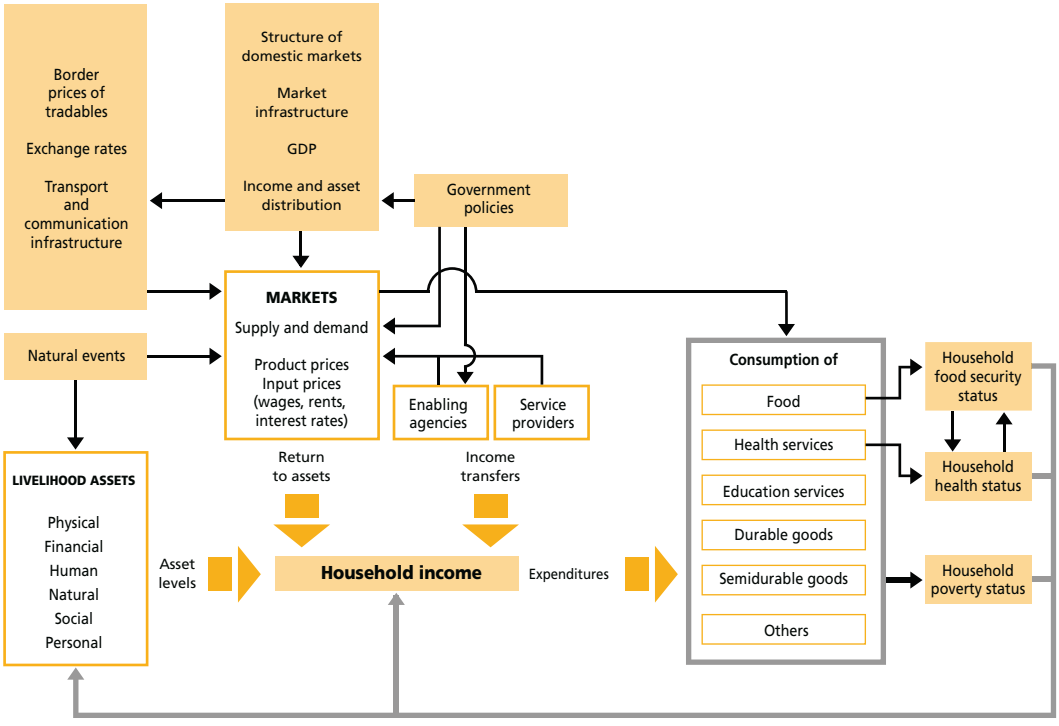
Developed countries that have well-developed social safety networks come closest to providing accurate estimates. However, for most developing countries, even an estimate requires the use of indirect methodologies, entailing brave underlying assumptions. Recognizing the critical need for this type of baseline data (see Box 2), as early as 1963 FAO began developing a methodology based on estimations of the inadequacy of calorie intake at the country level (FAO, 1963). Subsequently, in 1977, 1987 and 1996 (FAO, 1977, 1987, 1996b), FAO published regional and global aggregates of the number and proportion of hungry based on that indicator, although without revealing the estimates for the individual developing countries used in the aggregations. FAO's estimates of the proportion of populations found to be undernourished were used at the country level to derive an index of food security for the purpose of comparing the food security status of its 91 developing country members in 1993 (FAO, 1994) on the occasion of the 19th Session of the Committee on World Food Security (CFS).

Setting global targets to end hunger

It was only after the 1996 World Food Summit that FAO's estimates became a benchmark for monitoring progress in political action towards eliminating hunger.

FIGURE **1**

Factors and processes affecting household poverty and food security



Source: FAO.

BOX **2**

Estimating undernourishment: FAO methodology

The FAO methodology used to estimate the number and proportion of undernourished people (FAO, 2004a, p. 14) is based on the calculation of three key parameters for each country: i) the average amount of food available per person; ii) the level of inequality in access to that food; and iii) the minimum number of calories required for the average person.

The average amount of food available is drawn from country "food balance sheets", which FAO compiles annually for each country as follows:

- a calculation is made of the amount of each food commodity that is produced and imported by a country, and withdrawn from stocks;
- the amount that is exported, wasted, fed to livestock or used for other non-food purposes is subtracted from this; and
- the caloric equivalent of the resulting total amount of food available for human consumption is divided by the total population.

The end result of this calculation is an average daily food intake or dietary energy supply (DES) by country.

In addition, household survey data are used to derive a "coefficient of variation" to account for the degree of inequality in access to food within a country. Similarly, since a large adult needs almost twice as many calories per day as a three-year-old child, the minimum requirement per person for each country takes into account its mix of age, gender and body sizes. FAO reports the proportion of the population whose daily food consumption falls below that minimum daily requirement as being undernourished.

An International Scientific Symposium on Measurement of Food Deprivation and Undernutrition, held in 2002, concluded that FAO's methodology is the currently available means of estimating prevalence of undernourishment at the global and regional levels (FAO, 2003a, p.6).

This was based on a pledge made by the heads of state and government or their representatives who attended the WFS in 1996. They committed themselves to achieving global food security and pledged "an ongoing effort to eradicate hunger in all countries", setting a goal of reducing the number of undernourished people to half its 1990–1992 level no later than 2015 (FAO, 1996a). At that time, the estimated number of hungry in developing countries was 842 million, representing 16 percent of the world's population.

The individual estimates for developing countries were first published in 1999, in the first edition of *The State of Food Insecurity in the World*, and have been updated and published in subsequent issues. Today, these estimates not only provide the basis for monitoring and analysing progress towards achieving the WFS goals, they also contribute to monitoring progress towards the first United Nations Millennium

BOX **3**

Significance of the WFS and MDG targets

- **WFS: Reduce by half the *number* of hungry people by 2015**
- **MDG 1: Reduce by half the *proportion* of hungry people by 2015**

Although the WFS and MDG targets use the same methodology, the WFS target is the more ambitious. Indeed, continued population growth means that the proportion of hungry people in the developing countries will need to be cut by much more than half if the WFS target is to be met. If the MDG target is achieved in 2015 by the developing countries as a group, current population projections suggest that the world will still have around 585 million undernourished, far more than the WFS target. On the other hand, reaching the WFS target will require a reduction in the proportion of undernourished in the developing countries to 7 percent, which is still 6 percent lower than the 13 percent level estimated for 2005–2007, the most recent period for which official data are available.

Development Goal (MDG 1): to eradicate extreme poverty and hunger.[1] Specifically, the hunger estimates assess the efforts of United Nations (UN) members in achieving the target of "halving, between 1990 and 2015, the proportion of people who suffer from hunger". FAO's Committee on World Food Security (CFS) played an important role in ensuring that the indicator is used for purposes of monitoring the two targets (FAO, 2001). Although seemingly similar, the WFS goal of halving the "number" of hungry and the MDG target of halving the "proportion" of hungry seek different outcomes, as shown in Box 3.

Figures 2 and 3 illustrate the trends in the number and proportion of undernourished people at the global level between 1969–1971 and 2010. Until recently, the methodology averaged three consecutive years in the calculation of the two indices, in order to smooth out the effects of short-term phenomena, such as seasonal crises. However, due to the nature and severity of the food and fuel crises of 2007–2008 and the ensuing financial crisis, the indices at the global and regional levels have been calculated and reported annually since 2008.

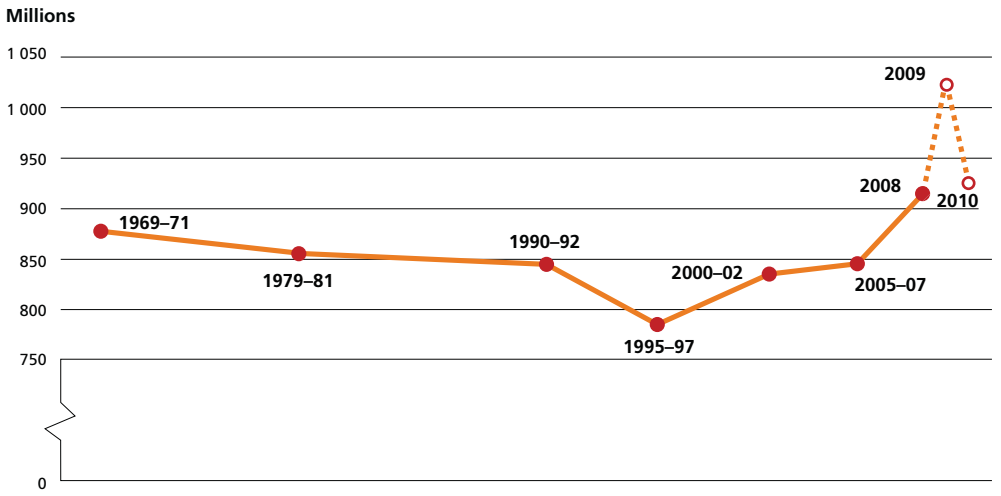
Global trends in progress towards targets

From the early 1970s to the mid-1990s, both global indicators showed downward trends. The number of hungry people dropped from around 878 million to around 738 million, and the prevalence of hunger dropped from 26 percent to 14 percent.

[1] These FAO estimates constitute indicator 1.9 used in assessing the efforts made towards achieving target 1.C of the first MDG. These and other data used in monitoring the progress towards achieving the MDGs can be accessed at: http://unstats.un.org/unsd/mdg/Data.aspx.

FIGURE 2

Number of undernourished people in the world, 1969–71 to 2010

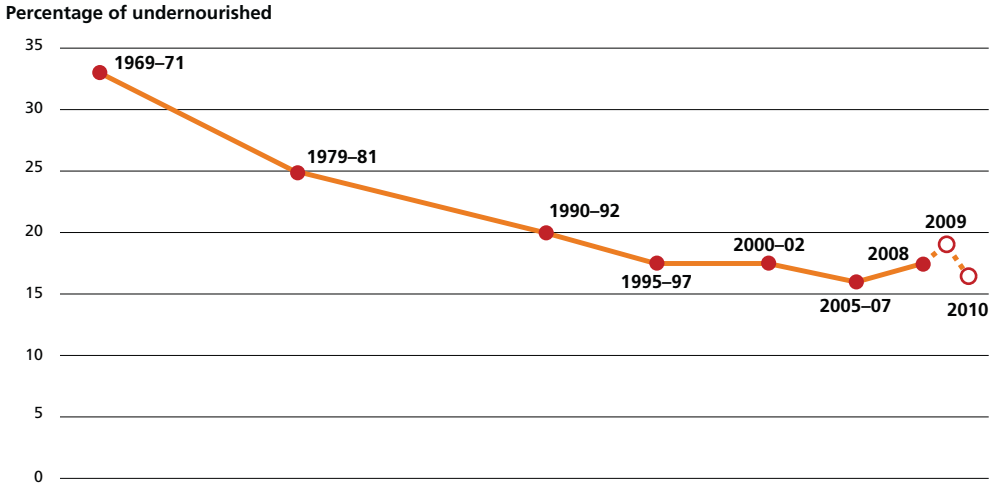


Note: Figures for 2009 and 2010 are estimated by FAO with input from the United States Department of Agriculture, Economic Research Service.

Source: FAO, 2010a.

FIGURE 3

Proportion of undernourished people in developing countries, 1969–71 to 2010



Note: Figures for 2009 and 2010 are estimated by FAO with input from the United States Department of Agriculture, Economic Research Service.

Source: FAO, 2010a.

From then onwards, the global trends diverged. The number of hungry rose to around 848 million by 2005–2007, while the prevalence fell slightly to 13 percent during the same period. The trends then converged with the onset of the triple F crisis: in 2009, the number of hungry rose steeply to more than 1 billion and the prevalence of hunger rose to nearly 20 percent. The estimates for 2010 indicated a slight improvement at the global level to 925 million (FAO, 2010a).

The trends at the regional, subregional and country levels have been far more variable. For example, in Asia and the Pacific, the number of hungry began rising in early 2000, mainly because of poor performances by some countries in South Asia. East and Southeast Asia did much better. The performance of countries in Latin America and the Caribbean was more encouraging, with the region as a whole exhibiting continuous improvement, although some countries were not able to share in that achievement. Africa as a region was unique in that it was not the improvements but the failures that were continuous. Very few countries succeeded in reducing the number of hungry over a period of more than 15 years. Apart from those that already had very low levels of hunger, fewer than ten were successful in achieving mostly modest improvements, and only three achieved the WFS target for 2005–2007.

This variability and, in many instances, the inability to be on track to achieve either of the two targets stem from the multidimensional and complex nature of food security and nutrition. It reflects differences in countries' policies, economic, social and cultural environments and natural resource endowments.[2]

The fact that many countries were not successful in meeting their WFS targets clearly indicated the need for a broader alliance at the international level to accelerate action to reduce world hunger. This led FAO to call a second summit, the World Food Summit: *five years later*, in 2002, to encourage countries to reaffirm their commitments. The global events that began in 2007 further highlighted the importance of such collaboration, especially when the impacts portended such dire consequences for so many people in many vulnerable countries.

The memory of the 1974 food crisis had faded when, nearly half a century later, developments at the international level again disrupted global commodity markets, including many food commodities. Understanding the underlying causes of those developments was essential if there were to be appropriate international and national responses that could lessen their negative impacts on food security. FAO responded once more by organizing meetings and summits to raise awareness of the problems, seek solutions and achieve coherence in policy responses.

Progress hampered in 2007–2009

The causes of the global food and fuel crisis of 2007–2008 and the global financial crisis that immediately followed were quite different, but both played primary roles in reversing, halting or slowing progress towards achieving the WFS and MDG 1 targets. Their effects on the food security of vulnerable groups in vulnerable countries

[2] For an empirical analysis identifying the factors responsible for the changes in the number of undernourished in the developing countries during the 1990s, see FAO, 2003a.

were similar, because both led to significant declines in real household incomes. However, there were differences between the countries and the households that they affected. Countries and households that were net importers and consumers of food and fuel stood to lose the most in a crisis caused by a hike in international food and fuel prices.[3] However, when the cause was financial,[4] the countries to be most affected were those that had large account deficits and thus faced sharp devaluations of their currencies. They experienced severe credit constraints and falling real GDP, with vulnerable populations experiencing sharp declines in their incomes as a result. Those households affected by both crises were, of course, the hardest hit.

The fact that the number of hungry rose to 1 billion in the face of the triple F crisis in 2009 indicated how many households in developing countries did not have the livelihood entitlements to cope with the decline in their real incomes and had to resort to adjusting their food consumption, which resulted in undernutrition. This happened despite increases in the incomes of producers who had marketable surpluses and who could therefore benefit from the soaring international prices of agricultural commodities.

Addressing old and new challenges to eliminating hunger

The problems brought by the triple F crisis compounded longer-standing challenges that the international community and governments had committed to address in various conferences and fora. International agricultural commodity markets had been tightening for some time prior to the onset of the food and fuel crises.

On the supply side, the challenges were, and still are: i) a lack of investment; ii) slowing growth in yields; iii) agriculture's declining share in development aid; and iv) a declining availability of funds for research and development.

On the demand side, the challenges posed were, and still are, i) an increase in the demand for food, stemming from changing patterns of consumption in emerging economies experiencing rapid economic growth; and ii) continued population growth and urbanization in many developing countries.

When these problems occur in a context of declining levels of global stocks,[5] any supply or demand shock might lead to a significant increase in the level as well as the volatility of prices.

That is precisely what happened in 2007, owing to record oil prices and droughts in major exporting countries. Oil prices had an impact on the demand side, because a resulting increase in demand for biofuel production resulted in energy crops competing with food crops in the field. On the supply side, high oil prices increased

[3] Several FAO documents and publications provide detailed explanations as to the underlying causes of the food and fuel crisis and the nature of the impacts on food security on developing countries and vulnerable groups (FAO, 2008a, 2009a).

[4] See FAO, 2009b.

[5] The decline in the level of global stocks of many agricultural commodities occurred because of the implementation of multinational trade agreements that reduced publicly held stocks, the high cost of storing perishable products, the development of other less costly instruments of risk management, increases in the number of countries able to export, and improvements in information and transportation technologies.

the cost of producing and transporting agricultural commodities. Other challenges, such as foreign exchange volatility and an increase in speculative activity in derivative agricultural markets, further complicated and disrupted agricultural commodity markets.

Both the old and the new challenges remain, mainly because neither the international community nor national governments have devoted sufficient resources to addressing this very complicated set of problems. While lists of corrective measures have been formulated, they have still to be prioritized and their implementation effectively scheduled. The political will, required competencies and resources have also been seriously lacking to date. The fight against hunger is taking place in an interdependent, uncertain, mobile and violent world, where national interests are still paramount.

Hunger and poverty decrease as economies transform

The experience of countries that have succeeded in reducing hunger and malnutrition shows that economic growth and poverty reduction policies, as such, do not automatically ensure success. The source of growth matters too. Cross-country analyses show that gross domestic product (GDP) growth originating in agriculture is, on average, at least twice as beneficial to the poorest section of a population as growth generated in non-agricultural sectors. This is not surprising, considering that 75 percent of the poor in developing countries live in rural areas and derive a significant part of their livelihood from agriculture and related activities. For agriculture-dependent countries in particular, agricultural growth is pivotal for overall growth and development as well as for poverty reduction.

Many developed countries based their successful economic transitions on vibrant agricultural sectors. It was the precursor to the industrial revolutions in Europe and the United States of America (USA) and, more recently, to those in China, the Republic of Korea, Thailand, Viet Nam and other rapidly growing Asian economies. During these transformations, investment in agriculture and education created agricultural surpluses, kept real food prices low and helped stimulate overall economic growth. At the same time, overall economic development created new employment opportunities that helped absorb the rural labour surplus that emerged from the transformation of agriculture. The result has been a transition from many small subsistence producers in those countries to fewer and larger commercial farmers, more non-farm employment and larger farm operations overall.

The outlook to 2050 suggests that many developing countries will be on the pathway to such a transformation. While the role of agriculture as a driver of overall growth is expected to diminish over time along with its share in GDP, the experience of today's middle-income countries suggests that agriculture's role in poverty and hunger reduction will continue to be significant. Agriculture's contribution to hunger reduction consists of more than just producing food where needs are most pronounced. Agriculture also contributes by creating employment, generating income and supporting rural livelihoods.

Population: 9.2 billion people to feed in 2050

The world's rapidly increasing population puts pressure on all aspects of human existence and must be superimposed over all efforts to achieve food security. With the world's population expected to reach 9.2 billion by 2050, no sector feels the pressure more dramatically than agriculture, which will need to produce food for 2.3 billion more people than at present.

To meet this demand, agriculture must produce more food, feed, fibre and biofuel feedstock from a finite resource base and with a smaller rural labour force. It must also be able to contribute to overall development in agriculture-dependent developing countries, reduce pressure on natural resources by adopting more efficient and sustainable production methods and adapt to climate change.

Preparing for future scenarios

Nearly all of the world's population growth is forecast to take place in developing countries, with sub-Saharan Africa's population growing the fastest, increasing by 114 percent by 2050, and East and Southeast Asia's the slowest, increasing by 13 percent by 2050. Urbanization is foreseen to continue accelerating – 70 percent of the world's population will live in urban areas by 2050, compared with 49 percent today. Rural populations will actually decline, after peaking sometime in the next decade, and urban dwellers will rely on purchasing rather than growing their own food.

At the same time, per capita incomes in 2050 are projected to be a multiple of today's levels, with relative inequality in incomes being considerably reduced, as the recent trend of developing country economies growing significantly faster than those of developed countries is likely to continue in the future.

The process of producing projections for global production, consumption and trade of agricultural goods and the number of hungry for the future is difficult and outcomes are uncertain. Nevertheless, informed estimates are necessary to gauge a plausible range of outcomes and develop an appropriate range of actions to cope with them.

Estimates from "most likely" scenarios, and from scenarios that consider the possible effects of climate change and increased bioenergy demand, underline the importance and urgency of establishing effective poverty reduction strategies, food security and nutrition initiatives, safety nets and rural development policies and programmes focused on increasing smallholder agricultural production and productivity in developing countries. These measures are, of course, no different from those addressing current food security issues.

Food demand and production

Feeding a global population of 9.2 billion will require an increase in overall food production of some 70 percent between 2005/07 and 2050. Production in the developing countries will almost need to double.

Demand for cereals for both food and animal feed will reach about 3 billion tonnes by 2050, up from today's estimated 1.8 billion tonnes. Liquid biofuels have the potential to change some of the projected trends and increase world cereal demand, although their production and impact will depend mainly on energy prices and government policies. Other food product demand that is related to higher incomes in developing countries – such as meat demand for dairy, fish and aquaculture products and vegetable oils – will grow much faster than demand for cereals produced for food. Livestock already constitute 30 percent of agricultural GDP in the developing world, and the livestock subsector is one of the fastest-growing in agriculture.

The expected growth in purchasing power in developing countries will lead to dietary changes that are increasingly orientated towards animal source foods and away from staple foods of vegetal origin. Overall meat consumption in developing countries is expected to account for around 82 percent of projected global growth in the next decade. Much of this expansion will take place in the Asia and Pacific region, especially in China, and in Latin America, led by Brazil, and it is expected to outpace growth in member countries of the Organisation for Economic Co-operation and Development (OECD) by a factor of 2:1 in the next decade. Renewed investment, capacity development, improved infrastructure and the introduction of modernized, intensive and integrated production technologies are the main factors spurring higher growth in the former group of countries, and this is especially true for poultry in China, Brazil and India and, to some extent, in the Commonwealth of Independent States (CIS).

International trade

Trade in agricultural commodities is expected to expand considerably. For example, developing countries' net cereal imports will increase almost threefold to reach nearly 300 million tonnes by 2050 which, by then, will account for some 14 percent of their cereal consumption, up from 9.2 percent in 2006–08. Self-sufficiency in cereals would continue to be low in the Near East and North Africa, the region most dependent on food imports. At the other extreme, Latin America and the

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PHOTO 1

Food production in the developing countries will almost need to double to meet overall needs in 2050.

Caribbean, now a net cereals-deficit area, may become fully self-sufficient, reflecting the surplus production potential of major countries in the region. The other regions may see some decline in self-sufficiency, but they will remain in the 80–95 percent range compared with 83–100 percent at present.

Natural resources

More than 90 percent of the growth in crop production globally (more than 80 percent in developing countries) will result from higher yields and increased cropping intensity, with the remainder coming from land expansion. The expansion in arable land will be about 70 million ha (or less than 5 percent) up to 2050, with the expansion of about 110 million ha (or 11 percent) in developing countries being offset by a decline of some 40 million ha (or 7 percent) in the developed countries. However, after 2050, total arable land in the world is expected to decline from 1 660 to 1 630 million ha in 2080. At that point, South and East Asia and the Near East and North Africa will be at the level of the developed countries in terms of declining arable land, while land expansion will continue in all of sub-Saharan Africa and, to a lesser extent, in Latin America.

Land equipped for irrigation is expected to expand by some 22 million ha (7 percent) by 2080, although with virtually no further growth after 2050. The harvested irrigated area could expand by some 40 million ha (12 percent) up to 2050 but would decline afterwards. In this case, the equipped area would not change, as the infrastructure is already in place, but its utilization – and maintenance – would decline. Nearly all of this increase would be in the developing countries. Water withdrawals for irrigation would grow at a slower pace but still increase by almost 6 percent (or some 165 km^3) by 2050, mainly (but not only) due to a slowly improving efficiency in water use. After 2050, water withdrawals should start to decline as a result of the declining harvested irrigated area but also because of a decline in harvested rice area and its intensive water use for flooded paddy fields. The exceptions are sub-Saharan Africa and the Near East and North Africa, where water withdrawals would continue to grow.

Crop yields would continue to grow but at a slower rate than in the past. This process of decelerating growth has been underway for some time. On average, the annual rate of growth in crop yield for the projection period is expected to be about half (0.8 percent) of its historical rate (1.7 percent), although these rates would be 0.9 and 2.1 percent, respectively, for developing countries. The question is whether the world's resource base can support these projected and needed increases in land, water use and yields.

Land resources. In a global agro-ecological zone study (Fischer *et al.,* 2002) providing a comprehensive assessment of the impacts of climate change on agro-ecosystems this century, FAO and the International Institute for Applied Systems Analysis (IIASA) indicate that ample land resources with potential for crop production are still available, although this result needs to be qualified. Much of the suitable land

not yet in use is concentrated in a few countries in Latin America and sub-Saharan Africa, while many other countries in these regions with growing rural populations are extremely land-scarce. Much of their available land, furthermore, is suitable for growing only a limited range of crops, and not necessarily those for which there is the highest demand. In addition, much of the land not yet in use is affected by chemical or physical constraints, endemic disease or a lack of infrastructure, or else it has important environmental characteristics or value that prevent its use.

Water resources. The availability of freshwater resources is similar to the picture of land availability – more than sufficient globally but very unevenly distributed, with an increasing number of countries, or regions within countries, reaching alarming levels of water scarcity. This is often the case in those countries of the Near East and North Africa and South Asia that have few remaining land resources. A mitigating factor could be that there are still many opportunities to increase water-use efficiency.

Crop yields. The potential to raise crop yields even with existing technologies seems considerable and, provided the appropriate socio-economic incentives are in place, the difference between agro-ecologically attainable yields and actual yields are bridgeable gaps that could be exploited. Similarly, there is considerable scope for narrowing performance gaps in livestock production. Aquaculture, the fastest growing food production system (6.6 percent annually), offers new opportunities if well managed.

Access to food

Over the coming decades, the projected global economic growth of about 2.9 percent annually is expected to lead to a significant reduction in, or even near elimination of, absolute "economic" poverty in the developing countries (absolute poverty is defined as people living on less than US$1.25 per day in 2005 prices). Nevertheless, even in 2050, the world will still be far from solving the problem of economic deprivation and malnutrition for significant parts of the population.

Global production increases alone will not be sufficient to ensure food security for everyone, unless governments ensure that access to modern inputs by smallholder farmers and access to food by the needy and vulnerable are significantly improved. Even though the prevalence of chronic undernourishment in developing countries could fall from around 16 percent today to 4.8 percent in 2050, some 370 million persons would still be undernourished in 2050. Of the three developing regions with the highest numbers of undernourished, declines would be most pronounced in East and South Asia, but less so in sub-Saharan Africa.

Based on these projections, the WFS target of hunger reduction may not be reached until well into the 2040s. One major cause of the persistence of hunger is the fact that insufficient food is produced in the countries where three-quarters of the world's poor live.

Climate change and bioenergy

The assessments summarized above reflect the assumptions that many experts view as "most likely" to hold over the next 40 years. However, they do not reflect the effects of possible changes in climate and bioenergy demand on agricultural production or food security. The uncertainties surrounding the magnitude and spatial characteristics of climate change, the range and efficiency of adaptation possibilities, future developments in fossil fuel markets and policy measures implemented for encouraging bioenergy usage do not allow for the same type of "most likely" outcomes. Instead, they use scenarios regarding climate change intensities and patterns, and bioenergy usage to derive a range of outcomes – without knowing the likelihood of their happening. The results reported by different studies differ significantly because of the differences in the scenarios and the models used. Nevertheless, results suggest that it may be difficult to reach the WFS target, even by 2050.

The measures for addressing the climate change and issues related to increased bioenergy demand are no different from those adopted for current food security issues. However, addressing the longer-term issues stemming from climate change and bioenergy might require additional measures. For example, focusing research on crop breeding and management programmes suited to high temperature and drought conditions, and implementing environmental preservation measures that i) ensure both macroclimate and microclimate effects are considered in all experiments and variety trials; and ii) determine the heat-tolerance limits of currently grown as well as alternative crops and varieties.

Urbanization and migration: ensuring reliable food supplies for mega-cities

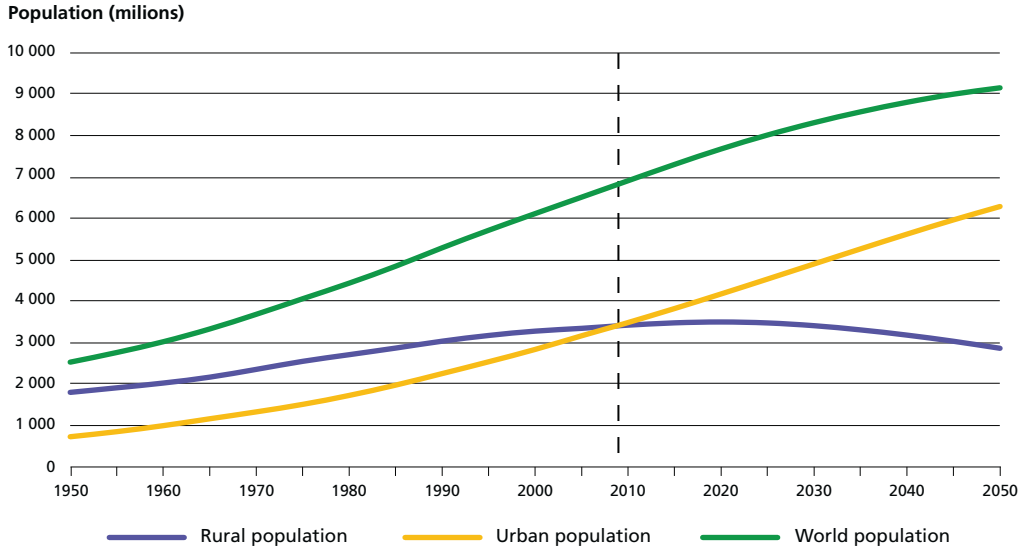
Urbanization will continue to be one of the key drivers of change in ensuring reliable food supplies in the future. This will not only be a challenge for urban areas. Rural areas will be facing the need to produce more food for growing urban populations while dealing with the movement of populations from rural areas to cities. Ensuring food supplies in the context of rapid urbanization therefore involves rural development, whether directly or indirectly.

Urban food security and nutrition

The rapid movement of people from rural to urban environments and natural population growth rates in urban areas (see Figure 4), particularly in the Southern Hemisphere, represent both an opportunity and a threat. It means an opportunity for many poorer rural people to improve the quality of their lives through improved employment, income and access to services. It is a threat, however, if these movements are not supported by appropriate planning. Even though food is available, it is not always accessible by poorer households that may not have enough money to purchase it (UN, 2010a). Poor people in urban areas in developing countries face a daily struggle to feed their families adequately and spend as much as 70 per-

FIGURE **4**

Urban and rural populations of the world, 1950-2050



Source: UN, 2010b.

cent of their total income on food. History shows that food and nutrition insecurity in cities brings risks of social unrest and conflict, as demonstrated in the food crisis riots in cities around the world in 2007 and 2008.

While there are now more people living in cities than ever before, it is important to recognize that large regional disparities do exist. Developed countries are home to 1.2 billion people, some 75 percent of whom reside in cities, while only about 45 percent of the 5.7 billion people living in less developed countries are city dwellers.

The world's urban population is not distributed evenly among cities of different sizes. More than half of the world's 3.4 billion urban dwellers live in cities or towns with fewer than 500 000 inhabitants. These small cities account for about half the urban population in both the more developed and less developed regions. Between 2009 and 2025, small urban centres with fewer than half a million inhabitants are expected to account for 45 percent of the expected increase in the world's urban population (UN, 2010c). Urbanization shows multiple trends in terms of population growth, geographical expansion, socio-economic heterogeneity and management of natural resources.

All cities need to provide housing and shelter, infrastructure, health and education services. In addition, secure, adequate and reliable food supplies are a core requirement in the daily lives of urban populations that rely on markets for their food. Continuing urbanization brings food and nutrition challenges that are magnified by transformations in food demand and markets, rising food prices and the impact of climate change. Ensuring the human right to food for the majority of

the world's population, particularly for the poorest people, involves addressing these issues and keeping them high on the political agenda.

Food and agriculture make a particularly important contribution to local economies. As urban areas develop, they have a critical impact on food security and nutrition and income-generating activities, affecting formal and, especially, informal sectors in terms of food production, processing and marketing. Urbanization also tends to induce growth in the number of middle- and upper-income consumers, whose food choices and dietary patterns tend to be more energy- and GHG emission-intensive. Such changes in demand typically bring major changes in agriculture and in the supply chain (Satterthwaite, Mc Granahan and Tacoli, 2010), ranging from physical infrastructure to associated information technologies.

FAO and its partners support countries and local governments in addressing a broad range of issues that associate urbanization and food security and nutrition. This support encourages countries to adopt a comprehensive approach to ensuring good nutrition for people living in their expanding cities, especially the most vulnerable. Focusing on food and nutrition security and livelihoods in urban and peri-urban areas is a prerequisite for helping poor city dwellers attain a healthier life, and for enabling city authorities and local governments to broaden their strategies for achieving the Millennium Development Goals. Food and agriculture can be a critically important strategic driver for innovative approaches to local development.

Food system approach

A food system includes all processes and infrastructures involved in making good and nutritious food available for a population. While access to good, nutritious and inexpensive food is often taken for granted in urban areas, the urban food system is a complex system that relies on the support and coordination of many actors in public, private and civil society, with local authorities playing a key role in providing a vision and creating a framework of regulations and infrastructures. People, as consumers and citizens, are drivers of this food system. By purchasing their chosen food, they help to guide markets and production. The food system itself can contribute to achieving more balanced diets if supported by a vision and a sound policy framework. Food security and nutrition require political commitment at national and local levels.

More balanced and sustainable diets are directly linked to consumption of more fresh food such as vegetables, dairy products, fish and eggs. Local food production, including urban and peri-urban agriculture for crops and livestock, makes an important contribution to this because the food supply chain effectively connects local producers to food processing and marketing actors. Shorter food chains, with stronger urban-rural linkages, benefit local actors by reducing transportation costs and hazards, and allowing better control of production quality and sanitary conditions. Small-scale activities such as micro-enterprises throughout the food chain may provide women, in particular, with opportunities for generating income and accessing fresh and nutritious food, thereby facilitating their integration into urban economic and social life.

BOX **4**

Urban and peri-urban agriculture in Latin America and the Caribbean

In Latin America and the Caribbean, FAO provides support in sustainable urban and peri-urban agriculture, increasing its sustainability and efficiency through strengthening simple, appropriate and locally validated technologies. It also supports socio-economic interventions, including supporting community organizations (Bolivia, Peru, Colombia), marketing (Uruguay and Argentina), food security and nutrition (Colombia) and institutional capacity building (Brazil); helps municipalities integrate urban and peri-urban agriculture into municipal management in the context of food security; and develops policy instruments for promotion and support of these initiatives.

Several of these successful programmes have reached substantial numbers of beneficiaries. For example, the Urban Agriculture Programme for Bogotá reached 50 000 families and almost 5 000 urban farmers.

Food system and climate change. A food system approach, with action at local, national and global levels, should be an integral part of a city's strategy in preparing for climate change. At the local level, the practices of farmers and producers can help maintain biodiversity. Adaptation of agricultural production and natural resources management, particularly of land, forests and water, lead to better watershed management which, in turn, can prevent floods and contribute directly to disaster risk management for cities.

Urban purchasing power. Cities play an important role as driver of the local food and agriculture economy. The purchasing power of urban households can support local food systems centred on the city, strengthening and adapting urban-rural linkages (agriculture inputs, natural resources, flows of food, people and money). Urban in-migrants bring with them their cultural backgrounds regarding agriculture and food but may have to adopt new methods of acquiring, preparing and eating food. People living in urban areas often maintain links with rural areas through, for example, ownership of land and houses, or through seasonal participation in planting and harvesting of crops, and these links can be made better with appropriate food-policy frameworks. Urban-rural linkages are critical to ensure balanced programming and planning with a local perspective at rural and urban levels, but in line with a national vision.

Supporting and managing an urban food system

Local authorities have an important role in defining and implementing policies at the local level with participation of stakeholders from the public and private sectors, and from civil society organizations and consumer associations. Nutrition education

needs to be promoted, as consumer behaviour is a critical issue in good nutrition. For example, school gardening programmes can be effective tools. Public authorities can help consumers by developing labels and certifications covering food provenance and quality standards.

Land tenure and urban planning policies should take into account agriculture and food. This means reserving space and managing infrastructures for efficient food supply systems (transportation facilities and wholesale markets) and protecting land as necessary for appropriate agricultural production. Maintaining local food production also requires that city development and land-use plans ensure land is preserved for agricultural use. Improving agricultural production in urban and peri-urban areas can be supported by effective planning mechanisms, such as strengthening food-related infrastructure to ensure producers and consumers at the territorial level have efficient access to markets. Encouraging producers to organize themselves into associations is helpful for improving their relationships with local authorities and for facilitating information flows, particularly regarding available land. Public procurement mechanisms, including food purchases for schools and hospitals, can support the food system by involving local agriculture and food producers.

In addition, cities may be vulnerable to natural or human-induced crises that can seriously disrupt the food system. Local governments should develop more resilience by implementing urban policies that integrate food and agricultural issues as well as management of natural resources, including trees, land and water, within a holistic territorial approach. Urban and peri-urban forestry and agriculture development both contribute to the support of environmental and social functions, including mitigating and adapting to climate change, reducing urban heat islands and reducing propensities to floods. Preparedness, disaster risk management and response strategies in these cases need to be further developed. Specific attention should be paid to assisting and targeting internally displaced people in urban areas, especially where these consist of large numbers of people in limited urban and peri-urban areas.

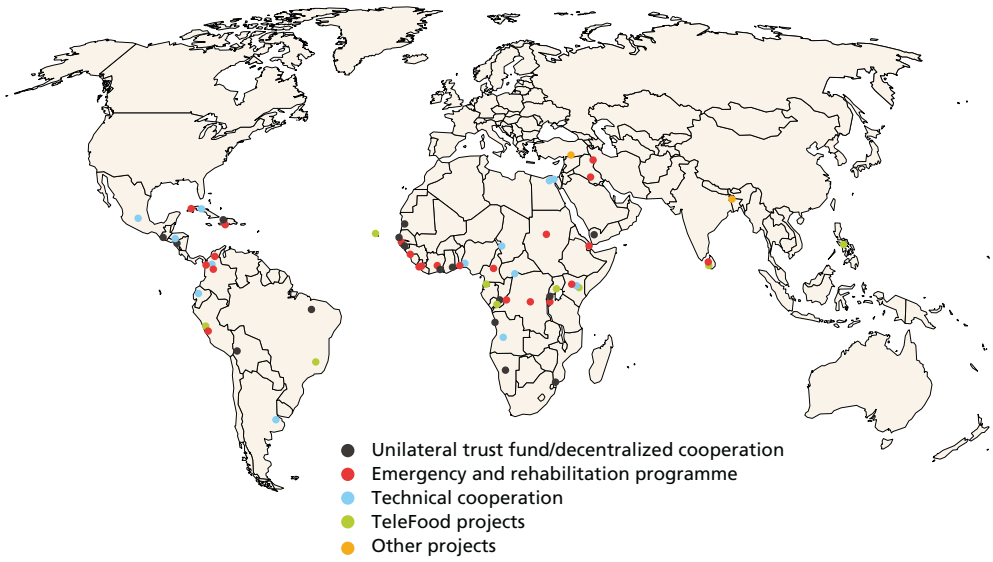
Local and rural development for cities, including environmental services

At local and national levels, FAO supports the development of policies and the implementation of innovative programmes. FAO's multidisciplinary Food for the Cities initiative has implemented projects in a wide range of areas: food supply, nutrition education, school gardens, urban agriculture and horticulture, support to small producers in urban and peri-urban areas, and waste management.

Technical guidance and capacity development tools improve the effectiveness and sustainability of the food system, from production to post-production, with special attention to strengthening livelihoods and increasing food availability, safety and accessibility. FAO provides policy guidance at the municipal and national levels to integrate food and agriculture as part of urban and territorial land-use planning, and in relation to rural-urban linkages. Promoting the protection and

FIGURE **5**

FAO projects within urban and peri-urban areas, 1995-2009



Source: FAO.

improvement of the urban and peri-urban environment is key to i) improving urban resilience and adaptation to natural disasters and climate change; ii) reducing negative impacts on agriculture, water and urban infrastructures; and iii) providing opportunities over the longer term for significant savings in impacts and costs.

Given the major challenges to ensuring food security and nutrition in cities, different actions should be undertaken at the global level. The Food for the Cities initiative draws on FAO's cross-cutting expertise to address food security and nutrition and advise on agricultural responses to urbanization. In addition, FAO has set up dedicated multi-stakeholder platforms for dialogue and action in formulating policy on good governance on food, agriculture and cities. This requires sharing information and good practices that take stock of urban food security and agriculture policies, legal frameworks and programmes that cities and countries around the world have already developed, or are developing, with a view to their systematization and wider dissemination. Guidelines, criteria and indicators for use by policy-makers need to be developed that deal with urban development in relation to agriculture, livestock, aquaculture, land-use planning and forestry, as well as urban food system planning and development.

Changing patterns of food consumption

The last few decades have seen fundamental changes in food consumption. While staple food consumption and total energy intake have continued to rise, patterns

of food consumption and diets have evolved towards more processed and packaged foods and more meat, eggs, dairy products, sugar, fats and oils. These are energy-dense diets that also are higher in sodium, saturated fats and cholesterol. Such trends are expected to continue until 2050, although at a slower pace because global food consumption will near its saturation point with a slowing of population growth and rising incomes.

However, the increased intake of saturated fats, cholesterol and sugar in diets has meant an increased prevalence of overweight, obesity and related non-communicable diseases. These have significant social costs, in the form of increased health expenditures and lost productivity, and private costs, in the form of deterioration of quality of life. Abandoning traditional diets also can lead to an increase in micronutrient deficiencies, a type of malnutrition that already exists throughout the world in poor households that cannot afford to pay for diversified diets. Meanwhile, on the positive side of new consumption habits, a growing focus on the nutritional and health benefits of fish and fishery products has resulted in a greater demand for seafood worldwide. Global fish consumption has increased gradually but steadily, reaching an all-time high of 17 kg per capita per year in 2007.

Current trends

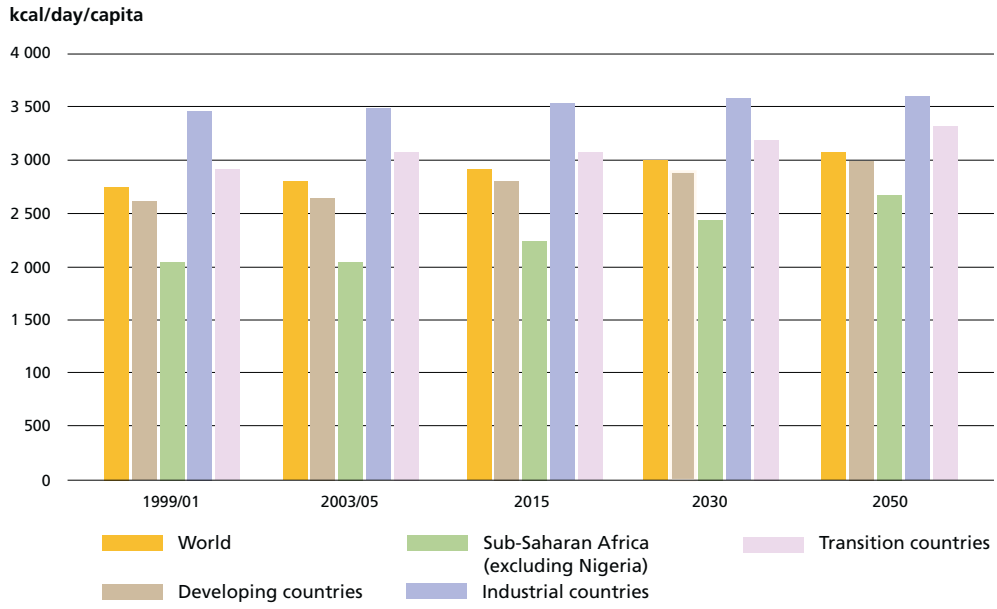
Changes in consumption patterns already have taken place in most developed countries, with many developing countries now undergoing a similar transition, and more countries likely to have similar changes by 2050. Despite the growth in their absolute levels, the relative importance of consumption of carbohydrate-based staples, namely cereals, starchy roots, bananas and plantains (CRBP), has been in pervasive decline in both developed and developing countries. Owing to rapid increases in their consumption, oils and fats, meat and fish, dairy products and, to a lesser extent, sugar together constitute more than half of the total dietary energy supply (DES) in developed countries and almost one-third in developing countries.

These changes have been taking place against a background of increasing per capita food consumption, which is foreseen to continue well into 2050 (Figure 6). There also has been substantial variation in commodity composition during the past few decades (Figure 7). Developed countries have exhibited the lowest variation in consumption patterns, partly due to the fact that food consumption in these countries has reached saturation levels, so there is less substitution among food types. By contrast, developing countries have shown pronounced variability. Among them, countries located in South Asia have experienced the largest changes in dietary patterns, mainly because of a strong increase in consumption of fats and oils and a marked decrease in consumption of pulses. Food consumption in East and Southeast Asia has increased more than in any other region, accompanied by large variation in food patterns such as higher consumption of meat, sugar and oils and fats and rapidly declining consumption of CRBP foodstuffs.

In sub-Saharan Africa, growth in total food consumption has been the lowest of any region, and substitution among major food groups has been limited, with CRBP

FIGURE **6**

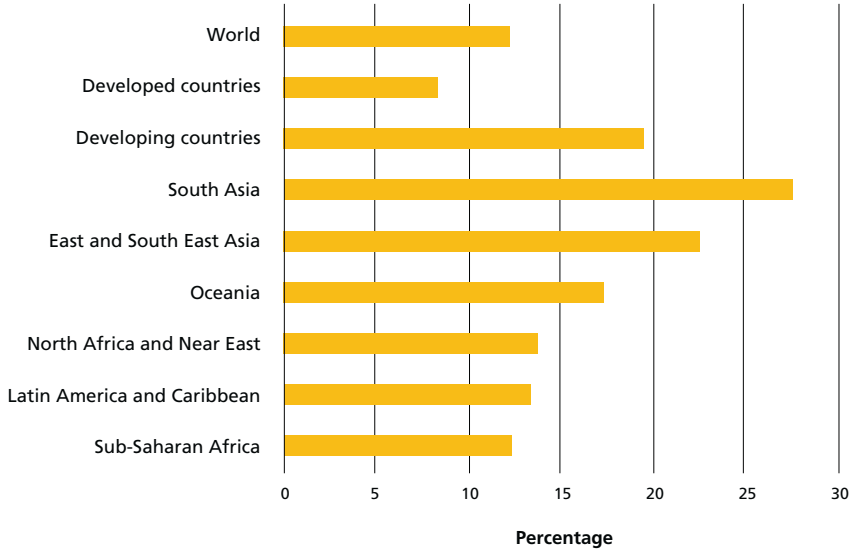
Per capita food consumption



Source: Alexandratos, 2009.

FIGURE **7**

Variation in dietary patterns, 1961–2001



Source: FAO 2004b. The "variation" in aggregate consumption patterns is measured by the average of the coefficients of variation over the period 1961–2001 for each food item included in the study.

foods continuing to dominate diets. As a result, dietary patterns have been relatively stable over time for the region. Likewise, regional food patterns have varied little in North Africa, the Near East, Oceania, Latin America and the Caribbean, even though they have experienced moderate-to-large growth in overall energy intake. The developing regions also have shifted towards finer grain products, mainly wheat and rice, and away from traditional products such as millet, sorghum, cassava and sweet potato.

It is clear that dietary patterns in most regions have undergone varying degrees of change, but there is a marked relationship between the level of total energy intake and dietary shares of particular food commodities. The developed countries with highest DES have the lowest shares of CRBP and pulses. At the other extreme are the countries of central Africa. They rank highest in terms of undernourishment, with around half the DES intake but double the CRBP and pulses food shares of developed countries. By contrast, all other commodity dietary shares are positively related to the level of DES.

Drivers of changes in consumption

A series of factors has driven these trends, such as rapidly falling real prices for food, at least until the early 1990s; rapid economic growth and increased incomes in many developing countries; population growth; rapid urbanization; emergence of new marketing channels and the proliferation of supermarkets; and freer trade and globalization of the food economy with the arrival of large, transnational food companies and fast-food chains.

Globalization, industrial development, population increase and urbanization have changed patterns of food production and consumption in ways that profoundly affect ecosystems and human diets. The causes and consequences of the dramatic reduction of food diversity and the simplification of diets are complex and not limited to specific cultures, with the overall health of the population, agricultural practices, market conditions and the situation of the environment within a given country all contributing to the complexity.

Real income and food expenses. People in developing countries spend a large proportion of their income on food: a great deal more than the 15 percent estimated for developed countries. Consumers in developed countries are much less responsive to changes in income and food prices than those in developing countries. Irrespective of the level of development, the consumption of staple commodities hardly responds to changes in prices or incomes, while consumption of higher-valued food categories tends to respond much more, especially in low-income countries. Thus, given that consumer reactions to income and price changes differ across food types, rising income or variations in prices will change the composition of food demand and these changes will be more pronounced in developing countries and, at least initially, will tend to improve diets of the poor. By contrast, consumers in developed countries usually make relatively small adjustments between food consumption groups in their overall food intake when they experience changes in income or prices.

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PHOTO 2
The proliferation of supermarkets contributes to changing dietary patterns.

Population growth and urbanization. Population growth has been and will be a significant influence in determining the increase in overall demand for food, along with the increase in income growth. For example, the slowing of population growth and the reduced sensitivity of overall food consumption at higher income levels will reduce the pressure on limited resources in the future, plus ageing of populations will lead to further changes in food consumption patterns. On the other hand, urbanization and changes in real income have been among the most important factors changing the structure of food demand and consumption. While most developed countries have largely completed this transition, it is still an ongoing process in many developing countries. Apart from the fact that urban incomes are, on average, much higher than rural incomes, rural and urban diets differ due to the nature of urban lifestyles and changes in the way food is processed, marketed and prepared in urban areas.

Urban lifestyles and processing and marketing of food. Urban lifestyles, on average, are more sedentary than rural ones, expending less energy and thus less reliant on energy-providing staples. Moreover, changing work habits and increased participation of women in the workforce have tended to reduce time devoted to the preparation of food and increase frequency of eating out. New and improved marketing and distribution infrastructure, proliferation of supermarkets with their sophisticated food handling systems, and better roads and ports have improved access by foreign suppliers, increased the importance of imports in overall food supply, and promoted globalization of dietary patterns. These tendencies have increased the consumption of processed foods that contain more total fat, trans-fatty acids, sugar and sodium, and less dietary fibre, minerals and vitamins.

Health effects of new consumption patterns

Within limits, the shift towards higher meat and milk consumption reflects a desirable nutritional goal for many developing countries. Both the increased quantity and quality of protein and access to essential minerals and vitamins in the diet benefit infants and children by promoting steady growth in the first years of life.

Similarly, improved bio-availability of iron is good for women who are at increased risk of anaemia in their reproductive years. However, as intake levels rise further, these benefits decline rapidly. Once intake reaches adequate levels, there is no good argument for continued increases. On the contrary, high intakes are associated with considerable risks and detrimental health effects, including increased incidence of some cancers and cardiovascular diseases.

Addressing negative impacts in developing countries. The adverse impacts of rapid changes in consumption patterns, or "nutrition transition", are likely to be compounded by a number of factors that are specific to developing countries. This may not only mean that the nutrition transition proceeds faster in developing countries, but also that its adverse impacts are likely to be felt more strongly there. For example, those whose mothers were undernourished during pregnancy or who were stunted as children have a predisposition to obesity in later life. In addition, many developing countries lack adequate health promotion and healthcare systems that could help prevent and cope with the adverse impacts. The measures necessary to address these challenges are complex and varied. The first involves fighting hunger today in a way that minimizes the predisposition of infants and children to develop obesity and non-communicable diseases later in life.

- *Focus on pre-natal and infant nutrition.* Maternal and child nutrition programmes, such as the USA-backed 1 000 Days Campaign, are designed to ensure infants receive proper nutrition during their early years, and also help improve nutrition during pregnancy and pre-pregnancy. By helping curb a likely obesity epidemic, these programmes will yield an extra return in the future – over and above their immediate anti-hunger dividend. Given the speed with which consumption patterns are changing, and the higher susceptibility of developing country consumers to obesity and non-communicable diseases, there is an urgent need to design and devise policy measures that help avoid adverse nutritional outcomes in developing countries.
- *Conserving biodiversity and traditional foods.* Agricultural biodiversity has an increasingly acknowledged role to play in moderating nutritional problems. The food systems of indigenous peoples demonstrate the importance of a diversified diet based on local plant and animal species and traditional food for health and well-being. In most cases, the increase in consumption of processed and commercial food items over time decreases diet quality. Countries, communities or cultures that maintain their own traditional food systems are better able to conserve local food specialties with a corresponding diversity of crops and animal breeds. They are also more likely to show a lower prevalence of diet-related diseases.

Several policies have been proposed to deal with the adverse nutritional outcomes. Nutrition education with emphasis on traditional food and preparation might also help.

Conclusion

Global population is forecast to reach 9.2 billion by 2050. That means 2.3 billion more mouths to feed from the same resource base we have today, and against a backdrop of rising numbers of hungry and malnourished. FAO, with its mandate to ensure global food security, maintains its focus on the agriculture sector as the driver of economic growth in the developing world but also as the sector that has the potential to support the poorest and most food-insecure of the world's population.

The central issues of population, food demand and agricultural production include the effects of increasing urbanization which not only means more people must purchase their food instead of growing it, it also means that increased production will have to be accomplished with a smaller rural labour force. Specifically, looking towards 2050:

- overall food production will need to increase by 70 percent and production in developing countries will need to double; and
- cereal production will need to increase from today's 1.8 billion tonnes to 3 billion tonnes.

This can be done, but it will require the adoption of more efficient and sustainable production methods that at once can adapt to and contribute to mitigating climate change. In a context of urbanization, FAO advocates a food system approach that ensures urban and peri-urban food quality and safety through shorter food chains, strong urban-rural linkages and sound management of natural resources.

CHAPTER 2

Pressures on natural resources and the environment

In the 21st century the world faces a stark contrast between the availability of natural resources and the demands of billions of humans who require those resources for their survival. There was a time when natural resources seemed infinite. Yet, as the world's population has increased, the availability of natural resources that support human life – food, freshwater, quality soil, energy and biodiversity – have decreased proportionately, and existing stocks are being increasingly polluted, degraded and depleted.

With an increasing percentage of the Earth's surface dedicated to cropland and the fact that a full 70 percent of abstracted freshwater is used by agriculture, there is no question that agriculture needs to be at the centre of any discussion on natural resource management and global environmental objectives.

The paradox of food insecurity and hunger is that at the global level, there is sufficient production to provide nutritionally satisfactory food to everyone. Yet one in seven people in the world suffers constant hunger. In spite of the global adequacy of food supplies, people in countries with persistent food insecurity problems lack access to the global plenty. In many countries, food security depends on the performance of local agricultural production.

Investing in the development of agriculture will be particularly effective in those countries with high population growth. However, the natural resource base of some of these countries may not be sufficient to make significant progress. Therefore, serious thought needs to be given to supplementing efforts to develop agriculture with interventions in other sectors that are not affected by agricultural resource constraints.

Land and water resources

The availability of good quality land and water resources, together with an enabling socio-economic and institutional environment, is essential for food security. The range of land uses adopted for human needs is primarily determined by demographic and socio-economic drivers, cultural practices and political factors, such as land tenure systems, markets, institutions and agricultural policies. Environmental conditions are also a determining factor, including climate, topography and soil characteristics.

Land resources

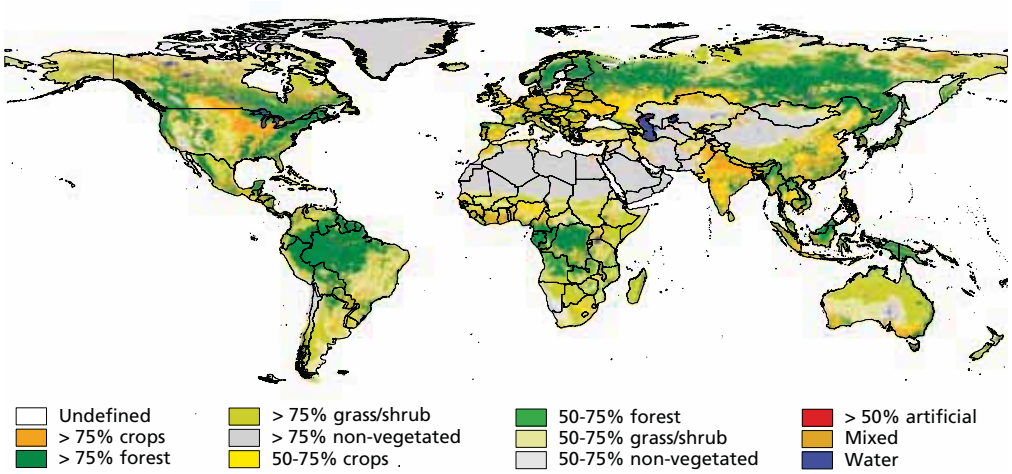
According to FAO, the global land mass comprises about 13.3 billion ha, of which about 12 percent is currently in use for cultivation of agricultural crops, 31 percent is under forest and 40 percent comprises grasslands, woodlands, wetlands and other ecosystems. Driven by human needs and technological capabilities, substantial shifts in land use have taken place in the last decades. During the last 50 years, forest ecosystems have declined by about 15 percent while the area of pasture and cultivated land has increased.

The current 1.6 billion ha of cultivated land represent the better and more productive part of global land resources. Locally, owing to population pressure and lack of prime or good-quality options, less suitable and marginal lands have been converted to cropland. Through unsustainable use, high-quality agricultural land in some areas has been degraded as a result of human-induced water and wind erosion, nutrient mining, topsoil compaction, soil pollution and salinization caused by improper irrigation and drainage practices. Once degraded, the land is frequently abandoned and left as marginal grassland and woodland, with only a part of it developing into secondary forest ecosystems.

Nearly one-third of the world's arable land has been lost through erosion during the last 40 to 50 years, with losses continuing at a rate of more than 10 million ha per year. This degraded land has been replaced by converting mainly prime and good-quality agricultural land resources – namely those available in grassland, woodland and forest ecosystems – into cultivated land.

FIGURE **8**

Dominant land use and cover



Source: FAO, 2011a.

Soil and terrain constraints

In developed countries, about 60 percent of cultivated soils, some 366 million ha, are assessed as having only minor or no soil and terrain constraints, with soil nutrient availability reported to be the most limiting factor for the other 40 percent. In less developed countries, 42 percent of cultivated soils, about 410 million ha, have only minor or no constraints, while nutrient availability is the predominant cause of soil constraints for the remaining 58 percent.

Soil nutrient availability is by far the most prevalent soil limitation in most regions, but particularly in the tropics and in large parts of central Africa and central South America. Although the natural fertility status of soils may have deteriorated over time through nutrient mining, if correct soil management and appropriate fallowing are adopted, the natural status might be restored over time. Under high-input farming conditions, low natural nutrient availability can be alleviated by mineral fertilizer application, provided the soil has an adequate nutrient retention capacity.

Low nutrient retention capacities are found in southern Africa, the Amazon area, central Asia and northern Europe. In those areas, increased use of fertilizers alone may prove less effective for increasing crop yields.

Vulnerable land-use areas and systems at risk

The capacity of some local production systems to achieve the higher rates of agricultural intensification required to meet projected food demand is constrained by multiple factors: increasing pressures on land and water resources from population growth, changes in dietary habits, climate change, biofuel production, land degradation, and water pollution and depletion due to unsustainable practices and competition for ecosystem services (e.g. the diversion of water supplies for industry and urban users).

The production systems where these conditions exist or are anticipated constitute "systems at risk". They warrant appropriate remedial action that entails: i) technical options to promote sustainable intensification and to reduce risks that are acceptable for either rainfed or irrigated conditions; and ii) the creation of enabling conditions, including the elimination of institutional mechanisms that reinforce inefficiency, social inequity and the degradation of resources. Distortions in the incentives framework need to be removed, land tenure systems and access to resources need to be improved, and planning and management as well as transboundary and international cooperation established. Efforts to facilitate knowledge exchange and appropriate adaptive research are also crucial.

Mitigation and management measures

Rather than drastically changing land-use practices, which may only be required in a limited number of areas, the increased environmental risks can be managed by mainstreaming adaptation and mitigation into core development work and investments in:

- capacity development in land-use planning and adapted, sustainable land-use management;
- infrastructure development to reduce damage and protect assets;
- weather stations and climate monitoring and information services;
- technology transfer combined with local innovation to ease land-use transition and reduce resource degrading practices in cropping, pastoral and forest systems and aquaculture;
- early warning and emergency response systems based on sound vulnerability assessments;
- innovative risk financing mechanisms and insurance schemes to spread residual risks;
- payments for environmental services to provide incentives for the required changes towards better land and water management, reduced greenhouse gas emissions, enhanced carbon sequestration in plants and soils and biodiversity conservation;
- more efficient energy use (no-till systems, use of sustainable fuel), including a focus on use of wastes and residues – primarily from agro-processing units, integrated food energy systems and biofuel projects that set aside land to meet local food needs.

In situations where drastic changes in land-use patterns are necessary, access to surface water and groundwater needs to be factored in, and this has implications for both intensive agriculture and animal production. In addition, rights for land and water use now tend to be administered separately, meaning that before any comprehensive reform of land-use planning is enacted, the interface between these systems must be fully appreciated. Critical considerations include recognition of customary rights, transparency and stability of use rights, and the impact of land-use planning on national and international river basin water balances and water scarcity.

There also is a pressing need to invest in and improve capacity for land-use planning at national, regional and local levels. Improved planning can improve resource allocations, increase investments and local action-oriented planning and thereby support the transition to more sustainable and productive land-use systems and, at the same time, facilitate adaptation to population growth, migration, climate change and economic conditions. In Mozambique, experiences in land management and negotiated territorial planning have been recognized by the private sector, including smallholders, as the main engine for economic development. This has encouraged private investment in land development, within the framework of a negotiation process involving all stakeholders. Such investments have the potential to stimulate production, address problems related to soaring food prices and increases in global hunger, reduce rural-urban migration and respond to negative effects of climate change.

Sustainable land management

To meet the challenges described in earlier sections, namely the rapidly increasing demand for food and energy in the face of land scarcity and associated risks of

conflicts over natural resources, uncontrollable migration, ecosystem and environmental degradation, and the need for mitigation of and adaptation to climate change, a paradigm shift and new approach to governance of land resources is needed. Such a new governance system must be based on the principles of what is referred to as sustainable land management (SLM).

SLM comprises a series of technical and management practices based on intensive agro-ecology that could be used as a base for an emerging "green agriculture". Technically, these concern the integration and wide application of the following practices:

- crop management techniques – including conservation agriculture, use of improved seeds and germplasm adapted to local land uses and ecosystems, integrated pest management, mulching and residue management;
- pasture and rangeland improvement methods – including planned grazing processes, area exclusion for grazing recovery or enrichment planting, and improved breeding;
- forest improvement – including agroforestry, planting, natural regeneration, shelterbelts and fire protection;
- improved soil management – including retention of crop residues and soil cover, addition of organic matter or soil carbon with compost, manure and green manure (cover crops), integrated nutrient management with wise use of mineral fertilizers, and zero or reduced tillage;
- improved rainwater management – including contour ridges and tied ridges and natural vegetative strips.

The underlying principle of SLM is that it should be managed by the users according to social approaches. It should entail community-based participatory planning and technology development, which builds on rural people's skills and capabilities to plan, develop and implement the required practices. In addition, it should ensure the participation of marginalized groups and involve landscape, territorial and participative land-use planning. It also calls for people-centred learning approaches, using participatory adult learning methods in which land users learn about integrated management of crop, livestock, fishery and forest production, land degradation problems and input supply and marketing constraints.

People-centred approaches enable those who are actually involved to identify ways to address issues, test and monitor different practices, and review and share their findings. Farmer Field Schools, an approach supported by FAO, follows this method and has been very successful working with farmers in their fields to raise awareness of environmental issues and also to improve production.

FAO has also designed and implemented policies, programmes and projects on land and natural resources management to enable member countries to produce more food of better quality while using less land and water per unit of output; providing rural people with resources and opportunities to live a healthy and productive life; applying clean technologies that ensure environmental sustainability; and contributing productively to local and national social and economic development.

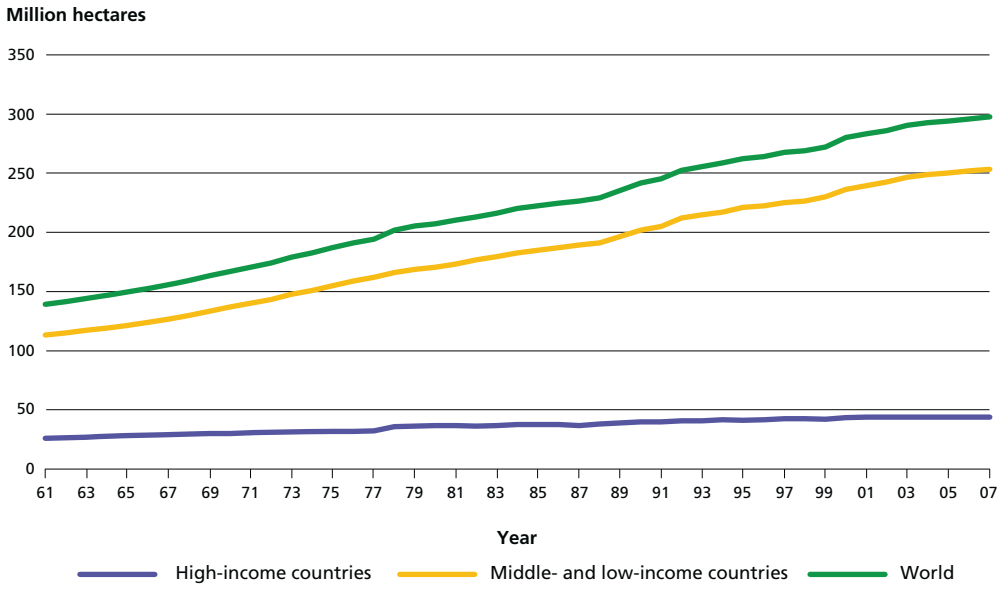
Land tenure

Providing adequate rights of access to land and other natural resources and the secure tenure of those rights is essential to fostering sustainable and progressive agricultural development. Secure land tenure empowers and enables development and is a valuable safety net as a source of shelter, food and income, especially in times of hardship, and leads to greater environmental security. Farmers are quite naturally more inclined to invest in improving their land if they have secure tenure and can benefit from their investments. Secure tenure can include community user rights, leasehold and tenancy arrangements to private land titles. Without secure tenure and access rights to water and forest resources, the alternative is for farmers to exploit marginal land, abandoning it when it becomes unproductive, which implies either migrating to search for employment in urban areas or, where possible, moving on to clear forests and other fragile land areas that are available. With increasing population pressure, fallow periods shorten and the land is again exploited before it has time to recover through natural regeneration processes.

Resources and ecosystem degradation is exacerbated in marginal or fragile lands where natural recovery tends to be longer and fails to regenerate former levels of productivity. An FAO-led initiative underway to develop voluntary guidelines for responsible governance of land tenure is explained in Chapter 4.

FIGURE **9**

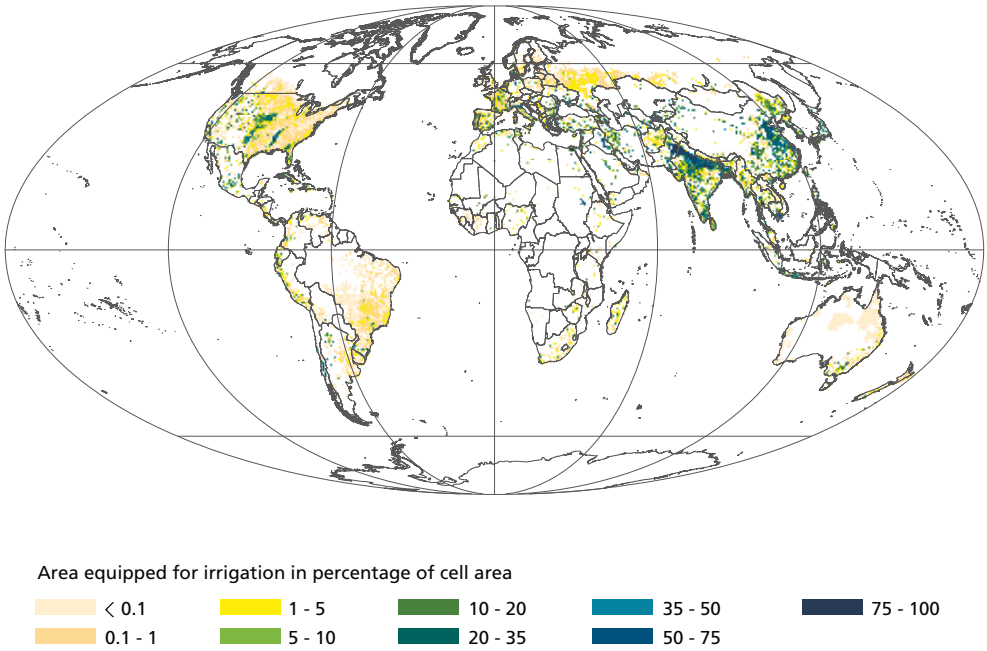
Evolution of areas equipped for irrigation, 1961-2007



Source: FAO, 2011b, 2011c.

FIGURE **10**

Part of total land area equipped for irrigation



Source: Institute of Physical Geography, University of Frankfurt and FAO, 2011c.

Water resources

The management and control of freshwater, mainly through irrigation, to produce crops, water livestock and manage aquaculture have proved essential to livelihoods and economic development. Without that control and management of freshwater resources, the world's agricultural systems would not have been able to meet unrelenting increases in demand for food and fibre. The land simply would not have been available to meet such demand under rainfed conditions.

Irrigation and implications of growing water scarcity

Today, rainfed agriculture continues to provide the base-load of cereal and fodder crops and currently accounts for 60 percent of global agricultural production. Where climate has been variable and the pressures of human demand have risen, however, the volatility of rainfed agriculture has become untenable. Intensification of production through water control has been necessary to make up the 40 percent shortfall and provide a buffer against the volatility inherent in rainfed production.

Globally, the area of land under cultivation increased from 1.4 billion ha in 1961 to 1.6 billion ha in 2010, a net increase of about 14 percent. All of this increase is attributable to irrigated cropping. In fact, land under rainfed systems has shown a

very slight decline, while the irrigated area more than doubled from 140 million in 1961 to 300 million ha in 2009. In addition, thanks to increased productivity, the area needed to feed one person has been reduced significantly.

In the years ahead, the trend towards higher consumption of animal protein will have consequences not only for more intensive production of fodder crops, but also for watering livestock, which will become even more critical considering the prospect of more variable weather patterns. Controlling water resources will enable agricultural systems to be more responsive to these changing demands. Applying knowledge, technology and the strategic targeting of investment in water control will be a key to closing the gaps between supply and demand. It is thus imperative to pay attention to the critical role of water in poverty alleviation, food security and economic growth.

The growth in areas served by irrigation has been spectacular. It would not have occurred without investment in water infrastructure, which includes water storage, conveyance, energy supplies, roads and marketing, and a corresponding response from farmers who invested private capital in irrigation systems. Growth in the number of private tubewells that provide on-demand, just-in-time water services continues to eclipse growth in areas serviced by the control of rivers and lakes. A recent FAO inventory of country data found that almost 40 percent of the global area equipped for irrigation relies on groundwater as an exclusive or supplementary source of water.

Impacts of irrigation on poverty and food security

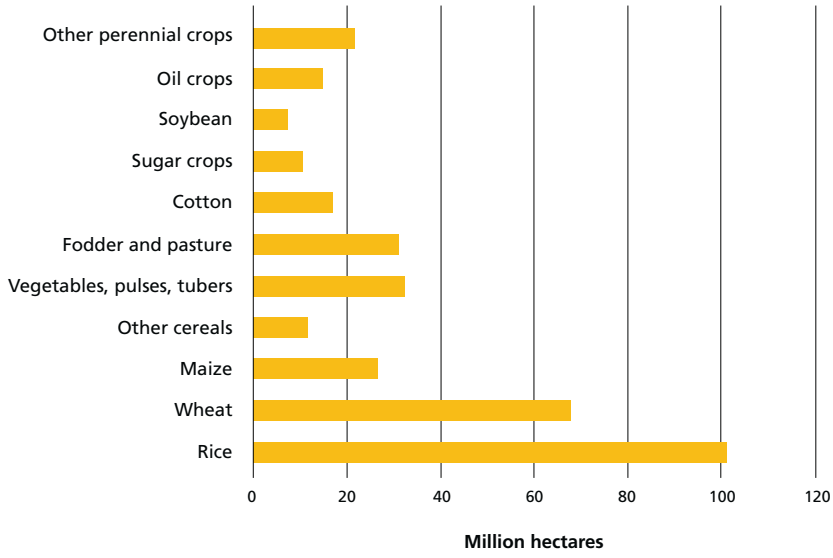
Where vibrant markets for irrigated production are present, farm incomes and food security have been transformed. The consistent support by FAO and the International Fund for Agricultural Development (IFAD) to smallholder irrigation has become an integral part of national food security programmes, where the economics of irrigation technology and markets have converged – although this has not been without risks.

Irrigation reduces poverty through increased food output, higher employment, and higher real incomes. It also supports the poor through a multiplier effect which drives an increase in non-farm rural output and employment as the level of rural spending rises. Irrigation also contributes to risk reduction by reducing variability in output, employment and income, allowing for more productive investments and lessening the periodic liquidation of capital, such as livestock, during times of crisis.

However, despite these poverty-reducing benefits of irrigation, many irrigated systems can have negative impacts on the poor in situations where adverse social, health and environmental costs have not been mitigated. It must be noted that irrigation can only be effective in reducing poverty if the schemes are well managed – poor irrigation performance is associated with higher poverty levels. The incidence of poverty is also generally correlated with an individual's position within a scheme – tail-enders are typically poor – and with inequitable land distribution. Irrigation's positive impact on poverty is highest where landholdings – and therefore water – are equitably distributed.

FIGURE **11**

Global distribution of harvested irrigated crops, 2009



Source: FAO, 2011c.

As Figure 11 illustrates, irrigation has been especially important for countries with high population densities, particularly Asia. What is more perplexing is why the uptake of intensive agriculture has not been more pronounced in parts of the world where land and water resource endowments appear adequate. Sub-Saharan Africa is a case in point – only 4 percent of its cultivated area is equipped for irrigation.

Environmental costs of growing water scarcity

The expansion of irrigated areas has come at a cost. Globally, 2 710 km^3 per year, or 70 percent of the total water withdrawn from rivers and aquifers, is used by agriculture, compared with 19 percent by industry and 11 percent by the municipal sector. Clearly, agriculture has a lot to account for.

The reduction of river flows, loss of aquatic habitat, salinization of land and depletion and degradation of aquifers are common indicators of the environmental pressure irrigation places on natural resources. Countries have developed their water resources extensively over the past 50 years through a combination of policies and investments that have increased supply and stimulated demand. Some 45 percent of the world's rural population lives in river basins that are categorized as physically water scarce with respect to overall demand.

Salinity associated with poor drainage, or waterlogging, affects 11 percent of the irrigated land (34 million ha), mostly in arid areas. Pakistan, China, the USA and India represent more than 60 percent of the total (21 million ha). Less evident, but equally pernicious, are the impacts related to accumulation of fertilizer and pesticides

in the environment, that bring with them risks to human health and can reduce productive wetland biodiversity and aquaculture. The concentration of these agrochemicals in the environment can be attributed to irrigated agriculture, where the incentives to sustain reliable levels of production are clearly much higher. FAO's integrated pest management (IPM) programme has proved effective in reducing pesticide use in many irrigated areas, but more needs to be done to reduce this accumulation and halt the impact on human health and environmental integrity.

Role of water in integrated natural resources management

Linking land and water systems to meet an increasingly sophisticated set of competing demands has become a well-accepted global priority. Integrated river basin development has been embraced as an ideal tool for reconciling these demands since the middle of the 20th century. But the practice has been overtaken by the sheer pace of economic development and the expansion of urban, industrial and agricultural land use in river basins. Ten years into the 21st century, a return to integration should be much better informed. Advanced knowledge of the hydrological cycle, improved agricultural practices and new tools for mitigating the impacts of chemical pollutants and managing wastewater now offer a set of knowledge-rich solutions for reducing environmental impact. Taken together with new institutional approaches to resource management that are much more inclusive of water users, there is now scope for achieving positive change across the key land and water systems that furnish the global food supply. Conservation of forests and wetlands, the natural regulators of the hydrological cycle, are particularly important in this context.

The increasing pressure and demand on water resources for agricultural production requires an integrated and ecosystem approach to water resources management. Integrated and collaborative watershed management is an appropriate approach since it addresses all aspects of local livelihoods, including agriculture, pasture, forestry and hydrology and aims at ensuring sustainable management of natural resources. Forests are particularly important as they play a crucial role in the hydrological cycle, capturing and storing water, preventing soil erosion, and serving as natural water purification systems. Forests influence the amount of water available, regulate surface and groundwater flows and ensure high water quality. Moreover, forests and trees contribute to the reduction of water-related risks such as landslides, local floods and droughts, and help prevent desertification and salinization. Forested watersheds and wetlands supply three-quarters of the world's accessible fresh water for domestic, agricultural, industrial and ecological needs.

Water and agricultural intensification

In the years ahead, the largest contribution to increased agricultural output is likely to come from intensification of production in existing irrigated areas. Increased water productivity and higher cropping intensities will only be achieved through improved flexibility, reliability and timing of water service, and more efficient water use, which will require investments in both modernization of irrigation infrastructure and institutional capacity.

The availability of water for agriculture will become a growing problem in areas that use a high proportion of their water resources and expose their systems to high levels of stress. Climate change, which is expected to exacerbate these stresses, plus the continuing risks of pollution, salinization and waterlogging and their potential impacts on downstream water-related ecosystems, will require careful management. Key food producers depend on groundwater, meaning declining aquifer levels may create a risk to regional food production, with possible implications on food prices at the global level.

The rate of expansion of land under irrigation already is slowing substantially. FAO has projected that the global area equipped for irrigation may increase at a relatively modest rate to reach 322 million ha in 2050 and 324 million ha in 2080. This compares with around 302 million ha for the baseline period of 2005/07. Most of this expansion is projected to take place in developing countries. This would represent an increase of around 7 percent, or 0.1 percent per year, much slower than in recent years, considering that between 1961 and 2009, irrigated area grew by 1.6 percent per year globally, and by more than 2 percent per year in least developed countries (LDCs).

The trend in water use by agriculture is also slowing as the performance of irrigation systems and agronomy improve, raising the productivity of both irrigated land and water. But rapid transitions from rural to urban settings are further concentrating patterns of demand. Since agriculture will continue to be the main water user, improved agricultural water use in irrigated agriculture will have a direct impact on local and regional water demands. Allocations taking raw water away from agriculture to other higher utility uses – municipal supplies, environmental requirements and hydropower generation – are already taking place, but there is still scope for these allocations to be optimized in economic and environmental terms. Agriculture also will need to benefit from the progressive increase in use of treated wastewater from the urban sector.

Improved agricultural water use has resulted in higher crop yields and cropping intensities, but there is still considerable scope for technical efficiency gains at all levels of agricultural production. Technical improvements are anticipated in two key areas.

- *On-farm irrigation management.* Water deliveries will need to be better tailored to crop needs and soil conditions. Reductions of water losses through modernized conveyance, better field application (e.g. drip and sprinkler), enhanced soil moisture management, and reduced runoff and evaporation from bare soil will all enhance on-farm irrigation efficiency. In addition, local water reuse will further increase efficient utilization of the resource.
- *Irrigation scheme water management.* In order to improve utilization of the water resource at system level, two main strategies need to be accelerated: first, the systemic modernization of irrigation schemes to suit farmer demands which will involve managerial and institutional changes where necessary; and second, the transfer of responsibility for management of the irrigation system

TABLE 1

Area equipped for irrigation, projected to 2050

CONTINENT REGIONS	Area equipped for irrigation				
	Area *Million hectares*			Annual growth *Percentage*	
	1961	2009	2050	1961-2009	2009-2050
AFRICA	**7.4**	**13.6**	**17**	**1.3**	**0.5**
Northern Africa	3.9	6.4	7.6	1	0.4
Sub-Saharan Africa	3.5	7.2	9.4	1.5	0.6
AMERICAS	**22.6**	**48.9**	**46.5**	**1.6**	**-0.1**
Northern America	17.4	35.5	30	1.5	-0.4
Central America and Caribbean	0.6	1.9	2.4	2.5	0.5
Southern America	4.7	11.6	14.1	1.9	0.5
ASIA	**95.6**	**211.8**	**227.6**	**1.7**	**0.2**
Western Asia	9.6	23.6	26.9	1.9	0.3
Central Asia	7.2	14.7	15	1.5	0
South Asia	36.3	85.1	85.6	1.8	0
East Asia	34.5	67.6	76.2	1.4	0.3
Southeast Asia	8	20.8	23.9	2	0.3
EUROPE	**12.3**	**22.7**	**24.6**	**1.3**	**0.2**
Western and Central Europe	8.7	17.8	17.4	1.5	0
Eastern Europe and Russian Federation	3.6	4.9	7.2	0.6	0.9
OCEANIA	**1.1**	**4**	**2.8**	**2.7**	**-0.8**
Australia and New Zealand	1.1	4	2.8	2.7	-0.8
Pacific Islands	0.001	0.004	–	2.9	–
WORLD	**139**	**300.9**	**318.4**	**1.6**	**0.1**
High-income countries	26.7	54	45.1	1.5	-0.4
Middle-income countries	66.6	137.9	159.4	1.5	0.4
Low-income countries	45.8	108.9	113.8	1.8	0.1
Low-income food-deficit countries	**82.5**	**187.6**	**201.9**	**1.7**	**0.2**
Least-developed countries	**6.1**	**17.5**	**18.4**	**2.2**	**0.1**

Source: FAO, 2011b, 2011c.

from government agencies to non-governmental agencies, such as water users' associations or private enterprises.

Promoting responsible use of scarce water resources

Promoting responsible water use for agricultural production, a key feature of FAO's current water programme, will need to be accelerated if food production is to be maintained and the benefits of irrigated production equitably distributed.

The role of governments will remain fundamental in setting directions for agricultural water management, but governments cannot do it alone. The private sector is beginning to recognize its role in water management, and business leaders are mobilizing through initiatives such as the CEO Water Mandate, a public-

private initiative of the UN Global Compact designed to assist companies in the development, implementation and disclosure of water sustainability policies and practices. But the potential for greater and more concerted action remains considerable.

Improved agricultural water management is fundamental to any water reform. In many local water balances, fishers and aquaculturists, pastoralists and farmers are the prime stakeholders in planning and implementing sustainable land and water management. Therefore solutions have to include the incentives, facilitation and empowerment needed at the local level, such as secure land tenure and water use rights, rural credit and finance and access to technology and good practices. The involvement of community and farmers' organizations is also essential.

There is a pressing need to transform land and water institutions. While our current institutions have helped drive land and water management to unprecedented levels of productivity, many of the problems of degradation of land, water and biodiversity have resulted from institutions not keeping up with a rapidly changing world.

It also will be critical to ensure that intensifying agriculture through water control is sustainable. At the outset, the basic water allocations to agriculture have to be negotiated with competing users and neighbouring countries. This will have to be done transparently with the establishment of clear water-accounting procedures in river basins and aquifer planning frameworks that establish priorities for water uses and environmental standards.

Finally, it will be essential to embed agricultural water resources management into the broader context of natural resources management, livelihood improvement and biodiversity conservation.

Forests

Humans place high expectations on the world's forests, which provide a range of wood and non-wood forest products, including timber, fuelwood and charcoal, paper, food medicine and fodder. At the same time, they provide vital services at the global and local levels, including biological diversity, mitigation of and adaptation to climate change, soil and water conservation and provision of employment and livelihoods. Yet our forests face growing pressure from a number of natural and human-induced threats.

The world's forest area was estimated to be slightly more than 4 billion ha in 2010, which represents 31 percent of global land area and an average of 0.6 ha of forest per capita. However, forest area is unevenly distributed. The five most forest-rich countries – the Russian Federation, Brazil, Canada, the USA and China – account for more than half (53 percent) of the global forest area, while 64 countries with a combined population of 2 billion have forest on no more than 10 percent of their land area, and ten have no forests at all. These include a number of fairly large countries in arid zones, as well as many small island developing states (SIDS) and dependent territories.

Forests and food security

Forests contribute to each element of the food, fuel and financial (triple F) crisis, particularly to the aspects affecting the rural poor who depend on forests for fuelwood, for a wide variety of food products and as a source of income. FAO's work over the last 20 years has clearly demonstrated the contribution that forests make to food security in Africa. This is also true in the case of Asia and Latin America, particularly for the poorest of the poor. Likewise, much of the cooking fuel in the developing world still comes from wood – either as charcoal or firewood. Inadequate supplies mean poorly cooked or uncooked food, or food that is expensive to cook. While this problem continues to threaten food security, it also places pressure on remaining natural forests. When the rural poor collect wood, branches and leaves for fuel instead of leaving them on the ground to decompose and fertilize the soil, the soil becomes impoverished and less useful for a growing population.

Forests contribute substantially to livelihoods in many ways. For example, globally, they contributed some US$468 billion in global gross value added in 2006, including a substantial amount in rural areas where few alternative economic activities exist.

Forest resources under threat

Deforestation. FAO's 2010 Global Forest Resources Assessment estimated that about 13 million ha of forest were converted to other uses – largely agriculture – or lost through natural causes each year of the 2000–2010 period. This compares with a revised figure of 16 million ha per year in the 1990s. Both Brazil and Indonesia, which had the highest net loss of forest in the 1990s, have significantly reduced their rate of forest loss, while in Australia, severe drought and forest fires have exacerbated the loss of forest since 2000.

At the same time, afforestation and natural expansion of forests in some countries have significantly reduced the net loss of forest area at the global level. The global net change in forest area in the period 2000–2010 is estimated to be a loss of 5.2 million ha per year, an area about the size of Costa Rica. This substantial reduction, 37 percent less than the 8.3 million ha annual net loss in the period 1990–2000, is due to both a decrease in the deforestation rate and an increase in the area of new forest established through planting, seeding or natural expansion of existing forests.

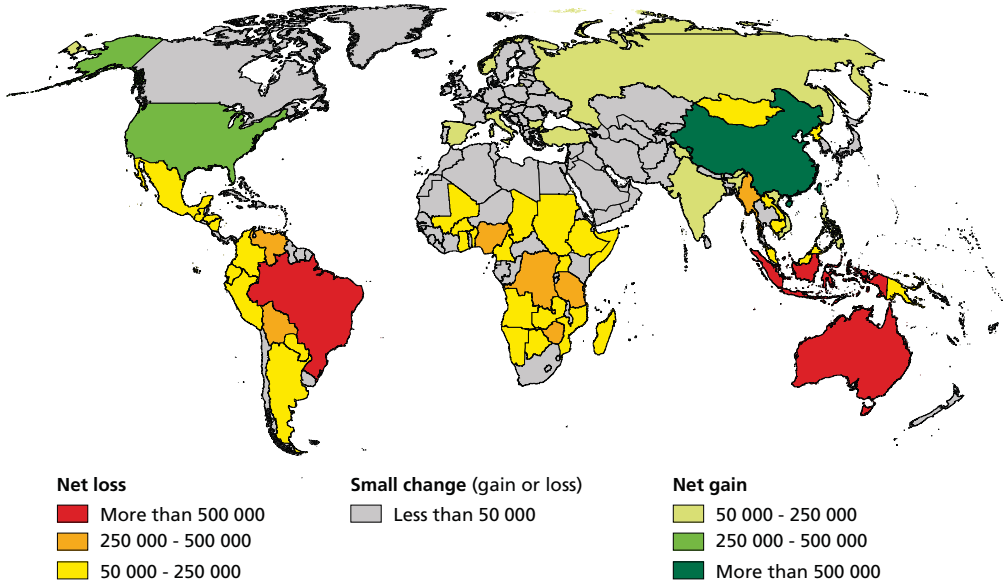
However, it is clear that most loss of forests continues to take place in the tropical region, while most of the gain takes place in the temperate and boreal forests in Asia (see Figure 12).

The causes of deforestation are many and vary from place to place. Generally speaking, most deforestation in Latin America results from large-scale conversion of forests to agricultural crops or to pasture for livestock, while most of the clearings in Africa are small-scale conversions to agriculture – often preceded by shifting cultivation. Asia had a positive balance in 2000-2010.

Although accurate figures are hard to come by, mismanagement of forests, fires and other causes have led to the degradation of millions of hectares of forests, which is often a forerunner for deforestation.

FIGURE **12**

Annual change in forest area, 2005-2010 (hectares)



Source: FAO, 2010b.

Climate change. Forests, like other ecosystems, are affected by climate change and are slow to adapt to and recover from its effects. Forests are also subject to a variety of disturbances that are themselves strongly influenced by climate. Disturbances such as fire, drought, landslides, species invasions, insect and disease outbreaks, and climatic events such as hurricanes, windstorms and ice storms influence the composition, structure and functions of forests (Dale *et al.*, 2001). Climate change is expected to affect forests' susceptibility to disturbances, as well as the frequency, intensity, duration and timing of such disturbances. For example, increased fuel loads, longer fire seasons and the occurrence of more extreme weather conditions as a consequence of a changing climate are expected to result in increased forest fire activity (Mortsch, 2006).

Insect pests and diseases, natural disasters and invasive species. Outbreaks of forest insect pests damage nearly 35 million ha of forest annually, primarily in the temperate and boreal zones. The mountain pine beetle, *Dendroctonus ponderosae*, native to North America, has devastated more than 11 million ha of forest in Canada and the western USA since the late 1990s and is spreading well beyond its normal range – an unprecedented outbreak exacerbated by higher winter temperatures. Diseases, severe storms, blizzards and earthquakes also have damaged large areas of forest since 2000. Woody invasive species are of particular concern in small island

developing states, where they threaten the habitat of endemic species. Information availability and quality continue to be poor for most of these disturbances.

Forest fires. The last decade has seen many big fires with severe impacts on human lives, assets and forest areas. In Australia in 2009, 430 000 ha of vegetation burned, 2 133 homes were destroyed and 173 people died; in Greece in 2007, 270 000 ha of vegetation burned and 84 people died; and in the Russian Federation in 2010, about 6 million ha burned and 50 people died directly from fires – not counting the indirect impacts on human health through increased heat and smoke. For the year 2000, of the 350 million ha of global land area affected by fire (JRC-EU, 2005), a significant proportion was forest and woodland.

Progress in reversing forest loss

Considerable progress has been made towards reversing the overall trend of forest area loss. Yet deforestation, including uncontrolled conversion of forests to agricultural land, continues at an alarmingly high rate in many countries and pressures are expected to increase in some regions because of an increase in population and the prediction that food production needs to increase by 70 percent by 2050. Considerable cross-sectoral efforts are needed to reach the goals of no net loss of forest area globally and sustainable management of all forests. Lessons can be drawn from countries that have satisfactorily reversed deforestation, including Costa Rica, the Philippines, India, China and Viet Nam.

Mountains

Mountains cover 24 percent of the Earth's land surface and they are home to 12 percent of the world's population, with a further 14 percent living in their immediate vicinity.

More than half the world's population relies on the freshwater that flows from mountains, and all the major rivers in the world – from the Rio Grande to the Nile – have their headwaters in mountains. Mountains, sometimes called nature's water towers, play a central role in collecting and storing fresh water. Yet today, as worldwide demand for freshwater continues to soar unabated, deforestation of mountain woodlands, mining, agriculture, urban sprawl and global warming are all taking their toll on mountain watersheds. For example, while the number of people on the planet has doubled over the last century, the demand for freshwater has jumped six-fold. Some of the freshwater obtained from mountains is stored in glaciers. Yet mountain ecosystems are extremely vulnerable to the impact of global warming and many mountain glaciers are melting at unprecedented rates.

Increasing awareness of mountain people and ecosystems

Mountains received global attention for the first time at the Rio Earth Summit in 1992 where a chapter on mountain ecosystems was included in Agenda 21. Since

then, important progress has been achieved in mountain areas, thanks in particular to the International Year of Mountains 2002 and the launch of the Mountain Partnership, a global alliance created at the 2002 World Summit on Sustainable Development. It currently has more than 170 members, including governments, intergovernmental and non-governmental organizations. In some countries, as a consequence of these international efforts, national committees have been established to promote integrated mountain development involving all partners.

Mountains and food security

Mountains are home to at least one-fourth of the world's poorest and most food-insecure people, yet development agendas often neglect them. Many mountain communities are plagued by shortages of food and periods of hunger. Nutrition studies indicate that mountain populations suffer from high rates of micronutrient deficiencies which, coupled with hunger, is the cause of the higher infant and maternal mortality rates in mountain regions. In many mountain areas, local people have traditionally depended on fish as an important source of animal protein, but today it is usually in short supply in mountain regions. In some regions, food insecurity is a consequence of chaos created by conflict and war. In others, periods of hunger arise as mountain farmers abandon traditional farming practices in favour of modern methods that prove unsustainable on fragile mountain terrain. Many men, women and families have no choice but to migrate to lowland cities, leaving their mountain communities to disintegrate and entire cultures and languages to disappear. One way to reduce the number of hungry people living in mountain areas is to empower them to protect local mountain ecosystems and their agro-biodiversity, and to promote peace and stability in mountain regions.

Mountain biodiversity

Mountains are a major source of the biodiversity that contributes to the world's food production. Of the 20 plants that supply 80 percent of humanity's food, six

PHOTO 3

Increased forest fire activity is one expected result of climate change.

– maize, potatoes, barley, sorghum, apples and tomatoes – originated in mountain areas. Several others found new homes in the mountains and evolved into many different varieties. Many of these species have disappeared from lowland areas, crowded out by human activities. Many others exist nowhere else but on mountains. Isolation and relative inaccessibility have helped protect and preserve species in mountains, and these precious reserves of genetic diversity provide insurance for the future, particularly as the demands of the global economy continue to turn lowland habitats into fields of high-yield, monoculture food crops that feed many of the word's people but are vulnerable to evolving pests and pathogens. Recently, however, a growing number of mountain farmers are abandoning age-old practices and adopting modern, high-yielding farming techniques that reduce biodiversity and tend to be unsustainable in mountain areas.

Natural hazards

Mountains are highly susceptible to natural hazards. Many people in mountain regions who live in extreme poverty are forced to settle in unsafe areas. Their isolation means they do not receive warnings of impending threats and, if tragedy strikes, they wait longer for emergency help. At the same time, fragile mountain environments are under increased stress from the growing demands of modern society and climate change. Excessive logging strips protective forests. Development of tourism infrastructure upsets fragile ecological balances. Inappropriate road construction makes mountain slopes unstable and mismanaged mining raises the possibility of landslides. Gravity pushing down on sloping land compounds the destructive power of storms and heavy rains, producing avalanches, landslides and floods.

More than half of the deaths caused by natural disasters occur in mountains and adjoining lands. It is not possible to protect people completely from hazards, nor is it wise to wait until a catastrophe occurs. Developing integrated strategies and policies on disaster risk management at a national level, increasing capacity development for preparedness, mitigation response and rehabilitation are just some of the activities that need to be undertaken.

Working to overcome marginalization

Although some progress has been made, and mountains are receiving more attention than before, they are still marginalized in the major decision-making processes, both at the global and national levels. The increasing demand for water, the consequences of global climate change, growth in tourism, population trends, the pressures of industry and agriculture in a globalized world are just some of the current challenges facing the sustainable development of mountain regions. Because mountain people reside far from centres of commerce and power, and suffer high rates of illiteracy, their voice in government policy- and decision-making is limited. Policy reforms, good governance and empowerment of local communities, as well as increased investment in mountain regions should feature more prominently on the development agenda.

Biodiversity

One of the greatest challenges facing the world this century is to achieve global food security while conserving its biological resources and diversity. Long-term food security cannot be achieved if production gains are made at the expense of the natural environment. Biological diversity, defined by the Convention on Biological Diversity is "the variability among living organisms from all sources, including ... terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UN, 1992).

Ecosystems are the assemblage of diverse living organisms interacting in communities, each within its own habitat. The diversity of ecosystems includes oceans, lakes, rivers, deserts, rangelands, forests, wetlands and mountains, and also landscapes modified by humans, such as croplands, pastures, reservoirs and woodlots. Scientific knowledge continuously advances in its understanding of ecosystem functions and of the ecological services from which humans derive benefits.

About 1.75 million species have been identified, with many scientists believing that there could be from 3 million to 100 million species yet to be documented. Understanding of genetic diversity has contributed enormously to improving agricultural production. Farmers have worked with genetic diversity for thousands of years to develop varieties of crops and breeds of livestock that meet their needs, and that are adapted to respond to production challenges such as changing temperatures, droughts and waterlogging, and to enhance their resistance to disease, pests and parasites. Fish farmers have only recently begun to domesticate a tiny fraction of the vast biodiversity of aquatic organisms. Most farmed aquatic organisms are still very closely related to their wild relatives.

The value of biodiversity: the basis of food security

Biodiversity provides humans with food and nutrients, and is a source of raw materials for clothing, wood, shelter and fuel, draught power and transport, manure for fertilizing crops, plants for medicines, and materials for biofuels and manufacturing. Wild plants and animals are the origin of all domesticated crops, fish and livestock. Biodiversity provides ecosystem services essential for agriculture such as pollination, pest and disease regulation as well as nutrient cycling. Genetic diversity and adaptation enable farmers, fishers and livestock keepers to respond to changing environmental conditions and consumer demands for new and improved foods and other products. Indigenous peoples' traditional food systems indicate the need to address food biodiversity in all its dimensions (Kuhlein, Erasmus and Spigelski, 2009).

Economic benefits deriving from biodiversity are significant. Agriculture is one of the world's most economically important sectors, for both developing and developed countries. It is estimated that about 75 percent of the world's poor live in rural areas and depend to some extent on some form of agriculture. Animal genetic

resources are estimated to contribute to the livelihoods of about 1 billion people and to provide 25 percent of the protein consumed by humans (FAO, 2009c). About 25 percent of the ice-free terrestrial surface on the planet is used for grazing, and 34 percent of total arable land is used for feedgrain production. Overall, agricultural production is the main source of income for half of the world's human population (FAO, 2010c).

Forest biodiversity is also an essential resource, with more than 1.6 billion people depending on forests to varying degrees for their livelihoods, providing them with income, food, fibre and fuel, and grazing for livestock. At least 350 million people live inside or near forested areas (FAO, UNEP and UNFF, 2010), and more than 10 million are employed in the formal forest sector (FAO, 2010d). Forest wildlife and aquatic resources are important sources of protein and income for many communities, as are other non-timber forest products including nuts, fruits, mushrooms, wild plants as vegetables, spices and many other food products. Forest biodiversity also provides economically valuable products such as oils, saps, resin and wax.

Aquatic biodiversity

Oceans and seas provide about 90 percent of the world's fishery catch. In 2008, reported catches from inland waters exceeded 10 million tonnes, but actual production is believed to be many times higher. Accurate information on the biodiversity of inland fisheries is lacking, with more than half of the catch not even identified. Capture fisheries and aquaculture production supplied the world with about 115 million tonnes of food fish in 2008. Overall, fish provided more than 3 billion people with at least 15 percent of their average per capita animal protein intake. Lakes, rivers, ponds, streams, groundwater, springs, cave waters, floodplains, as well as bogs, marshes and swamps, provide a rich supply of biodiversity that is often an important source of food and income for local people. Aquaculture is the fastest-growing sector of animal-origin food production, and will soon overtake capture fisheries as a source of food fish. In 2008, nearly 45 million people were directly engaged, part time or full time, in primary production of fish, either by fishing or in aquaculture. Over the last three decades, employment in the primary fisheries sector has grown faster than the world's population and employment in traditional agriculture. (FAO, 2010e).

Ecosystem services

Ecological processes that provide benefits for humans are termed ecological services. For example, biodiversity performs ecosystem services for farmers, livestock keepers, fishers and foresters, such as pollination, soil formation and maintenance of soil fertility, soil and water conservation, and disease regulation. Forests regulate hydrological cycles, ameliorate weather events, protect watersheds and assist in avalanche control. Aquatic ecosystems help maintain the Earth's hydrological cycle, provide for energy production and transport, recreation and tourism, nutrient cycling, and represent the largest carbon sink on the planet.

Biodiversity also plays a critical role in adaptation to environmental stress. For example, it enables humans to use genetic resources to select crops and animals and adapt them under changing production conditions. Biodiversity also contributes to ecosystem resilience. All humans depend on biodiversity to meet their basic needs for food, clean water and oxygen, and for a source of countless medicines and raw materials. Biodiversity is also of immense cultural, spiritual, recreational and social value.

Biodiversity trends

Globally, biodiversity is being eroded and species are becoming extinct. According to biodiversity assessments, amphibians face the greatest risk, and coral species are deteriorating most rapidly in status; inland fish are the most threatened group of vertebrates used by humans. Nearly one-quarter of all plant species are estimated to be threatened with extinction. The abundance of assessed populations of vertebrate species fell by nearly one-third on average between 1970 and 2006, and continues to fall globally, with especially severe declines in the tropics and among freshwater species. Natural habitats in most parts of the world continue to decline in extent and integrity. Wetlands, sea-ice habitats, salt marshes, coral reefs, sea-grass beds and shellfish reefs all show serious declines, and forest loss and fragmentation continues (Secretariat of the Convention on Biological Diversity, 2010). The principal pressures driving biodiversity loss include habitat change, overexploitation of resources, pollution, invasive alien species and climate change. These stressors are constant or increasing in intensity (Millennium Ecosystem Assessment, 2005).

Despite significant efforts to conserve biodiversity and use resources and ecosystems in a sustainable manner, the biodiversity trends tend to be negative. This has implications not only for current food supply systems, but also for the future. Genetic diversity is an insurance policy against future threats to food security. Its loss reduces our capacity to adapt crops and livestock to environmental changes, emerging diseases or changing consumer demands. Most future scenario projections show high

PHOTO 4

FAO has contributed to an improved understanding of how demand, competition and other market-related factors affect biodiversity and food production.

BOX **5**

FAO support for biodiversity conservation

FAO will continue to play a pivotal role in improving food security, nutrition and poverty reduction while seeking to conserve natural resources, including biodiversity. Its activities include hosting and facilitating related meetings for its partners, policy-makers and natural resource stakeholders, and supporting field activities across the agricultural spectrum. FAO also participates in developing and managing a range of global assessments, approaches and instruments in the pursuit of conservation goals. Examples of activities include:

- promoting and supporting its member countries in the application of sustainable management approaches and codes of conduct, such as the ecosystem approach, sustainable agriculture, sustainable production intensification, sustainable diets, sustainable forest management, and the Code of Conduct for Responsible Fisheries (FAO, 1995, 2008b), as well as the implementation of the International Treaty on Plant Genetic Resources for Food and Agriculture and, under the guidance of the Commission on Genetic Resources for Food and Agriculture (CGRFA), the implementation of a Global Plan of Action for genetic resources in the different sectors;
- preparing global resource and biodiversity assessments and sectoral global plans of action, including fisheries and forests assessments and subspecific and genetic level assessments for plant, animal, aquatic and forest genetic resources planned in the CGRFA's Multi-Year Programme of Work and leading to the report on the *State of the World's Biodiversity for Food and Agriculture*, due in 2017;
- facilitating implementation of global instruments such as the International Treaty on Plant Genetic Resources for Food and Agriculture, the International Plant Protection Convention and the Rotterdam Convention.

levels of extinction and loss of habitats and loss of genetic resources continuing throughout this century, with associated declines in some ecosystem services that are important to human well-being (Millennium Ecosystem Assessment, 2005).

Biodiversity conservation, food security and nutrition

The many pressures on biodiversity and the urgent need to achieve global food security make it extremely challenging to achieve the sustainable use of natural resources. However, past and recent successes provide both hope and experience. Biodiversity in domesticated species requires continuous human management, and global plans of action for animals and plants, prepared by FAO, are providing a basis for improving management, including ensuring farmers and livestock keepers

have appropriate economic, social and ecological reasons to keep using particular breeds or varieties, thus reducing the risk of their becoming extinct. Conservation and new patterns of sustainable use are being promoted, and there is an improved understanding of how economic and market-related factors (e.g. changing demand, competition) affect biodiversity and food production. There is also a need to address the degradation of natural resources and lack of access to these resources on the part of farmers and livestock keepers.

Greater efforts are needed to meet the challenge of achieving food security while conserving and sustaining biodiversity, including:

- more effective governmental leadership to ensure that there is a national vision for biodiversity while pursuing food security and economic development;
- improved resource stewardship by people, governments, business interests and organizations;
- improved application of the ecosystem approach in fisheries and aquaculture, forestry and agriculture (also known respectively as sustainable forest management, sustainable production intensification and sustainable fisheries management);
- greater investment in biodiversity in all countries and financial and technical assistance for developing countries.

There are grounds for hope that food security and nutrition can be achieved and the loss of biodiversity halted if policy and economic frameworks are set correctly, awareness of the need to live within the capacity of the Earth`s natural resources and systems grows, and significant investments are made to achieve the sustainable use of natural resources. FAO remains committed to supporting its member countries in their efforts to achieve food security and eradicate poverty, while maintaining the Earth's natural resources and rich biodiversity.

Conclusion

In many countries, food security depends on the performance of local agricultural production, but the natural resource bases of some of these countries are not sufficient to make significant progress and in many cases, the resources that do exist constantly face pollution, degradation and depletion.

Global land mass comprises 13.3 billion ha, of which about 12 percent is used for cultivation of agricultural crops; 31 percent is under forest; and 40 percent comprises grasslands, woodlands, wetlands and other ecosystems. Yet, by today's accounting:

- one-third of global arable land has been lost through erosion in the last 50 years;
- forest ecosystems have declined by about 15 percent in the last 50 years, and deforestation averaged around 13 million ha per year for the last decade (which an improvement over the 16 million ha average of the previous decade);

- nearly one-quarter of all plant species are threatened with extinction;
- irrigated land more than doubled from 140 million ha in 1961 to 300 million ha in 2009, increasing production but, when not well managed, contributed to depletion of aquifers, waterlogging, salinity and an inequitable distribution of the benefits from increased production.

The availability of quality land, water, forest and biodiversity resources is critical for food security. FAO is committed to ensuring land tenure security for local landowners and supports the principles of sustainable land management (SLM), which is based on the full involvement of local land users in management processes. Calling for greater efforts to achieve food security while conserving and sustaining natural resources, FAO promotes ecosystem approaches and works with governments but also with the private sector and civil society to design and implement guidelines, codes of conduct and other international instruments to set the path towards a more sustainable use of natural resources.

CHAPTER 3

Climate change

The world has awakened to the reality that our climate shows alarming signs of changing – more rapidly and more dramatically than at any time in recorded history. Climate change affects the frequency of extreme weather events, alters agricultural growing patterns and affects the distribution patterns of pests, weeds and diseases that threaten crops and livestock. The overall impacts of climate change on agriculture and food security are expected to be increasingly negative, especially in areas already vulnerable to climate-related disasters and food insecurity. The implications for food production, food security, agriculture, forestry and fisheries are enormous. Understanding those implications, and analysing how agriculture can be part of the solution as well as part of the problem, is fundamental.

The threat of climate change

Climate change poses a serious threat to food security for many of the world's poorest countries and millions of its poorest households, although the threat is certainly not limited to poor countries. Rich and poor countries alike will feel the impact of changing rainfall patterns, extreme weather events and rising sea levels. The difference is that poor countries – and vulnerable groups in those countries – lack the financial resources available to wealthier countries to enable them to reduce their risk (UNDP, 2006).

Climate change refers to the variations in climate on many different time scales, from decades to millions of years, and the possible causes of such variations. It may result from natural factors in the climate system, or from consequences of anthropogenic (human) activities, such as increasing atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs). It also can be affected by changes in solar activity and in the Earth's orbit around the sun.

Climate change impacts at different levels

Science has made great progress in understanding the global, continental and regional impacts of climate change, although when, where and how it will affect specific countries remains uncertain. Changes in temperature and precipitation, and increases in extreme weather events are likely to affect the potential for food production in many areas of the world, especially in Africa and Asia. Potential effects include disruption of food distribution systems and their infrastructure and changes in the purchasing power of the rural poor.

BOX **6**

Global assessment of climate change

Changes in the atmosphere, the oceans and glaciers and ice caps now show unequivocally that the world is warming, according to the Intergovernmental Panel on Climate Change (IPCC). With major advances in climate modelling and the collection and analysis of data, scientists have determined with a high level of confidence that the marked increase in atmospheric concentrations of GHGs, such as CO_2, methane (CH_4) and nitrous oxide (N_2O) since 1750 has resulted from human activities (IPPC, 2007a).

In considering the impacts of climate change, vulnerability and prospects for adaptation, the IPCC has concluded, among other things, that precipitation, runoff and water availability are very likely to increase at higher latitudes and in some wet tropics, including populous areas in East and Southeast Asia. On the other hand, they are expected to decrease over much of the area in the mid-latitudes and dry tropics, which are already water-stressed. The Panel also considered it very likely that the upward trend in hot extremes and heat waves would continue. Drought-affected areas are expected to increase and extreme precipitation events are predicted to become more frequent and more intense, thus increasing the risk of floods. It is also probable that, in the near future, tropical cyclones, typhoons and hurricanes will become more intense, bringing higher peak wind speeds and heavier precipitation, as a result of the increase in tropical sea surface temperatures. At the same time, there is less confidence in projections of a global decrease in numbers of tropical cyclones (IPPC, 2007b).

The IPCC clearly indicates that improving the ability to assess climate change impacts at national and subnational levels will require improvements in the extent and quality of climate variability monitoring because short-term climatic fluctuations have profound implications for food security. There is a great need for detailed impact assessments for agriculture that take into consideration the physical, biophysical and socio-economic complexities of, for example, African countries, which is where most vulnerable populations live (Gommes *et al.*, 2009). These assessments require databases of climatological, meteorological, phenological (plant and animal life cycle events), soil and agronomic information as well as related methods and tools (Ramasamy and Bernardi, 2010).

Ecosystems

Species, organisms and ecosystems have adapted to their regional climates continuously over time. Changing climates can potentially alter ecosystems and the many resources and services they provide to each other and to society. The IPCC concluded that, if global mean temperatures increase by 2 °C to 3 °C compared with pre-

industrial levels, 20 to 30 percent of species assessed may be at risk of extinction this century. These changes may have either adverse or beneficial effects on species. For example, climate change could benefit certain plant or insect species by increasing their geographic distribution, with either positive or negative impacts on ecosystems and humans, depending on whether the species are invasive, such as weeds or mosquitoes, or valuable to humans, such as food crops or pollinating insects.

During this century, if GHG emissions and other changes continue at or above current rates, the resilience of many ecosystems is likely to be threatened by an unprecedented combination of change in climate and other global change drivers, especially land-use change and overexploitation. By 2100, ecosystems will be exposed to atmospheric CO_2 levels that will be substantially higher than during the past 650 000 years, and to global temperatures that will be at least among the highest of those experienced in the past 740 000 years. This will alter the structure, reduce the biodiversity and upset the functioning of most ecosystems, thereby compromising the services they currently provide (IPCC, 2007b).

Aquatic ecosystems

Climate change is bringing substantial changes to the world's capture fisheries, which are already under stress from other influences. Inland fisheries – mainly found in developing countries of Africa and Asia – are at a particularly high risk which, in turn, threatens the food supply and livelihoods of some of the world's poorest populations. There are also consequences for aquaculture, which is especially significant for populations in Asia. Climate change will probably have an impact on fish community composition, production and seasonality processes in plankton and fish populations. In general, climate change is expected to drive the ranges of most terrestrial and marine species towards the poles, expanding the range of warmer water species and contracting the range of colder water species.

There is evidence that inland waters are warming. Generally, high-latitude and high-altitude lakes will experience reduced ice cover, warmer water temperatures, a longer growing season and, consequently, increased algal abundance and productivity. In contrast, some deep tropical lakes will experience reduced algal abundance and declines in productivity.

For aquaculture, a rise in sea level in coming decades will increase the upstream intrusion of salt water, affecting brackish water and freshwater culture practices. The expected increase in extreme weather events may also affect aquaculture through the physical destruction of facilities, loss of stock and spread of disease. At the same time, climate change might also offer opportunities for aquaculture. Some inland waters could experience an increase in the availability of phytoplankton and zooplankton, which would boost production. While increased salinity in deltas will push some aquatic farming upstream, it could also provide additional areas for shrimp farming, which is often a higher-value commodity.

Fisheries-dependent economies, coastal communities and fishers are expected to experience the effects of climate change in a variety of ways, with displacement and migration of human populations; coastal communities and infrastructure facing

sea-level rise and changes in the frequency, distribution or intensity of tropical storms; and less stable livelihoods and nutritional issues owing to changes in the availability and quantity of fish for food. Fisheries governance will need flexibility to take account of changes in stock distribution and abundance. The form of governance that is generally considered to be the best for improving the adaptive capacity of fisheries is an ecosystem approach that aims to achieve equitable and sustainable fisheries and accepts inherent uncertainty (Cochrane *et al.*, 2009).

Livestock

Livestock contribute 40 percent of the global value of agricultural output and support the livelihoods and food security of almost 1 billion people. Today, rapidly rising incomes and urbanization, combined with underlying population growth, are driving demand for meat and other animal products in many developing countries. Supply-side factors, such as the globalization of supply chains for feed, genetic stock and other technologies, are further transforming the structure of the sector.

Livestock production places increasing pressures on natural resources. Corrective action, needed to encourage the provision of public goods such as valuable ecosystem services and environmental protection, should involve addressing policy and market failures and developing and applying appropriate incentives and penalties.

The livestock sector is increasingly recognized as both a contributor to the process of climate change as well as a victim. Policy interventions and technical solutions are therefore required to address both the impact of livestock production on climate change and the effects of climate change on livestock production.

GHGs can arise from all the main steps of the livestock production cycle: emissions from feed-crop production and pastures are linked to the production and application of chemical fertilizer and pesticides, to loss of soil organic matter, and to transport. In addition, when forest is cleared for pasture and feed crops, large amounts of carbon stored in vegetation and soil are released into the atmosphere.

In contrast, the livestock sector can play a key role in mitigating climate change. The adoption of improved technologies, encouraged by appropriate economic incentives, can lead to reduced emissions of GHGs by livestock and, when good

PHOTO 5

The livestock sector is both a victim and a contributor to the process of climate change.

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management practices are implemented on degraded land, pasture and cropland can become net carbon sinks, sequestering carbon from the atmosphere.

Some of the greatest impacts of climate change are likely to be felt in grazing systems in arid and semi-arid areas, particularly at low latitudes. Here, climate change effects on forage and range productivity will have far-reaching consequences for animal production. Reduced rainfall and increased frequency of droughts will reduce primary productivity of rangelands, leading to overgrazing and degradation and possibly resulting in food insecurity and conflict over scarce resources. There is also evidence that growing seasons may become shorter in many grazing lands, particularly in sub-Saharan Africa, and it is probable that extreme weather events will increase.

Demographics

Recent studies show that population growth has been one driver of the increase in CO_2 emissions over the past several decades, and that urbanization, ageing, and changes in household size also affect energy use and carbon emissions. Urbanization may lead to an emissions increase of more than 25 percent, particularly in developing countries. This indicates that CO_2 emissions scenarios need to pay greater attention to the implications of urbanization and ageing, particularly in areas such as China, India, the USA and the European Union (O'Neill *et al.*, 2010).

In addition, the number of people living outside their country of birth increased from 75 million in 1960 to 191 million in 2005, a rise from 2.5 percent to 3.0 percent of the world's population. If the percentage of international migrants either stays at 2005 levels or continues to rise at the same rate as in the last decades of the twentieth century, there will be between 235 and 415 million international migrants in the world by 2050, 40 percent more than at present. At the same time, movement within national borders is at least as significant numerically as international migration, and is certainly the most significant form of migration for poor people (Black *et al.*, 2008). Climate change is certainly one of the drivers for additional mass migration estimated to range from 150 to 200 million (Stern, 2007).

Food supply

Climate change will affect all four dimensions of food security: food availability, access to food, stability of food supplies, and food utilization – with the overall impact differing across regions. Climate change will increase the dependency of developing countries on imports and accentuate the existing concentration of food insecurity in sub-Saharan Africa. It will also affect South Asia. Based on quantitative assessments, the first decades of the 21st century are expected to experience low impacts from climate change, but also lower incomes and a still higher dependence on agriculture. During these first decades, the biophysical changes will be less pronounced but climate change will have a particularly adverse effect on those who are more dependent on agriculture and have less capacity to cope with its impacts. By contrast, the second half of the century is expected to bring more severe bio-

physical impacts but also a greater ability to cope with them (Schmidhuber and Tubiello, 2007).

In addition to the impact of increasing population, urbanization, biofuel competition, and natural resource stresses caused by direct effects of climate change, its impact also will be especially felt in terms of reduced productivity in tropical low-latitude regions where many poor countries are located and where production growth is most needed. Potential agricultural output up to 2080–2100 may be reduced by up to 30 percent in Africa and up to 21 percent in developing countries as a whole. The total future demand for agricultural commodities may exceed the demand for food and feed more or less significantly, depending on the expansion of demand for biofuels and on the technology used for the conversion of agricultural biomass into biofuels. The development of the bioenergy market will determine how well it will be possible to meet the growing demand with the available resources and at affordable prices (FAO, 2009d).

Plant, animal and human health

Changes in the incidence, distribution and intensity of pests and diseases resulting from climate change are likely to cause additional crises in plant and animal health. The range of crop weeds, insects and diseases is likely to expand, and climate change is expected to affect vector-borne diseases and may also result in new transmission pathways and different host species.

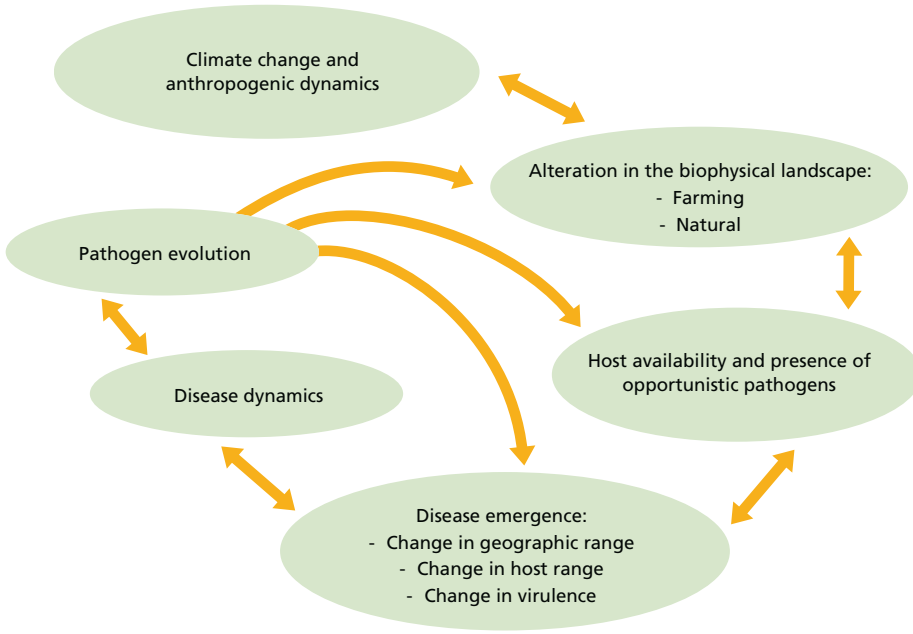
The emergence of diseases – whether infections appearing for the first time in a population or diseases that have existed in the past but are rapidly increasing in incidence or geographic range – may take different forms. The most common is a change in the geographic range of a disease. Less frequent and more dramatic is a jump in virulence. In a third category of disease emergence, the pathogen will adjust its host range, which may take the form of a species jump, including from animals to humans. The risk of a severe pandemic causing millions of human casualties and disrupting society and the global economy remains real. Figure 13 depicts the relevant pathogen-host-environment interactions.

The three disease emergence pathways broadly correspond with typical sets of drivers: changes in host range, shifts in disease virulence and range expansion.

- *Host range change.* A species jump may occur in a situation where the host habitat, the host community composition or the host contact network structure becomes altered so that increasingly more spillover takes place to a new and/or alternative host. While landscape changes, such as the encroachment of forest and game reserves, are among the common set of drivers, usually there is no single cause. Climate change forms part of this pathway of disease emergence, along with the effects of land pressure, deforestation and loss of biodiversity.
- *Virulence shifts.* The role of climate change in virulence shifts is less obvious. However, the disease emergence category featuring an expansion of the geographic range of the disease is both relatively common and more likely to be affected by climate change. This group of diseases comprises arthropod

FIGURE **13**

The effects of climate change on disease emergence



Source: FAO.

vectors, migratory birds, and pathogens carried by food and inanimate objects, or fomites. A set of global factors is believed to be driving a worldwide redistribution of hosts, vectors and pathogens. Climate change almost invariably plays a role, enhancing or decreasing the introduction and invasions of disease agents, caused by the greater mobility of people, increasing trade and traffic volume of animals, animal products and commodities. Pathogens transmitted by arthropod vectors are sensitive to climate change because humidity and temperature are essential to the environmental "envelope" of the vector, dictating distribution, ecology and behaviour. An early spring or an increase in weather extremes will also affect vector abundance and disease transmission.

- *Range expansion.* Range expansion may take the form of a travelling wave, with new colonies being established just outside the perimeter of existing disease distribution, coalescence of growing colonies, or involving saltation, with disease introduction into new areas and ecological settings. Long distance dispersion may result from human action while climate change may facilitate the establishment and colonization of an area by a disease complex where introductions have failed in the past. These dynamics would explain the ongoing encroachment of insect-borne diseases in temperate northern climate zones.

In general terms, climate change will enhance the emergence, and also extinction, of diseases at the animal-human-ecosystem interfaces. The ongoing globalization of diseases is difficult to manage, and a climate-smart farming landscape and more disease-resistant agro-ecological systems will require twin strategies – focusing on drivers of the disease and increasing resilience. Whereas progressive control of infectious diseases in humans and animals has proven a viable strategy, current dynamics in terms of new emerging diseases suggest that more attention should go to the drivers of disease flare-up. In addition, prevention will have to extend beyond the technical, to developing social and ecological resilience to the incursion of disease.

Adaptation and mitigation in agriculture

The effects of climate change – more frequent and intense weather events, shifts in seasons, pest and disease patterns, increases in salinity and rising sea levels – have already had an impact on many countries. This has focused attention on the fact that agriculture in developing countries must undergo a significant transformation in order to achieve food security and respond to climate change (FAO, 2010f). Efforts should start with the adoption of practices and technologies that can improve farming systems in ways that support food security and development, but the transformation must also include a shift to more holistic views that recognize at once the increasing demands that climate change has put on agriculture and the range of benefits it can provide.

Agriculture needs to produce more food, feed and fibre through higher productivity. It needs to reduce wastage and to make it easier for farmers' products to reach markets and consumers. Agricultural production systems must become more resilient to disruptive events such as floods and droughts. This requires improving agriculture's management and use of natural resources, such as water, land and

PHOTO 6

Adapting to climate change involves both disaster risk management and medium- to long-term adaptive change management, which requires modifying behaviours and practices.

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forests, soil nutrients and genetic resources; and of external inputs, such as fertilizers and energy. At the same time, agriculture must establish better monitoring, warning and insurance systems, as well as finding ways to reduce its environmental impacts – including lowering its own GHG emissions – without compromising food security and rural development (FAO, 2010g).

Food security and climate change challenges will have to be addressed simultaneously, urgently and in a coherent manner. Transformations are needed in both commercial and subsistence agricultural systems, but with significant differences in priority and capacity. In commercial systems, increasing efficiency and reducing emissions, as well as other negative environmental impacts, are key objectives. In agriculture-based countries with a dependence on subsistence systems, the priority is to increase productivity to achieve food security (FAO, 2010f).

Promoting adaptation to changing climate

Adaptation is a matter of urgency, in particular for LDCs and SIDS. People who are already vulnerable and food-insecure are likely to be the first affected by climatic change. Adaptation requires adjustments to current or expected variability and changing average climate conditions, which can make it possible to moderate negative effects and take advantage of opportunities (IPCC, 2007b). It involves both disaster risk management, with its short-term focus on prevention, mitigating risks and preparing to deal with shocks, and medium-to-long-term adaptive change management, which requires modifying behaviours and practices (FAO, 2011d). Adaptation planning takes place at multiple levels, ranging from national planning to regional institutional development and to family farm planning. No matter the scale, adaptation targets the well-being and livelihoods of the men and women who are dealing with climate change impacts.

Most ecological and social systems have built-in adaptation capacities, but the climate variability and rapid rate of climate change now being experienced will impose new and potentially overwhelming pressures on those capacities, with current coping ranges likely to be exceeded more frequently and more severely. Indigenous knowledge of farmers, forest-dependent people and fishers and fish farmers can be a valuable entry point for localized adaptation. Nevertheless, to address complex and long-term problems caused by the changing climate, indigenous knowledge often needs to be complemented by scientific expertise (FAO, 2011d).

Adaptation involves combinations of strategy, policy, institutional and technical options that require a wide range of skills and multidisciplinary actions, including ecosystem-based and livelihood approaches. Particular attention has to be given to the most vulnerable groups and communities, e.g. those in fragile environments such as drylands, mountain areas, lakes and coastal zones (FAO, 2009e), as well as those disadvantaged by socio-economic factors such as land ownership, gender, caste and age constraints.

BOX **7**

Livelihood adaptation to climate change in Bangladesh

Five districts of Bangladesh regularly threatened by spells of drought or increasing salinization and seasonal flooding benefited from the Livelihood Adaptation to Climate Change Project. The Bangladesh Department of Agriculture and Extension (DAE) and FAO implemented the project from 2005 to 2009, as a subcomponent of the Comprehensive Disaster Management Programme implemented by the Government of Bangladesh and the United Nations Development Programme (UNDP).

Through the promotion of current climate risk management, combined with technical and institutional capacity development for medium- to long-term climate change adaptation, the project established a strong, collaborative institutional mechanism for the identification, validation, testing, evaluation and sharing of adaptation options. A country-specific menu of 90 adaptation practices covering various sectors was developed through a participatory process, linking bottom-up livelihood perspectives and top-down government perspectives. About 800 field demonstrations of local adaptation practices were conducted, monitored and analysed through the collaboration of extension staff, community groups and Farmer Field and Farmer Climate Schools as well as researchers.

By replicating successfully tested practices and incorporating them into district and subdistrict sectoral development plans, the project reached about 12 500 farmers through farmer field days, individual demonstrations and joint learning sessions. Selected good practices have been shared through international databases. The project facilitated the incorporation of climate change in the updated Plan of Action for disaster risk reduction of the DAE as well as the formation of a DAE working group on climate change. It also provided important insights on the successful initiation of adaptation processes that can be replicated in other countries and regions.

Effective adaptation involves creating the capacity to cope with more frequent, increasingly difficult conditions and gradual climate changes, even without being able to anticipate their precise nature. Under such circumstances, the focus will be on decision-making and capacity development that strengthen institutions, social learning, iterative planning, innovation and development processes. This means taking a "no regrets" approach, promoting adaptive actions that will be beneficial even if future impacts are uncertain and climate change threats do not occur exactly as anticipated (FAO, 2009f).

FAO supports countries in assessing climate change impacts and vulnerabilities, disaster risk management, sustainable land, water and biodiversity management, strengthening institutions and policies for adaptation, developing and disseminat-

ing technologies, practices and processes for adaptation and accessing potential sources of adaptation financing (FAO, 2009f).

The agriculture sector as part of the climate change solution

While agriculture is one of the sectors most vulnerable to the impacts of climate change and variability, agriculture, forestry and land-use change also contribute a significant share to global GHG emissions. According to the IPCC, 13.5 percent of global emissions originate from agriculture, mainly in the form of CH_4 and N_2O from fertilized soils, biomass burning, rice cultivation, enteric fermentation and manure, and fertilizer production. Three-quarters of the agricultural emissions originate from developing countries. Deforestation and forest degradation account for another 17 percent of global emissions (IPCC, 2007b).

Nevertheless, agriculture and forestry should not be seen as separate problems, but as part of a comprehensive solution. Existing forestry and agriculture practices have significant potential for mitigation by reducing, avoiding or displacing net GHG emissions and acting as a sink for carbon through enhancement of carbon stocks in biomass and soil. The inclusion of the agriculture and forestry sectors into mitigation efforts is crucial to keeping the impacts of climate change within limits that society can reasonably tolerate, which means stabilizing the increase of global average temperatures within a 2 °C range (UN-REDD, 2011).

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is cited as one of the most cost-effective approaches to mitigation. Its objective is to provide a financial value for the carbon stored in forests and to provide incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD+ goes beyond deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. The potentially significant North-South flow of funds for REDD+ action in developing countries could reward reductions of carbon emissions and may also support new, pro-poor development, help conserve biodiversity and secure vital ecosystem services and resilience to climate change. However, to achieve these multiple benefits, REDD+ requires the full engagement and respect for the rights of indigenous peoples and other forest-dependent communities (UN-REDD, 2011).

While suitable technologies and practices and economically feasible mitigation mechanisms exist, more work is needed to create the required capacity and infrastructure for their implementation over a wide range of farming systems and agro-ecological zones. In addition, simple but effective, accurate and verifiable methodologies for measuring and accounting for changes in carbon stocks are required. The challenge is to design financing mechanisms for remuneration of environmental services in general and for GHG mitigation services – through carbon sequestration and/or reducing CO_2, CH_4 and N_2O emissions in agricultural systems – provided by smallholder agriculture and forestry and the fisheries sector (FAO, 2009f).

BOX **8**

Mitigation of Climate Change in Agriculture

With an overall goal of making agriculture part of the solution to climate change, the Mitigation of Climate Change in Agriculture (MICCA) Programme has begun efforts to improve the collection and generation of data and fill data gaps regarding GHG emissions and mitigation potential, as well as to pilot projects that test agricultural practices and their contribution to mitigation in five developing countries. A five-year multi-donor trust fund project launched in early 2010, MICCA supports efforts to mitigate climate change through agriculture in developing countries and move towards carbon-friendly agricultural practices. In its first two years, the project will build the global knowledge base in the agriculture sector, but also focus on the global economic analysis of climate policy options, provide technical information in support of the United Nations Framework Convention on Climate Change (UNFCCC) process, and assess the synergies and trade-offs between agricultural mitigation, agricultural development and food security.

FAO supports country efforts in climate change mitigation through advocacy and by generating and disseminating data, knowledge and as well as supporting appropriate institutional structures in realizing the mitigation potential of agriculture, forestry and other land-use sectors (FAO, 2009f). UN-REDD and the Mitigation of Climate Change in Agriculture (MICCA) project (introduced in Box 8) are FAO's two major programmes for climate change mitigation. The UN-REDD programme is a collaborative partnership involving FAO, UNDP and the United Nations Environment Programme (UNEP). It assists developing countries in preparing and implementing national REDD+ strategies and it builds on the convening power and expertise of the three agencies in related economics, monitoring, governance, ensuring multiple benefits, and stakeholder engagement.

Climate-smart agriculture – building synergies

The food and agriculture sector is unique in the sense that adaptation and mitigation often go hand in hand (FAO, 2008c). Recognizing this, FAO promotes an integrated approach, building synergies among climate change adaptation and mitigation, food security and sustainable development. Food security and climate change can be addressed together by transforming agriculture and adopting practices that are "climate smart". These are the types of production system that increase productivity and resilience to climate change sustainably, reduce or remove GHGs and enhance the achievement of food security and development goals. They are crucial for achieving both food security and climate change goals (FAO, 2010f).

BOX **9**

Climate-smart agroforestry

Agroforestry is the use of trees and shrubs in crop and/or animal production and land management systems. Agroforestry systems range from improved fallows, home gardens and intercropping to fodder banks, live fences and tree apiculture. They provide multiple benefits for food security, climate change adaptation and mitigation. For example, they can increase resilience to extreme weather events and soil erosion through improved water retention and enriched soil quality, including soil fertility. They can also:

- diversify income sources and provide income buffers during crop failures;
- enhance productivity through integrated land-water management approaches;
- provide fodder, timber and fuelwood; and
- sequester carbon in vegetation and soils.

BOX **10**

Climate-smart fisheries and aquaculture

Adaptation to climate change is a key concern for the 540 million people who depend directly or indirectly on fisheries and aquaculture for their livelihoods, and are already facing many problems from overfishing, poor management and other terrestrial impacts. Broad implementation of the Code of Conduct for Responsible Fisheries and the promotion of climate-resilient sustainable intensification of aquaculture are examples of adaptation strategies in the sector.

Despite their relatively small contribution to GHG emissions, fisheries and aquaculture can play a role in mitigation through reductions in energy consumption and emissions along the supply chain as well as through sequestration of carbon. For example, establishing semi-intensively managed pond aquaculture or replanting mangroves in many aquaculture and fisheries areas could contribute significantly to the sequestration of carbon. Conducting extractive aquaculture operations with seaweeds and filter feeders can enhance carbon retention and capture in coastal ecosystems. The use of more energy efficient vessels, facilities, transportation systems, fishing gear and practices would lower fuel costs, reduce the carbon footprint and decrease the impacts on marine and atmospheric ecosystems – a potential win-win for fishery resources and those dependent on them.

For example, production systems can be enhanced by: i) improving components such as soil and nutrient management, water harvesting and use, appropriate irrigation scheduling, pest and disease control, management of genetic resources and harvesting, processing and supply chains; and ii) by promoting climate-resilient approaches that are appropriate to local environmental-geographical conditions. These include integrated rice farming systems, conservation agriculture, urban horticulture, integrated food-energy systems, low-energy-use aquaculture systems, sustainable forest management, more efficient livestock production systems, integrated cropping-livestock production systems and agroforestry (FAO, 2010f).

BOX **11**

Country support in conservation agriculture

Following is a selection of recent conservation agriculture cases (FAO, 2010f) in different countries and regions:

In ***Uzbekistan***, where monocropping of cotton is commonplace, FAO has contributed to increasing the productivity of cotton through conservation agriculture, including no-till, and diversification by rotating cotton with wheat and grain legumes and selected cover crops. *Results:* improved soil quality, crop development and yields, all well received by farmers.

In ***Egypt***, where the rice-cropping systems of the Nile Delta burn more than 50 percent of the 3–5 million tonnes of rice straw residues produced annually in the field as a practical means of disposal, conservation agriculture has introduced rice in rotation with a forage legume or wheat. *Results:* yields achieved under conservation agriculture equal to those grown under conventional practices with savings in time, fuel and labour needed for land preparation and crop management, as well as improved weed control, crop water consumption and improvement of soil conditions.

In ***Lesotho***, where farmers attended training in conservation agriculture, a crucial prerequisite for the correct adoption of the practice, along with a certain level of social capital, education and economic incentives for vulnerable households. *Results:* farmers have been able to boost agricultural yields and increase food production and overall resilience.

In ***Honduras***, where farmers moved from a traditional slash-and-burn system to *quesungual*, a conservation agriculture system that uses trees and mulch. *Results:* from the third year, yields of maize and sorghum increased, leading also to additional biomass for grazing and fodder sale. The application of the system not only meets the household subsistence needs for fruit, timber, fuelwood and grains, it generates a surplus which can be sold, providing an additional source of income.

Many effective climate-smart practices already exist and could be widely implemented in developing countries. However, considerable investment is still needed. It is still necessary to fill data and knowledge gaps, research and develop appropriate technologies, and provide incentives to encourage the adoption of climate-smart practices. Funding should also be targeted towards revitalizing research and development linkages and rebuilding neglected national agricultural extension services so they can support farmers as they make the transition to climate-smart agriculture. For example, the Farmer Field School system pioneered by FAO, along with Junior Farmer Field and Life Schools, offer valuable channels for knowledge transfer and for promoting climate-smart farming techniques. Public-private partnerships also need to be supported.

FAO has supported many countries over the last decades in promoting conservation agriculture, a no-till farming system (see section on Sustainable agricultural intensification in Chapter 6). Conservation agriculture is currently practised on 100 million ha of land across the world, on all sizes of farms and agro-ecological systems, especially in developing and emerging economies because of its tremendous potential for achieving sustainable and profitable agriculture based on the three principles: minimal soil disturbance, permanent soil cover and crop rotations.

Looking to the future, greater coherence among agriculture, food security and climate change policy-making is urgently needed to be able to capture synergies. Effective mechanisms that promote dialogue among policy-makers working in these areas still need to be established. In addition, effective systems of property policy and rights, use and access rights, and law enforcement are essential to improving natural resource management. To achieve greater coherence, what is required is an integrated landscape approach that takes into account all land uses in a holistic way and ensures that objectives among sectors do not compete with each other.

Energy for and from agriculture

As demand for food and energy grows, it will become more crucial to optimize land use and minimize fossil fuel dependence while ensuring food security. It is clear that land use will come under severe pressure to fulfil future energy and food needs. On the one hand, meeting the MDG goal of halving the proportion of undernourished people by 2015 will require a significant increase in the current level of commercial energy inputs into agriculture, particularly in developing countries (Best, 1998), a challenge compounded by the fact that agriculture will have to increase food production by 70 percent by 2050 – mainly through productivity increases. On the other hand, global energy demand is projected to increase by 45 percent between 2006 and 2030, and could double by 2050. Energy prices are projected to rise and become more volatile. Agriculture can, however, play a crucial role in supplying energy, through bioenergy. The global potential of sustainable bioenergy production is expected to account for 25 to 30 percent of global energy by 2050, including a tenfold increase in the production of liquid biofuels (IEA Bioenergy, 2010).

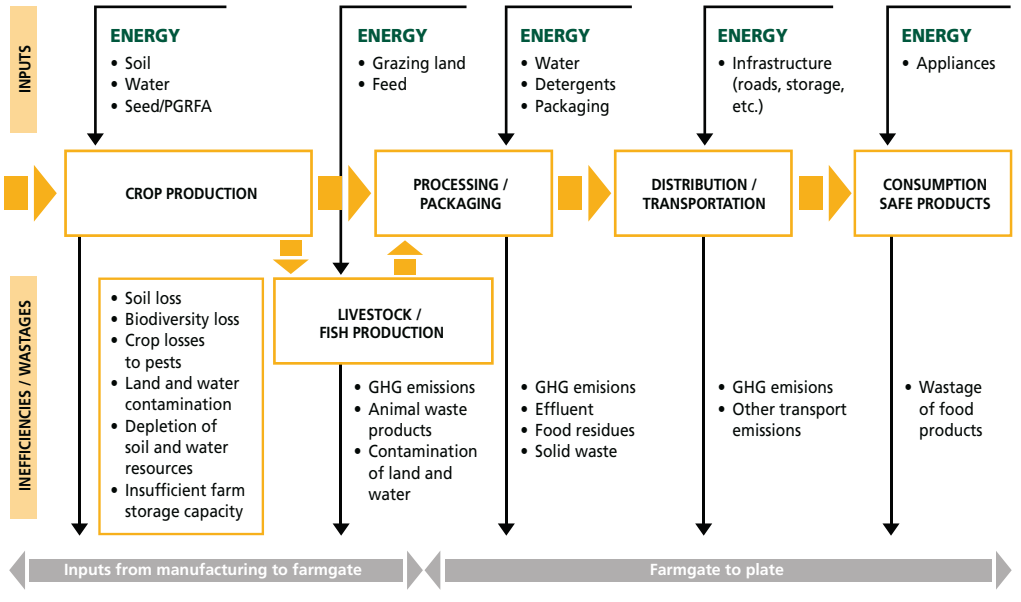
Addressing the food-energy-climate change nexus

Population growth, higher per capita food expenditures, and a greater reliance on energy-reliant technologies have all contributed to boosting food-related energy consumption (Canning, 2010). In OECD countries, the agriculture sector accounts for 3 to 5 percent of energy consumption. In developing countries, the figure is 4 to 8 percent (FAO, 2000a). In addition, food processing and transport in industrialized countries consumes up to twice the energy used by agriculture. In 2007, the USA's food system accounted for almost 16 percent of the nation's energy use. Between 1997 and 2002, more than 80 percent of its increase in annual energy consumption was food-related, with most of the increase in post-harvest stages.

Fossil fuel dependence along the food chain is high. By some estimates, more than 90 percent of food involves oil or natural gas for fertilizers, agrochemicals, tilling, cultivation and transport (Skrebowski, 2007). This is a precarious situation because of the resulting contribution to climate change and to the cost of inputs and on farming systems. At all production stages, fossil fuel combustion for heat and energy represents a major source of agricultural GHG emissions. In addition, nitrogen fertilizer production accounts for about 50 percent of the fossil fuel used in agricultural production (Foresight, 2011) and consumes about 5 percent of global natural gas supplies, while significant amounts of CH_4 can be emitted during the production of nitrate. Bioenergy production could contribute positively to GHG

FIGURE **14**

The food chain, including inputs, wastages and inefficiencies



Source: Adapted from FAO, 2010h.

emission reduction, although this is currently not always the case. Being energy-smart is therefore a key to climate-smart agriculture.

Energy costs strongly influence several parts of the food system. For example, the significant increase in fertilizer prices between 2005 and 2008 was strongly linked to the soaring price of oil at the time. The effects of high oil prices on low-income rural households and globally on agricultural inputs and farming practices can reduce agricultural productivity, thus exacerbating the pressures to expand the area of cultivated land which, in turn, brings with it the potential risks of increased GHG emissions.

Food security is linked to energy for and from agriculture in many ways. For example, energy is needed to produce and process food but the high cost of fossil fuel-dependent inputs may hinder production increases. Large-scale liquid biofuel development may influence food prices and access to land; food prices may also be heavily influenced by production costs, which are in turn influenced by the cost of fossil fuels for industrial agriculture. All stages of the food chain require energy, be it directly or indirectly, as illustrated in Figure 14.

Solutions to food-fuel-climate change nexus

The challenges of the food-fuel-climate-change nexus concern energy both for and from agriculture and must be addressed through a combination of measures. These include:

- better energy efficiency, through technological improvements, primarily before the farmgate;
- reducing food wastage, and thus its embedded energy;
- energy substitution, through increased use of renewable energy, including sustainable bioenergy.

Energy efficiency. Energy intensity – energy input per food calorie output – is a useful indicator of energy efficiency in food production. Globally, energy intensity in agriculture increased significantly until the mid-1980s, after which it decreased. This has been a crucial and positive change, indicating that in recent years, agriculture has managed to produce more food per energy input.

However, this global trend masks important differences between industrialized/OECD and newly-industrialized developing countries. While both groups have reduced intensity in land use as well as labour requirements, the energy intensity of fertilizers and agricultural machinery has lessened in industrialized countries since the beginning of the 1980s, but has steadily increased in developing countries since 1965. These different dynamics resulted in a reduction of energy intensity in industrialized/OECD countries from the mid-1980s and a significant increase in newly-industrialized developing countries since the 1960s.

In the industrialized/OECD countries, the reduction resulted from a combination of the collapse of high-input agriculture in the former Soviet Union countries in the mid-1980s, a more efficient use of inputs through increased adoption of

precision agriculture[6] starting in the same period, and an increase in the use of low or zero tillage techniques. Precision agriculture technologies often involve significant capital investment, so that even if farmers in developing countries had access to them, they would mostly be too expensive for smallholders and only viable for middle- to large-scale farmers.

In the newly industrialized developing countries, the steady increase in energy intensity has been dominated by high external inputs to farming systems, especially in China and India. However, low external input systems also have their place. They can perform quite well with low external inputs associated with high yields, as when energy inputs come mainly from human or animal labour. In this case, good performance comes from a more integrated use of resources, such as crops and livestock, and using agricultural residues as inputs to the farming system which reduces the need for external and fossil fuel-dependent inputs. Such systems are therefore a valid option for those farmers for whom precision agriculture is out of reach. In fact, it is possible to produce more (food) with less (fossil fuel energy) in farms of all sizes through conservation agriculture, which is an integral part of the sustainable crop production approach promoted by FAO (FAO, 2010h).

Reduction in food waste. Energy embedded in wasted food is significant. For instance, the losses between farmgate and the plate amount to about 2 percent of total annual energy consumption in the USA (Cuéllar and Weber, 2010). Roughly 30 to 40 percent of food from both developed and developing countries is lost to waste, which occurs for a variety of reasons (Godfray *et al.*, 2010), as illustrated in Figure 15.

Food losses in developing countries occur mainly on the farm and in the transport and processing stages. They are attributable to the absence of food chain infrastructure and the lack of knowledge or investment in storage technologies on the farm – hence more related to development constraints.

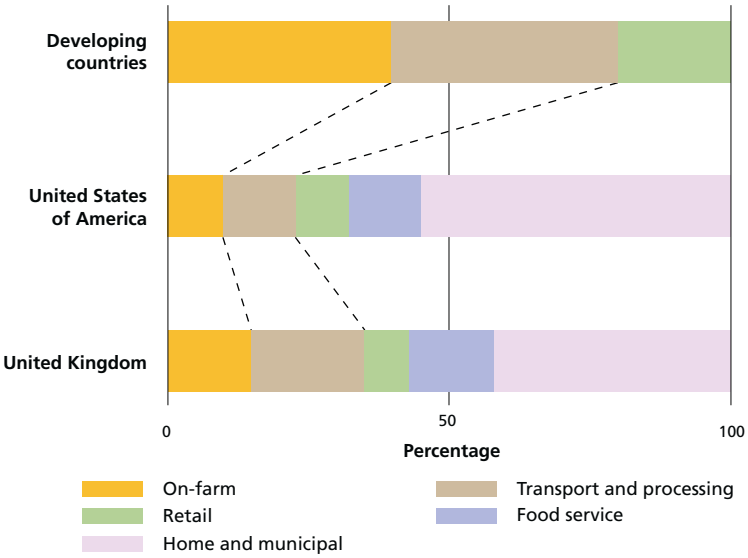
Food losses in developed countries occur mainly after the retail stage. Reasons include the relative cheapness of food, high food standards which lead to discarding of much edible food, and commercial pressures, such as "buy one get one free" offers.

In the USA, on-the-farm energy accounts for only one-fifth of the energy used by the food system, with the other four-fifths arising from transport, processing, packaging, marketing and kitchen preparation. In fact, the most energy intensive segment of the food system is the kitchen, which uses much more energy to refrigerate and prepare the food than was used to produce it. It is not unusual to have more energy used in food packaging than that contained in the food itself (Brown, 2006). Thus, while better food processing and storage facilities can help

[6] "Precision agriculture" (also called "precision farming" or "site-specific management") is defined as the application of a holistic management strategy that uses information technology to bring data from multiple sources to bear on decisions associated with agricultural production, marketing, finance and personnel.

FIGURE **15**

Makeup of total food waste in developed and developing countries



Note: Retail and home and municipal categories are combined for developing countries. *Source:* Godfray *et al.*, 2010.

avoid losses of food – and the energy embedded in it – they are themselves a significant user of energy.

A 2011 study (Gustavsson, Cederberg and Sonesson, 2011) commissioned by FAO from the Swedish Institute for Food and Biotechnology (SIK), found the following:

- industrialized and developing countries waste roughly the same quantities of food – respectively 670 million and 630 million tonnes;
- consumers in industrialized countries waste almost as much food each year (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes);
- fruits, vegetables, roots and tubers have the highest wastage rates of any food;
- food lost or wasted every year is equivalent to more than half of the world's annual cereals crop (2.3 billion tonnes in 2009/2010).

Energy substitution – energy from agriculture. Agriculture has a unique link with energy in that it both consumes and produces energy, the latter through bioenergy. Bioenergy is the oldest type of energy – for example wood for heating and cooking. It currently accounts for about 10 percent of the world's energy mix. Bioenergy is the only renewable source of energy that can replace fossil fuels in all energy markets – heat, electricity and transport. As a result, its share in the future energy mix is predicted to increase substantially – by 25 to 30 percent – according to the latest estimates (IEA Bioenergy, 2010).

Every day, between 2 and 3 billion people rely on solid biomass – wood, charcoal, agricultural residues and animal waste – for cooking and heating. They most often use open fireplaces or traditional cooking stoves which are both extremely inefficient and represent a major threat to health. Some 1.9 million people die annually as a result of exposure to smoke from cooking stoves. Moreover, the heavy dependence on wood for cooking in developing countries can lead to deforestation and forest degradation.

Among the different types of bioenergy, liquid biofuels have been the most controversial. To date, biofuels are the most readily available alternative to fossil fuels in the transport sector – and the only alternative possible for ship transport and aviation. This explains the sharp increase in demand over the last decade – more than a threefold increase for bioethanol and elevenfold for biodiesel (FAO, 2008d). This is despite the fact that in most countries, the best use of biomass for energy is in electricity and heat production. The main concerns regarding liquid biofuels – at least first generation biofuels based on sugar, starch and vegetable oils – relate to their environmental and food security risks, in particular those produced on a large scale. The environmental risks are related to possible biodiversity loss and GHG emissions caused by land conversion. The food security risks are related to possible competition for land between energy and food crops, and to the impact on food prices caused by the diversion of crops to biofuel production. However, as with many agricultural products, recent work by FAO and other organizations with a focus on bioenergy have found that liquid biofuels are not bad or good *per se*: it depends on how they are produced, including production of feedstock, land choice and farming practices, and the logistics of the biofuel supply chain (FAO, 2010i).

Experience in biofuel production has led to harvesting of good practices that minimize risks and harness the opportunities. For example, sound and participatory land-use planning, including agro-ecological zoning to define "no go" and "best bet" areas, can be followed for different feedstock crops. Brazil follows this practice for sugar cane and oil palm. Other good practices include the use of perennial plants on degraded land abandoned by farmers; combined cultivation of energy and food crops through rotations in mixed cropping or agroforestry systems; use of agricul-

PHOTO 7

The past decade has witnessed a more than threefold increase in demand for bioethanol and elevenfold for biodiesel.

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tural and forestry residues (except those used for soil management and animal feed); contract farming, whereby smallholders supply the feedstock for large processing plants and thus reduce the risks of land displacement; and use of dual-purpose crops that provide both fuel and food, such as sugar cane, cassava or palm oil – associated with policies that prioritize food production where necessary. Brazil and the Democratic Republic of Congo follow this last practice for sugar cane and palm oil, respectively.

Integrated food energy systems

The merits of the integrated food energy systems that apply several of the above-mentioned good practices have been recognized and are being scaled up in two different ways. The first combines food and energy crops on the same plot of land, intercropping trees for fuelwood and charcoal with food crops, as in an agroforestry system. The second uses by-products or residues of one type of product to produce another, such as producing biogas from livestock residues.

There are considerable expectations being placed on advanced biofuels, such as the second generation or lignocellulosic biofuels, and algae-based products that use feedstocks not used for food. Although there has been significant research and development to improve these second generation lignocellulosic biofuels and technologies are emerging, it will still be several years before it reaches a level of large-scale commercial deployment. Algae-based biofuels have a number of interesting characteristics, such as their high biomass productivity, the possibility of using marginal land, saltwater and waste streams as their nutrient supply, and using combustion gas as CO_2 to generate a wide range of fuel and non-fuel products (FAO, 2010j). However, the production costs of both lignocellulosic and algae-based biofuels are still significantly higher than those of traditional biofuels.

In addition to biomass, other types of renewable energy can be used to help agriculture and the food system become less dependent on fossil fuels. For example, wind power has been used for centuries to lift water for irrigation on agricultural land; and solar energy is used to power pumps, heat water, purify water and dry agricultural products. Hybrid systems that combine renewable and fossil energy for decentralized power supply are growing in importance, as they provide a more reliable and continuous energy supply than is possible with renewable energy alone and thus offer good potential for rural development.

Successful implementation of renewable energy initiatives in agriculture is linked to educational, financial, institutional and infrastructural requirements. Microcredit can ensure affordability and facilitate replication and private sector involvement. Inclusive business is another key element of successful applications and strategies, either as a means for end-users to generate income with renewable energy or to deliver technologies and services based on renewable energy to other end-users.

Addressing the food-energy-climate change nexus will undoubtedly be agriculture's greatest challenge this century. Meeting the world's growing demand for food and energy while adapting to – and minimizing the resulting impact on – climate change will require careful consideration of the pressures on land use, fossil fuel

consumption and food security. If it is to achieve this, agriculture will have to become more energy-efficient; food wastage must be minimized throughout the food chain; and the use of sustainable bioenergy and other renewables will need to increase.

Conclusion

Climate change is expected to affect food production and food distribution systems and infrastructure, particularly in the second half of the century. Agriculture is both a victim of the effects of climate change and a contributor to its causes. For example, agriculture contributes some 13.5 percent of the world's greenhouse gas emissions, and deforestation and forest degradation account for 17 percent more. Agriculture and forestry, however, should also be seen as part of a comprehensive solution to the problem: the inclusion of the agriculture and forestry sectors in mitigation efforts is crucial to keeping the impacts of climate change within limits that society can reasonably tolerate.

FAO policies and activities promote climate-smart agricultural practices such as integrated rice farming systems, conservation agriculture, low-energy use aquaculture, and sustainable forest and land management systems and agroforestry. It supports country efforts in climate change mitigation through advocacy, the generation and dissemination of data, knowledge and technology, and support for institutional structures focused on realizing the mitigation potential of agriculture, forestry and other land-use sectors. Two key climate change programmes through which FAO operates are UN-REDD and the Mitigation of Climate Change in Agriculture (MICCA) project.

CHAPTER **4**

Managing globalization in the agriculture sector

In today's globalized world, no country stands alone in efforts to ensure sustainable food and nutrition security for its people. No longer can the problems of people on one side of the world be ignored by those on the other. The impacts of shocks caused by climatic disasters, price fluctuations caused by crop losses or overproduction, the effects of transboundary diseases all ripple out and can take a toll on global markets and food supply.

The phenomenon of globalization, or the growing integration of economies and societies around the world because of increased flows of information, capital, labour, technology, goods and services – has integrated economies and societies around the world. Globalization itself is driven by four main factors: market liberalization; growth of international trade; an increase in international financial transactions and capital flows; and advances in information and communication technologies (ICTs) as well as logistics systems.

International trade and market access

International trade can have a major impact on reducing hunger and poverty in developing countries. Participation in trade allows access to larger markets and opens up opportunities for specialization in production and economies of scale. This can be of special importance for developing countries, particularly for smaller ones where the limited size of domestic markets discourages full use of their production potential. For example, almost 40 percent of global fish production enters international trade, allowing producers to reap the economic benefits from harvest while also contributing to food security by providing consumers access to fish products. For developing countries, this is particularly important. Not only are they responsible for more than 80 percent of total fish production, they are the origin of more than 50 percent of all fish that enters international trade.

At the same time, trade provides access to better and cheaper supplies, including food imports, and may stimulate flows of technology and investment. To the extent that international trade spurs broad-based economic growth, expanded participation in world markets can contribute to improvements in household food security.

However, increased openness to international trade has its costs. It may redistribute world production according to countries' competitive positions in the global markets. Inevitably, this means that certain industries in some countries may shrink, either absolutely or relative to others, as cheaper imports become available.

The resulting changes in the production structure and reallocation of resources may have a negative impact on food security, at least in the short term. Unemployment may rise, some productive sectors in agriculture may decline and the food system may become increasingly concentrated, shutting out small-scale farmers and firms.

Overall, countries that are more involved in trade tend to enjoy higher rates of economic growth. However, growth rates diverge widely for countries with comparable levels of trade activity, highlighting the importance of other factors in determining economic performance. Such factors include natural resource endowments, the size, skills and training of the workforce, and policies and institutions.

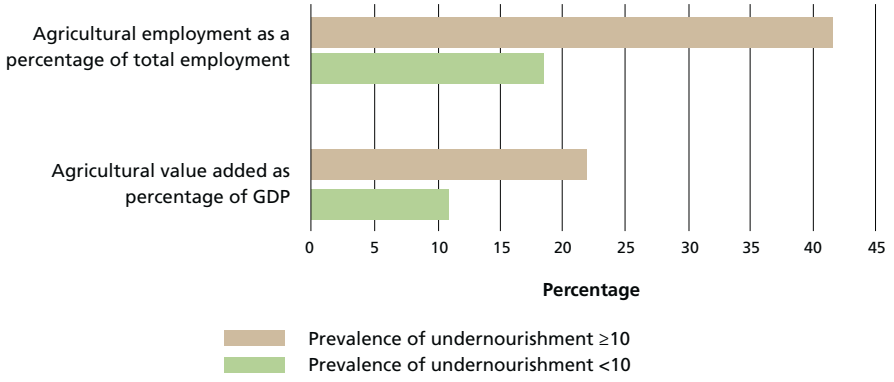
Indeed, while there is broad agreement that openness to international trade is a fundamental component of a policy mix that can foster economic growth, it is also recognized that, on their own, policies designed to open up trade are unlikely to lead to major improvements in a country's economic performance. Moreover, such policies cannot be a substitute for measures specifically aimed at reducing poverty and hunger.

Agriculture, trade and food security

Agriculture and agricultural trade play a particularly important role in both the national economies and the food security of developing countries. However, the relative importance of the sector is far greater in those countries where hunger is most widespread. In countries where more than 10 percent of the population is undernourished, agriculture represents on average more than 20 percent of GDP and more than 40 percent of total employment (see Figure 16). In more food-secure countries, the shares for agriculture are 11 percent of GDP and 18 percent of agricultural employment. With so many people earning their living and so much income being generated in the agriculture sectors of vulnerable countries, economic growth originating in the sector can have a particularly significant impact on poverty and hunger reduction. Increasing employment and incomes in the agriculture

FIGURE **16**

Agriculture and undernourishment in developing countries, 2006-2008



Source: FAO (preliminary estimates).

BOX **12**

Narrow export base leaves countries vulnerable

Many developing countries rely on exports of a small number of agricultural commodities for a large share of their export revenues. In fact, as many as 43 developing countries rely on one single agricultural commodity for more than 20 percent of their total export revenues and more than 50 percent of their revenue from agricultural exports. Most of these countries are in sub-Saharan Africa or Latin America and the Caribbean, and they depend on exports of coffee, bananas, cotton lint or cocoa beans. A high dependence on one, or just a few, export commodities leaves these countries extremely vulnerable to changing market conditions.

sector stimulates demand for non-agricultural goods and services, providing a boost to non-farm rural incomes as well.

Agriculture also accounts for much of the trading activity of developing countries, particularly those that are most food-insecure. For countries where the prevalence of undernourishment is more than 10 percent, agricultural products represent an average of about 26 percent of total merchandise exports. For countries where the prevalence of undernourishment is less than 10 percent, agricultural products represent an average of around 14 percent of total merchandise imports. The fact that agricultural exports represent more than one-quarter of the merchandise exports of vulnerable countries does not imply that agricultural trade contributes to food insecurity.

These countries heavily export agricultural products because agriculture is the mainstay of their economies and they need to import food. Moreover, it is in the countries that are less food-insecure (where the prevalence of undernourishment is less than 10 percent) that agricultural trade looms largest in relation to the scale of their agricultural economies. This reflects the fact that agriculture in these countries is more productive, more competitive and better integrated into world markets, suggesting that more robust agricultural growth can contribute both to reduced hunger and to increased integration in international trade.

Furthermore, poor access and poor integration with international markets limits the ability of countries with widespread hunger to import enough food to compensate for shortfalls in domestic production. Countries where more than 10 percent of the population goes hungry spend more than three times as much of their export earnings to import food than more food-secure countries. However, their poverty and limited trading activities constrict their export earnings as well as their ability to buy more food on international markets. As a result, despite spending more than 40 percent of their export earnings on food imports, food-insecure countries depend far more heavily on homegrown food. Countries where more than 10 percent of the population is hungry import less than 15 percent of

their food, compared with more than 33 percent in more food-secure countries (see Figure 17). Their relative isolation from international trade appears to be more a measure of vulnerability than of self-sufficiency.

It must also be stressed that levels of hunger and poverty also differ widely among countries with very similar levels of agricultural trade. This suggests that the impact of agricultural trade on food security is mediated by a range of other factors, including markets, institutions and policies to combat hunger.

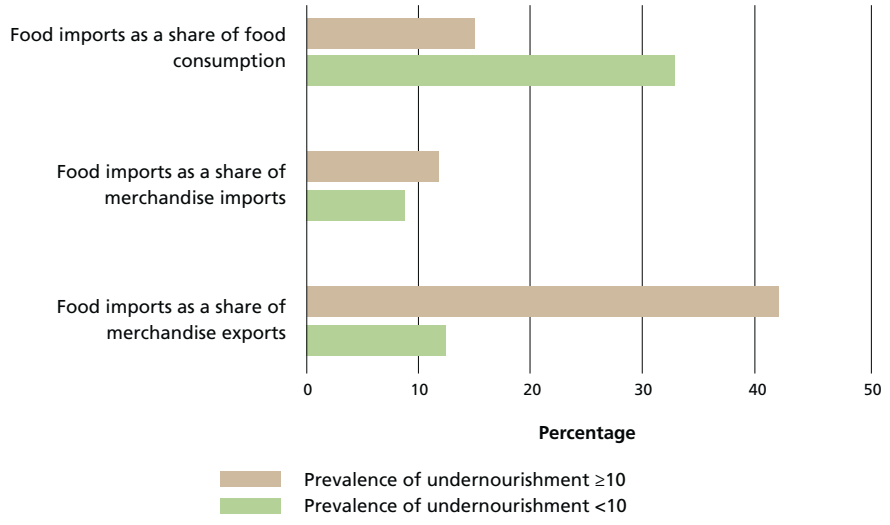
Establishing a "fair" rules system for agriculture

Despite the importance of agriculture and agricultural trade for developing countries in reducing poverty and hunger, the period leading to the launching of the Uruguay Round of multilateral trade negotiations in 1986 was characterized by the prevalence of production- and trade-distorting policies in a number of developed countries. These policies, put in place in periods of shortage during the 1950s and 1960s, had led to structural surpluses and an excess supply of a number of commodities on the world market. This was to the detriment of other countries, including many developing country exporters. In addition, many developing countries had the opposite problem: underproduction, resulting from their own disincentive policies, designed to extract resources for developing their manufacturing sectors, as well as from the distorted world market environment.

The existence of such policies in both developed and developing countries made it difficult for developing country agriculture to expand sufficiently to avoid the disarray of agricultural commodities in international markets during the 2007–2008 period. A lack of appropriate incentives, caused by direct distortions such as export

FIGURE **17**

Agriculture and trade in developing countries



Source: FAO (preliminary estimates).

BOX **13**

Defining "fair" trade

Researchers use three almost identical terms when discussing trade (ITC, 2010): fair trade, Fair Trade and fairtrade.

In international negotiations, **fair trade** is trade conducted according to transparent, non-discriminatory rules, so one exporter does not have an unfair advantage over another. **Fairtrade** is the label of an international community of organizations that belong to Fair Trade Labelling Organizations International (FLO) and apply **Fair Trade** principles.

taxes, and by indirect distortions such as protection of the manufacturing sector, together with overvalued exchange rates and declining investment in agricultural and rural development prior to the 1980s, set the scene for the first global food crisis in more than 40 years.

Uruguay Round

Multilateral trade negotiations on agriculture began in earnest with the onset of the Uruguay Round, the aim being to reduce such trade barriers and to establish a fairer, rules-based and transparent trading system. The seeds of this round of negotiations were sown in 1982 at a ministerial meeting of the General Agreement on Tariffs and Trade (GATT), the round was launched in Uruguay in 1986 and the relevant agreements were signed in Marrakesh, Morocco, on 15 April 1994. The Agreement on Agriculture (AoA) was an important step in reforming world agriculture. However, although it recognized the political difficulties in bringing agriculture under multilateral disciplines, the mechanisms it put in place left much to be desired, especially from the point of view of food-insecure developing countries.

The AoA, essentially a trade agreement, aims at stemming overproduction and associated trade-distorting policies. The problem of underproduction and associated disincentive policies in many food-insecure developing countries were not, and could not be, addressed by a trade agreement. As the issues under negotiation largely concerned developed country structural imbalances, developing countries did not fully engage in the negotiating processes and many of them signed on to the final agreement as if this had very little to do with their own agriculture sectors. In doing so, they agreed to production-restraining provisions, possibly limiting their policy options to boost domestic production in the future and legitimizing past distortions in developed countries. They also limited their export opportunities in developed country markets in the future.

Doha Round

These issues still confront many of the developing countries as the agricultural reform process continues under the Doha Development Round (DDR) of multilateral negotiations. The mandate for the DDR negotiations, which began in late-

PHOTO 8
Successful negotiations on fisheries subsidies could discipline the use of subsidies that lead to overcapacity and overfishing.

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2001, is no different than those of previous rounds, but it is now recognized that agriculture is of critical importance to the economic development of developing countries, which must be able to pursue agricultural policies that are supportive of their development goals, poverty reduction strategies and food security and livelihood concerns.

Now a decade into the negotiations, DDR has focused on a "modalities" phase, setting numerical targets and other details for achieving the objectives of the new round and determining the shape of the negotiations' outcome. The latest draft modalities paper was produced in December 2008.

The difficulty in reaching convergence in the negotiations has been the result of differing views on how best to reduce core distortions while allowing the policy space and flexibilities demanded by various country groups to cater for their own national interests. Although the implementation of the AoA had reduced agricultural market distortions to some extent, its architecture, in terms of specific instrumentation, allowed plenty of room for the developed countries to meet their legal obligations technically, while continuing to pursue the same distorting policies as before – policies for which they have sufficient financial resources. The developing countries, on the other hand, neither have the resources nor enjoy the flexibility to implement such measures. Moreover, there are still many trade barriers in developed country markets, including tariff peaks, tariff escalation and sanitary and phytosanitary measures, which effectively limit market access to developing country exports. If trade is to contribute to food security, these fundamental imbalances and loopholes of the AoA have to be removed.

Many of the policy instruments that could be implemented by vulnerable countries to improve the food security of their populations tend to run counter to the spirit of liberalizing trade. That is one of the important reasons why agreement has been so difficult to reach on many issues in the DDR negotiations.

Import subsidy. The most effective instrument for raising agricultural productivity and food production in food-insecure countries is the input subsidy, yet it has been identified as the most production- and trade-distorting among the various support

measures and has been used effectively to reduce overproduction in developed countries. In countries with a large population spending most of its income on food, an input subsidy does not penalize poor consumers, as would be the case with an output support policy, and it provides an incentive to producers by reducing their production costs.

Safeguard mechanisms. Food-insecure countries have been pushing to retain border protection for achieving market stability and maintaining producers' income during times of low international prices, given that they lack the budgetary resources to provide direct support. Although provisions for Special Products and Special Safeguard Mechanisms are envisaged in the DDR, and could be used by vulnerable countries for protecting their vulnerable producers, these have been important obstacles to an agreement being reached in the negotiations. With regard to Special Products, disagreements are about the total number of special products, those requiring no tariff cut, and the tariff reduction rate for other products. With regard to the Special Safeguard Mechanisms, disagreements are about when an import surge calls for protection of the domestic industry, the level of trade remedy measures to be applied when a surge is identified, and the number and frequency of use of the mechanism. Those who propose restrictions in the use of these instruments – mainly the developed and developing agricultural-exporting countries – argue that they could potentially block a significant share of their exports.

Under the AoA, applying export prohibitions, restrictions and export taxation in order to protect consumers against sudden increases in international prices of agricultural commodities, especially food commodities, is technically legal, provided these measures are applied temporarily. Such measures, of course, could put further upward pressure on international prices, as they did during the food and fuel crisis of 2007–2008. However, there is resistance on these issues from some WTO mem-

BOX **14**

Fisheries subsidies in the Doha Round

The mandate of the DDR negotiations specifically calls for clarification and improvement of WTO disciplines on fisheries subsidies, requesting that "appropriate and effective special treatment should be an integral part of the fisheries subsidies negotiations, taking into account the importance of this sector to development priorities, poverty reduction, and livelihood and food security concerns". Since 2008, FAO has participated in the Rule Group negotiations as an observer, providing technical assistance as necessary and monitoring the role foreseen for FAO in the new fisheries subsidies disciplines. The successful conclusion of the negotiations on fisheries subsidies could discipline the use of subsidies that lead to overcapacity and overfishing which, in turn, would have a positive impact on the state of aquatic resources.

bers and it is unlikely that stronger disciplines on export prohibitions, restrictions and export taxation will materialize from the Doha Round. Beyond the serious food security concerns of net food-importing countries resulting from weak WTO rules in this area, this raises doubts concerning the reliability of the world market as a source of food supplies, and the credibility and impartiality of efforts to reform world agricultural trade.

There are less controversial measures currently being negotiated, which are designed to help food-insecure countries. These include measures on stockholding, domestic food distribution programmes and food aid. Overall, however, the multilateral trading system and the rules that govern it can be helpful at the margin but are not the answer to food-insecurity problems of developing countries. Given the limited capacity of these countries to implement various provisions and take advantage of export opportunities, some differentiation between members of the WTO as regards their rights and obligations may have to be introduced. However, such special and differentiated treatment is not likely to be acceptable to all if it is to be made available across-the-board to all developing countries, since the market effect of such all-encompassing provisions would be large.

Private standards

The multilateral trade negotiations aimed at reducing barriers to trade relate to measures and standards that are implemented by public institutions through an intergovernmental process. Measures and standards applied by private firms remain outside these negotiations. The increasing trend towards the use of "private" standards raises several questions about the increased costs of compliance with demands that go beyond regulatory requirements, the potential anticompetitive behaviour of dominant firms, and private standards as *de facto* non-tariff barriers to trade, particularly for small producers in developing countries (ITC, 2010, p. 7). How such standards could be made transparent and whether a legal framework could be developed for them are issues that remain unexplored. These are important points because, if the trend continues to expand to cover more food commodities, they have the potential of making the "official" negotiations redundant.

Large land acquisitions for food exports

Over the last few years, large-scale acquisitions of farmland in Africa, Latin America and Central and Southeast Asia have made headlines across the world. International investors now actively seek land that previously had little apparent value or interest. These large land acquisitions, often dubbed "land grabs", are likely to have profound implications for the future of world agriculture and food security, with the potential to reshape the relations between agribusiness and smallholder farming. Exactly how the situation will evolve is still unknown, but it is likely to vary according to local and national contexts.

Precise quantitative assessments of the scale, geography and players in the global move towards large-scale land acquisitions are not yet available. However, some aggregate estimates, to a large extent based on media reports, have been compiled. The figures reported are likely to increase rapidly.

- In May 2009, the International Food Policy Research Institute (IFPRI) estimated that between 15 and 20 million ha of farmland in developing countries had changed hands since 2006 (*The Economist*, 2009).
- In September 2010, on the basis of press reports, the World Bank (Deininger *et al.*, 2010) identified tentative deals and intentions to acquire large land tracts amounting to a total of 42 million ha globally in just the 11 months between October 2008 and August 2009. About three-quarters of these deals (32 million ha) were in sub-Saharan Africa.
- In September 2010, on the basis of a larger number of transactions reported in the press during the previous three years, the International Land Coalition identified 277 recent and current large land transactions in 27 countries, for a global total estimated between 51 and 63 million ha (International Land Coalition, 2010).

The main category of investors include governments or government-backed companies operating with sovereign (state) funds, national private-sector companies, private foreign companies, and asset management funds. On the hosting side (countries receiving investments and supplying land), the main actors are often governments (particularly in Africa and Asia) and the land proposed for investments is state-owned or public land. In Latin America and Eastern Europe, the land targeted for investments is more often the property of private owners.

The nature of the land deals

One of the first studies of the major trends and actors involved in land deals found that foreign investments resulting in large-scale land acquisitions in the African region are more significant than domestic investments in the same activity, although these can also play an important role. The study, based on an empirical investigation in six African countries and undertaken by the International Institute for Environment and Development (IIED), FAO and IFAD (Cotula *et al.*, 2009),[7] found that most of the current large-scale land deals have been made by European biofuel investors as well as Gulf State and Asian investors. The private sector has acquired the most land, while government funds and sovereign wealth funds tend to be investing on a smaller scale. However, private investors may receive support from their home country governments, which provide diplomatic and financial support from their development funds to enable companies based in their countries to make the large-scale land investments.

[7] This publication, as well as some shorter papers by Lorenzo Cotula based (mostly) on the study, provide a large part of the information and analysis summarized in this sub-chapter.

In the majority of cases, the allocations/acquisitions have been made from state lands, and leasing is more common than outright sale of land. Lease terms can be up to 99 years, with annual charges paid by investors generally low – a maximum of US$12 per ha per year. Long-lease arrangements and competitive prices are a way for governments to attract foreign investors. In return, governments seek benefits in the form of new jobs, technology transfers, foreign currency and infrastructure development.

Factors underpinning land deals

There are a number of factors determining the recent surge in land investment. They include business opportunities linked to expectations of rising food prices and land values, the biofuel boom which has driven the interest in access to large tracts of land to grow feedstock, industrial demand for agricultural commodities, water shortages and the impact of climate change in home countries, and policy reforms designed to attract foreign direct investment (FDI) in recipient countries. This global picture of trends and drivers makes it difficult to distinguish the impact of land acquisitions for food exports from impacts driven by other anticipations and objectives.

Food security of the investor countries is one of the key drivers of the land investments. Investor country concern about food security burgeoned during the food price hikes of 2007–2008. Importing food through outsourced agricultural production, rather than depending on the world food market, perceived as costly and unpredictable, is seen as a way of securing food security for growing populations and heading off future social unrest associated with food supply difficulties, such as those that affected 33 countries during the 2007–2008 food price spikes.

Rising food prices make agriculture an increasingly attractive investment option. In recent decades, agricultural value chains have tended to concentrate on food processing and distribution. This has left the risks mainly in primary production, which has acted as a disincentive for investment in agriculture. Now the upward trend in commodity prices is tipping the balance by increasing the downstream risks to processors and distributors who are concerned about sourcing raw materials and boosting returns from production. This increases the attractiveness of agricultural production as an investment option, not only the acquisition of land itself, but also acquisition of shares in companies holding land, producing fertilizers, providing management services or otherwise involved in upstream agricultural activities.

Improved prospects for returns from agriculture also encourage speculative investment in land, especially after the global financial crisis resulted in a massive injection of liquidity and a collapse in equity and bond markets, thus precipitating a resurgence of interest in land and commodities (UNCTAD, 2009).

Food production for export through global commodity markets or through direct agreements between investors and host governments appears to be a major new

PHOTO 9

The impacts of land acquisition are likely to differ depending on the context and business model.

trend and central component in the current wave of large-scale international agricultural investments and land acquisitions. Nevertheless, the current wave of land acquisitions is still too recent to permit detailed evidence-based assessments of impacts and outcomes, positive or negative, on the livelihoods of affected countries and communities. These impacts are likely to differ according to contexts and to the types and business models of investments. Large-scale mechanized farming is likely to have different impacts on livelihoods and income distribution than contract farming which promotes smallholders' progress and improvement.

Although these deals held promise of financial investment, employment, technology transfers and income generation, evidence is scant as to whether the promise has been fulfilled. One challenge in assessing the impacts is that large-scale foreign deals are often part of a wider package of proposed bilateral development assistance that could include, for example, investment in large-scale infrastructure, such as ports or hydro-electric schemes. Any assessment of impacts, therefore, would need to consider the wider and longer-term impacts on the countries concerned.

For now, the empirical case studies present a mixed picture. Some conclude that at least some large-scale acquisitions have not lived up to expectations and, instead, have had a negative impact. Others show evidence that some foreign investments in agriculture are having a positive impact. More well-documented research on impacts, both positive and negative, is needed.

Opportunities and risks in land acquisition

There may be both risks and opportunities for those on the receiving end of large-scale land acquisitions. Increased investments may bring macro-level benefits, such as economic growth and improved government revenues, and may create opportunities for economic development and improvement in livelihoods in rural areas. However, as governments or markets make land available to prospective investors, large-scale land acquisitions also may result in local people losing access to the resources on which they depend for their food security – a particularly important issue as some key recipient countries may themselves face food security challenges. Studies by IIED, FAO and IFAD indicate that local people are likely to be under-

mined and left without secure rights to use state-owned land. The also indicate inaccessible registration procedures, legislative gaps and limited, if any, compensation for loss of land and sources of revenue.[8]

Factoring in rural development. Given their scale and locations, these investment deals need to address rural development and how the majority of the rural poor affected by the acquisition can benefit from the generation of diversified employment opportunities, support for the small-scale farming sector and community benefits resulting from a wider distribution of incomes generated. If large-scale land acquisitions and investments do not benefit the majority of small-scale farmers and pastoralists affected, they might easily become unsustainable, creating social unrest, mass migration and political instability. This requires careful design of large-scale land acquisitions and investments in land, because ensuring complementarity between large-scale investments and the small-scale farming sector will increase the potential to generate more income and wider employment.

Balancing opportunities and risks. Ultimately, the extent to which international land deals seize opportunities and mitigate risks depends on their terms and conditions. A number of points need to be addressed in this context:

- how the risks are to be assessed and mitigated, e.g. through project design and location considerations;
- which business models are to be favoured in project implementation, e.g. models range from large-scale (often mechanized) plantations to contract farming, purchase agreements, policy incentives and joint ventures;
- how costs and benefits are to be shared, e.g. in terms of safeguards against arbitrary land takings or revenue-sharing arrangements;
- how compensations are to be valued for lost resources and livelihoods, e.g. in the event of the displacement and resettlement of populations;
- how compensations are actually provided to the affected populations; and
- the players in decision-making and the consultation processes involved.

The trend of large-scale agricultural investments requires more attention at the global level. Time should be taken in negotiating contracts to ensure transparent agreements that take long-term public interest into account, including negotiating land allocations with local communities and including them in the new initiatives. The local population should be aware that the investments are both useful for their livelihoods and beneficial for local development.

There is a long way to go before achieving these objectives. Many countries do not have legal or procedural mechanisms in place to protect local rights, be they formal or informal. Local interests, livelihood patterns and welfare are often not taken into account when contracts are signed with outside investors. Land deals are too often characterized by a lack of transparency, which creates opportunities

[8] This paragraph is based on Cotula *et al.*, 2009.

PHOTO 10

Local interests, livelihood patterns and welfare must be taken into account when contracts are signed with outside investors.

for corruption. Such contracts tend not to maximize the public interest, and the first people to be affected are generally the rural poor.

Identifying and addressing the challenges

FAO is engaged in two major global initiatives that should contribute to identifying and addressing the challenges of ensuring that large-scale land investments and acquisitions are beneficial for rural development and food security, and for investor countries as well as land-supplying countries. These initiatives are the *Voluntary Guidelines on Responsible Governance of Tenure of Land and other Natural Resources* and the *Principles for Responsible Agricultural Investment*. Although different and separate, the two initiatives are strongly complementary.

Voluntary Guidelines on Responsible Governance of Tenure of Land and other Natural Resources. The objective of this initiative is to produce an international instrument that gives practical guidance to the private sector, states and civil society, setting out principles and internationally accepted standards and practices for responsible governance of tenure. In leading this initiative, FAO recognizes the importance of engaging with investors and recipient governments, the private sector and civil society to ensure that large-scale land transfers maximize the contribution of the investment to sustainable development, benefiting both investor and host countries, and both large investors and smallholder farmers (who make up the majority of rural people). This may include supporting policy reform in recipient countries towards greater transparency in decision-making and greater consideration of social and environmental issues.

When finalized, the Voluntary Guidelines will provide a framework and a point of reference to which stakeholders can refer when developing their own strategies, policies and activities in the land sector. The Guidelines will also enable governments, the private sector, civil society and citizens to evaluate and improve their governance of land tenure and other natural resources.

This initiative does not target the phenomenon of large-scale land deals. However, by stimulating the transparency and effectiveness of land institutions and land

tenure practices, the Voluntary Guidelines are likely to improve the way in which such transactions are assessed, negotiated, and implemented, both directly and indirectly.

Principles for Responsible AgriculturaI Investment. With a goal of developing a set of principles that respect rights, livelihoods and resources, FAO, the World Bank, the United Nations Conference on Trade and Development (UNCTAD) and IFAD have based their work on detailed research into the nature, extent and impacts of foreign investment and best practices in law and policy. The principles are intended to distil and encapsulate the lessons learned through this research. They also build on existing international commitments such as the *Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security*. The Principles aim to provide a framework to which national regulations, international investment agreements, global corporate social responsibility initiatives and individual investment contracts might refer. Since 2010, FAO has held a number of international consultations on the Principles, including during its regional conferences. In October 2010, CFS initiated an inclusive process of consideration of the Principles among its members.

Engaging the private sector in food security and sustainable development

There is growing appreciation of the contributions that agricultural companies can make to enhancing food security and supporting the transition to more productive and sustainable food production and supply systems. As FAO addresses the challenges of the twenty-first century, it recognizes that these companies have the capacity to provide agricultural inputs in an efficient and cost-effective manner and, at the same time, contribute to sustainability, food security and value addition by providing a market for farm produce. Today, agricultural companies work with farmers across the globe and play a key role in implementing programmes to support them. Their activities have potentially significant impacts on FAO's efforts to help countries achieve food security and sustainable agricultural development.

Consequently, FAO collaborates and consults regularly with agricultural companies and their associations in many initiatives at national, regional and global levels. Historically, FAO collaborated primarily with non-profit associations that represented the interests of agricultural companies, creating opportunities for representatives of these associations to participate in official meetings and multi-stakeholder consultations much more than it did with the individual companies and business leaders.

As it looks to the future, FAO is now extending its partnering strategy with the private sector, giving increased attention to dialogue with agricultural companies and business leaders and to integrated, multi-stakeholder, long-term strategic approaches that would otherwise be beyond its reach and that of its member coun-

tries. Four important sets of circumstances have led FAO to review and adjust its strategies and approaches for partnering with the private sector:

- *Market changes.* Dramatic and rapid changes are occurring in global food markets and food supply systems, many of them driven by global and national agricultural companies as well as by alliances initiated by associations such as GlobalGAP. FAO's Committee on Agriculture (COAG) called on FAO to help member countries respond to the "challenges of agribusiness and agro-industries development" during its 20th Session in 2007 (FAO, 2007a).
- *Member country requests.* FAO member countries have shown a strong interest in engaging the private sector in country-level policies and programmes to support agricultural development and they recognize the importance of the sector in their food security plans. COAG in 2009 considered issues related to "engaging the private sector in agricultural development" and requested FAO to reinforce capacities for partnering with the sector (FAO, 2009g).
- *FAO strategies.* An external evaluation, conducted in 2006–07, and its follow-up plan of action called for developing new approaches for partnership with the private sector (FAO, 2008e). FAO's new *Strategic Framework 2010–2019* calls for broadening the base of governance "to give full recognition to the roles and interests of the private sector, NGOs, regional economic organizations, regional development banks and other agencies" (FAO, 2009h).
- *Private sector transformation.* Many business leaders and companies have demonstrated that they are committed to developing sustainable food value chains through their own business operations as well as through partnerships, and they have also developed proactive procedures to reduce waste along the food value chain from farm to consumer and to improve the quality and nutritional value of products. While some companies clearly have a large-farm bias, a growing number of companies are adopting policies for working with smaller and medium-scale agricultural enterprises, including input suppliers, food manufacturers, distributors and retailers, in order to develop locally adapted solutions.

Governance and standard setting

Most of FAO's governance and standard-setting work is conducted through statutory bodies or commissions, many of them operating under joint oversight with other UN agencies. Generally these bodies and commissions are intergovernmental and only governments are members. However, all allow participation of other stakeholders as observers, including representatives of agricultural companies. Such companies are generally represented by their trade or industry associations rather than participating individually, but company personnel often attend meetings as representatives of their industry associations.

Although the official role of agricultural companies has been limited in the governance and standard-setting activities of FAO, there has been a general trend towards more substantive involvement of non-governmental stakeholders, with

some bodies now establishing formal advisory or consultative mechanisms including agricultural companies through their associations. The following list illustrates the diversity of approaches.

- *The Codex Alimentarius Commission and the FAO Committee on Commodity Problems* address issues that have a significant impact on agricultural companies, and they are affected by the actions of those companies. Membership of both bodies is limited to governments but non-profit industry associations are permitted to participate as observers.
- *The Committee for World Food Security (CFS)* includes non-governmental stakeholders as observers only, but it has recently been taking steps to enhance the opportunity for these stakeholders to have more substantive roles. In 2009, the CFS established an Advisory Group comprising five stakeholder categories, one of which is private sector associations and philanthropic foundations.
- *The International Code of Conduct on the Distribution and Use of Pesticides* contains provisions specifically targeted at the pesticide and food industries. Although associations representing these industries have only had observer status, the Code states that the "pesticide industry is invited to provide reports to the Director-General of FAO on its product stewardship activities related to observance of the Code."
- *The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade* includes a Chemical Review Committee in its implementation mechanism. The global trade association "Croplife International" participates regularly as an observer to represent industry interests. Under the auspices of Croplife, staff from companies such as Syngenta, Dupont Crop Protection, Bayer CropScience, and Dow Agrosciences have participated in committee meetings.
- *Advisory Committee on Paper and Wood Products* is a statutory body of FAO, established to advise FAO on issues faced by the industry and to provide a mechanism for direct communication between FAO and the private sector. The committee includes senior executives of companies or associations from all regions of the world, representing around 90 percent of the global pulp and paper industries sector.

FAO private-sector partnering strategy

FAO has undertaken a fundamental review of its partnership strategy, including modalities and priorities for partnering with the private sector. The strategy for optimizing the roles of the private sector in food security and sustainable development now recognizes the value of directly engaging agricultural companies and business leaders at the global and national levels.

To reinforce and mainstream new ways of partnering with agricultural companies and business leaders, FAO also has put together a roadmap for engagement with the private sector envisaging, among other activities, a new strategy for private-

PHOTO 11

FAO has long-standing, productive working relationships with several industry associations.

sector collaboration, renewed principles and guidelines for cooperation with the sector, risk management and due diligence procedures, and monitoring and evaluations tools. This updated strategy, considered by FAO's Programme Committee in early 2011, gives an overview of building principles, criteria for selecting partners and the types of partnering activities, focusing on development and technical programmes, norms and standard-setting work and policy dialogue.

Partnering with industry organizations

At the regional and global levels, FAO has had long-standing, productive working relationships with several industry associations, such as the International Fertilizer Association, the International Seed Testing Association, the International Seed Federation, the Asia and Pacific Seed Association, the African Seed Trade Association, the International Feed Industry Federation and the International Dairy Federation.

At the national level, FAO has worked with companies and producer organizations to help develop and strengthen associations that are specific to a commodity, location, industry or profession. Such associations and organizations have valuable roles in connecting producers and clients, crystallizing and expressing the viewpoints of affinity groups, taking collective action, facilitating networking among members and linkages with other enterprises and organizations, and providing training, information, technology and legal support.

Partnering in field programmes

In its field programme, FAO regularly collaborates with companies, commercial service providers and private-sector associations (including producer organizations) on value chain and subsectoral development projects. FAO offers strong support to innovation in pro-poor business models with particular attention to the producer-buyer relationship. This involves working directly with business managers to carry out business appraisals, develop strategies and prepare plans to improve competitiveness while strengthening procurement ties with small-scale producers. Working on both sides of the producer-buyer relationship, FAO has

helped identify and promote technologies, including inter-firm technologies, to raise productivity and to improve logistics, cold storage, traceability and product safety.

FAO regularly partners with local fertilizer, seed and other companies in developing strategies and carrying out actions to improve the efficiency of input supply and distribution, while also enhancing access for small farmers. In addition, FAO collaborates with agricultural companies in identifying and promoting technologies and business practices to improve efficiency and reduce losses in food processing and distribution, and to introduce food quality and safety management systems.

Recent FAO initiatives

In recent years, FAO has become more proactive in direct engagement with agricultural companies and business leaders while exercising caution in engagements that could be construed as compromising FAO integrity and neutrality.

Two global initiatives organized by FAO are particularly noteworthy:

- *The Global Agro-Industries Forum (GAIF),* organized in 2008 by FAO in partnership with UNIDO and IFAD and hosted by the Government of India in New Delhi. GAIF was attended by about 100 countries and included 12 roundtables for executive forum dialogue on strategies and actions to improve competitiveness and development impacts. Business leaders from all regions were invited to discuss their experiences and company strategies. The global event was followed by regional fora in Latin America and Asia, and a High-Level Conference on African Agribusiness and Agro-Industries Development.
- *A meeting of business leaders*, organized by FAO in 2009 in partnership with Milan Expo 2015 was a prelude event to the World Summit on Food Security.

BOX **15**

World Banana Forum

The World Banana Forum, one of FAO's first initiatives to establish a formal mechanism for sustained engagement with agricultural companies, brings together a wide range of stakeholders in the global banana sector, including producer organizations, trade unions, cooperatives, exporter groups, trading companies and retailers, as well as public agencies, governments, research institutions and civil society organizations. Launched by FAO with ILO and UNCTAD in December 2009, the forum promotes and supports dialogue and collaboration, and specifically seeks to enhance the social, economic and environmental sustainability of banana production and supply systems. It provides FAO with a continuing mechanism to communicate and collaborate with senior managers of leading banana producing and export companies.

During the meeting, business leaders discussed their initiatives for addressing food security and sustainable development. An important outcome was a statement on "Private Sector Actions to Reduce Food Insecurity".

The Director-General of FAO participated in both the GAIF and the Milan private-sector meetings and has followed up in discussions with business leaders to discuss opportunities for partnerships to promote sustainable business practices and food security.

FAO has convened a series of workshops and roundtables in its efforts to engage agricultural companies and business leaders in the technical work of FAO. In 2009, FAO convened an expert meeting for representatives of input industry associations in order to identify actions to improve agricultural inputs supply, as a follow-up to the 2008 High-Level Conference. Starting in 2010, FAO organized a series of regional agribusiness roundtables, involving business managers of small and medium-sized agricultural enterprises (SMAEs) who identified specific regional constraints on SMAE competitiveness. They also shared experiences on how they have sustained procurement from small farmers, introduced quality and safety management systems, developed branded and certified products, and improved logistics and operational efficiency.

Partnerships: agricultural company initiatives

As FAO has started to engage more directly with agricultural companies, it has become clear that many business leaders share concerns about future food security and sustainable development, are convinced that the private sector has an obligation to work effectively as a partner with governmental and non-governmental organizations in ensuring food security, and believe that there are sound business reasons for creating shared global and national agricultural value chains. These business leaders can and do influence their peers and can be instrumental in reshaping behaviour and commitment to food security and sustainable agricultural development.

Complementing its own initiatives, FAO has increased its participation in and support of initiatives launched by agricultural companies and business leaders themselves to promote and support sustainable and inclusive agricultural development. For example, the Sustainable Food Laboratory (SFL), a 2004 initiative of the Kellogg Foundation and Unilever, now has 70 members, mainly private sector businesses. The Sustainable Agriculture Initiative (SAI) Platform was founded by a coalition of leading global companies to promote agricultural practices and agricultural production systems that support sustainable agriculture. Both initiatives support dialogue and "learning from the field" concerning how to build sustainable and inclusive global value chains. FAO has designated representatives both for the SFL and SAI Platform, and it has held discussions on opportunities for enhancing collaboration.

Many companies such as Pioneer Hybrid, Bunge, Syngenta and Tetra Pak, have specific programmes to support sustainable and inclusive agricultural development. Representatives of these companies have been invited to FAO to discuss collabora-

tion. Yara International, Carrefour and other companies have been drivers behind corridor development in Mozambique and Tanzania, and FAO is actively supporting the Southern Agricultural Growth Corridor of Tanzania partnership.

A "New Vision for Agriculture" was developed under the auspices of the World Economic Forum between 2008 and 2010, through dialogue involving business leaders and representatives of the public and non-profit sectors. The New Vision defines joint priorities and makes recommendations on how to leverage public- and private-sector investment for agricultural growth, encourage best practices for the management of natural resources and drive inclusive agriculture sector development. In early 2011, FAO and the World Economic Forum (WEF) agreed in principle to develop a framework cooperation agreement that would systematize dialogue and collaboration in support of the New Vision for Agriculture.

These initiatives by agricultural companies have greatly expanded opportunities for FAO and its private-sector partners to develop and achieve shared vision, values and objectives related to food security and sustainable agriculture sector development.

Investing in agriculture

Countries that have attained high economic growth, managing at the same time to reduce poverty and the prevalence of undernourishment in their population, have often done so by achieving relatively higher growth in their agriculture sector. A sound policy environment, absence of conflict, good governance and functioning markets, including global integration, have been common elements among these high agricultural growth economies, as well as public investment in rural infrastructure.

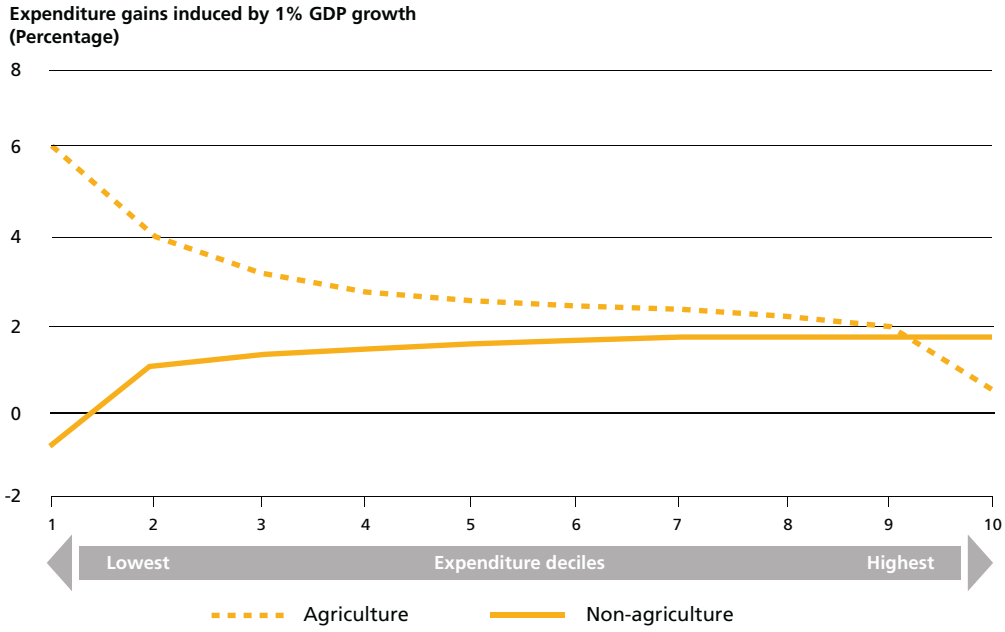
Benefits of agriculture-based growth

Government expenditure on agriculture is strongly correlated with capital formation in the sector, as it creates an enabling environment for private investment in terms of infrastructure and sustainable access to natural resources. There is sound evidence that agricultural growth is at least twice as effective in reducing poverty as GDP growth originating outside the agriculture sector (see Figure 18 and Box 16). In addition, the benefits of increasing agricultural production run well beyond direct benefits to millions of smallholder farmers. It extends to other positive factors such as increased food availability, reduced food prices and higher employment in both rural and urban environments as a result of input service provision and value addition along food processing chains.

In developing countries, increased agricultural productivity is central to economic growth and poverty reduction, particularly through its flow-on effect to higher wage job creation outside the agriculture sector. Yet with current population growth, worldwide demand for food is expected to increase by 70 percent by 2050 (and to double in developing countries). Long-term food commodity price increases can

FIGURE **18**

GDP growth originating in agriculture benefits the poorest



Source: Ligon and Sadoulet, 2007.

BOX **16**

Agricultural investment proven to reduce poverty

In China, following market liberalization and the introduction of the household responsibility system, agricultural growth was 3.5 times more effective in poverty reduction compared to GDP growth from outside the sector; in Latin America, agricultural growth was 2.7 times more effective in poverty reduction. More recently, in Ghana, steeply declining poverty has been attributed to strong agricultural growth.

Agricultural development, therefore, is a critical means for achieving MDG 1, which calls for reducing the proportion of people suffering from extreme poverty and hunger by half by 2015. That challenge is particularly acute in countries with agriculture-based economies, such as sub-Saharan Africa, but also in transforming economies in South and East Asia and the Near East and North Africa, where agriculture is no longer a major source of economic growth, but poverty remains overwhelmingly rural (82 percent of all poor).

therefore be expected, considering supply-side constraints such as land and water scarcity, underinvestment in rural infrastructure and agricultural innovation, a growing urban population and increased production risk linked to global warming.

While higher commodity prices offer opportunities for agriculture, those opportunities are not equally shared. For smallholder farmers to enjoy the benefit of rising prices, they must overcome a myriad of constraints and risks, typified by weak rural infrastructure and market linkages, and poor access to factors of production, including credit, agricultural inputs and knowledge. These constraints are exacerbated by degraded natural resource bases, the productivity-sapping impacts of HIV/AIDS, and new risks posed by climate change.

Agriculture is a strong option for spurring growth, overcoming poverty and enhancing food security, and growth in agricultural productivity is vital for stimulating growth in other parts of the economy. In sub-Saharan African agriculture-based economies, accelerated growth requires a sharp productivity increase in smallholder farming, combined with more effective support to the millions of subsistence farmers, many of whom are in remote areas. In Asia, overcoming widespread poverty in transforming economies requires further diversification into labour-intensive, high-value agriculture linked to a dynamic non-farm rural sector (World Bank, 2008).

Declining government spending on agriculture

It is clear that agricultural growth has a significant role to play in reducing poverty and hunger and it is also clear that growth in developing countries' agriculture sectors will not occur without significant public and private investments. Yet, over the past two decades, both domestic and foreign investments in agriculture have been in a state of decline.

Many agriculture-based countries still deliver low per capita agricultural growth and have not implemented the structural reforms necessary for higher agricultural productivity. Too many countries are inclined to implement policies and investment programmes that focus on urban interests at the expense of rural growth. Dependence on food aid frequently undermines investments in agricultural productivity growth and, in turn, the improvement in food security that would come from rising farm incomes. In addition, women, who typically account for the major part of smallholder farm labour, have uneven access to agricultural production factors such as land, inputs and knowledge, which also constrains agriculture-led growth.

This pattern is frequently reflected in domestic public expenditure for agriculture, which has generally been in decline since 1980, both in agriculture-based economies and in those emerging economies where poverty remains heavily concentrated in rural areas (Table 2). This is particularly noticeable in Africa, where domestic public expenditure in agriculture is well below the 2003 Maputo Declaration target, whereby African Union Heads of State pledged to raise spending on agriculture to 10 percent of national budgets by 2008 in support of the Comprehensive Africa

TABLE 2

Share of total government spending on agriculture

REGION	1980	1990	2000	2007
	Percentage			
Africa	5.9	6.0	5.4	3.5
Asia	7.0	7.1	5.2	5.2
Latin America and Caribbean	6.9	3.6	3.6	1.7
Total	**6.8**	**6.5**	**4.7**	**4.2**

Source: Fan and Saurkar, 2006.

Agriculture Development Programme (CAADP). To date, fewer than ten countries have achieved the target.

The cost of inadequate attention to agriculture, especially in agriculture-based economies, came into focus with the food crisis of 2007–2008. As shown before and during the crisis, strong government commitment is required to maximize the impact of agricultural development policy and public investment choices on growth in the wider economy and, consequently, on poverty. Governments, with donor support, need to address market failures, particularly those constraining labour-intensive smallholder food production and productivity. They must also create a favourable policy environment for private-sector investment, while focusing public investment on areas and commodities with high growth potential and strong forward and backward linkages to the wider economy. For many countries this will mean a focus on their rapidly growing domestic food markets. Countries must also ensure that social protection programmes effectively target the chronically poor and vulnerable, stimulate local growth and reduce risks faced by poor investors (DFID, 2005).

Official development assistance

Official Development Assistance (ODA) is an important source of public-sector investment for agriculture growth. However, it typically forms only about 15 percent of total public expenditure in the sector, the majority of public investment coming from national accounts. ODA to agriculture in developing countries has declined since the late 1980s. At the same time, several studies have shown that the level of national public spending on agriculture and rural areas also fell during the 1990s and early 2000s.

Over a 20-year period starting in the mid-1980s, ODA fell by 43 percent (Table 3) in constant 2007 prices. In 2007–2008, average bilateral aid commitments to agriculture from countries of the OECD's Development Assistance Committee (DAC) amounted to US$4.7 billion. Taking into account multilateral development financing agencies, the total was US$7.2 billion. When aid for rural development and food aid are factored in, the total rises to US$12.3 billion. On a more positive note, recent trends indicate a slowdown in the decline in ODA to agriculture (Table 4), and even the prospect of an upward trend: over the period 2003-2008, bilateral aid to agriculture increased at an average annual rate of 13 percent (in real terms). If

TABLE 3

Aid to agriculture and food security-related sectors, 2003-2008*

DAC countries	2003-04	2005-06	2007-08
Agriculture/Forestry/Fisheries	2 763	3 388	4 713
Rural development	622	729	776
Developmental food aid	1 358	1 053	1 204
Emergency food aid	1 976	2 131	2 284
Total DAC countries	**6 719**	**7 301**	**8 977**
Multilateral agencies	**2003-04**	**2005-06**	**2007-08**
Agriculture/Forestry/Fisheries	2 308	1 961	2 521
Rural development	253	216	224
Developmental food aid	823	1159	393
Emergency food aid	109	180	157
Total multilateral agencies	**3 493**	**3 516**	**3 295**
Total DAC countries and multilateral agencies	**10 212**	**10 817**	**12 272**
Percent Agriculture/Forestry/Fisheries	**49.66**	**49.45**	**58.95**

*Annual average commitments in US$ million, constant 2007 prices. *Source:* OECD, 2010a.

TABLE 4

Aid to agriculture as a percentage of total ODA

	2003	2004	2005	2006	2007	2008	2009
	*US$ million**						
ODA to Agriculture, Forestry, Fisheries	3 578	4 498	4 718	4 716	6 714	7 586	9 776
Total ODA	**90 294**	**100 907**	**122 020**	**127 240**	**132 965**	**157 019**	**151 599**
	Percentage						
Agriculture as percentage of total ODA	3.96	4.46	3.87	3.71	5.05	4.83	6.45

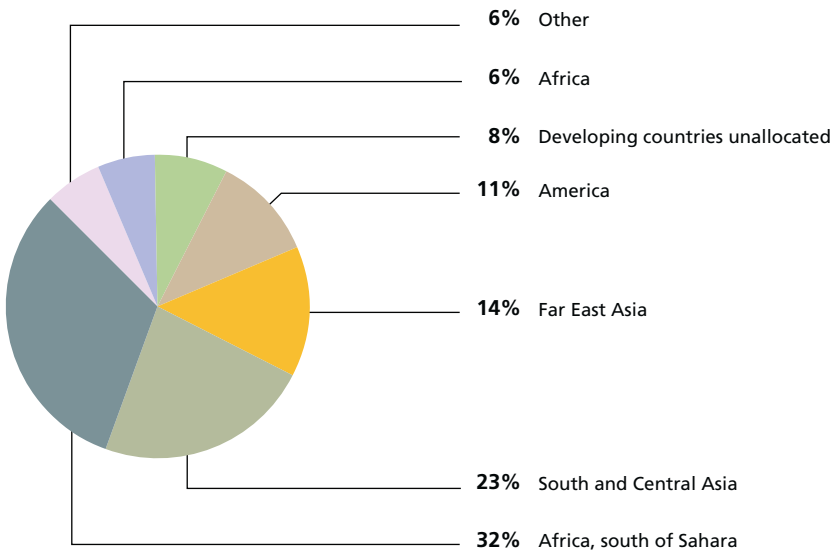
*Current prices 2003–2009. *Source:* OECD, 2010a.

delivered, recent G-8 and G-20 commitments, most notably the L'Aquila Food Security Initiative, also hold promise for continuing these recent positive trends.

Development assistance flows to agriculture have primarily targeted sub-Saharan Africa (31 percent) and South and Central Asia (22 percent). For both these regions, the share has increased over the last decade, from 27 percent in 1998–1999 to 31 percent in 2007-2008 for sub-Saharan Africa, and from 19 percent to 21 percent for South and Central Asia. Least-developed and other low-income countries received more than half of total aid to agriculture (excluding regional/multi-country aid that cannot be allocated to income groups) (OECD, 2010a).

FIGURE **19**

Regional breakdown of aid to agriculture*

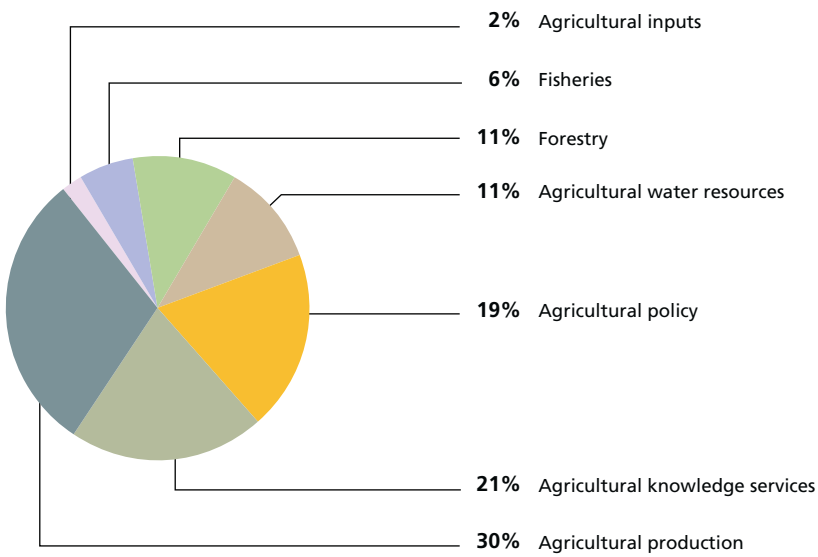


* Commitments in 2003-2008, constant 2007 prices.

Source: OECD, 2010a.

FIGURE **20**

Subsectoral breakdown of aid to agriculture*



* Commitments in 2007-2008, constant 2007 prices.

Source: OECD, 2010a.

BOX **17**

Investment in aquaculture

Evidence suggests that for aquaculture to develop effectively in sub-Saharan Africa, development efforts must be focused, targeting small- and medium-scale enterprises for production and service delivery in high-potential zones while also developing policies to entice the emergence and expansion of large-scale competitive enterprises. Such efforts require sizeable investment bank loans, which are often lacking, especially for small- and medium-scale farmers. Difficult access to bank loans arises from a lack of collateral, excessively high interest rates on loans, and bankers' perceptions that aquaculture carries a particularly high risk of failure. Farmers lack access to information on the modalities of applying for loans, and lenders have limited information on commercially successful aquaculture enterprises in the region.

To lessen this problem, borrowers need to be able to formulate and present their business proposals in a precise and concise manner that offers the lender a comprehensive picture of the proposed business, communicates how they expect to profit from the proposed enterprises and generate the funds for repayment of the loans sought. The problem of collateral could be eased through "no collateral" strategies such as group lending, village banks and solidarity groups, alternative collaterals such as titled land and moveable property, and through government loan guarantees. When affordable, government loan guarantees and subsidized interest rates could also be used to lessen the problem of high interest rates. It is after improving investments in the sector that aquaculture will effectively grow in the region, creating sizable employment and incomes along the value chain and enhancing food security.

Within the agriculture sector in 2007–2008, ODA flowed primarily to agricultural production (31 percent), agricultural knowledge services (21 percent – including agricultural research and education, plant breeding, plant and animal protection, marketing, credit and farmer organization inputs) and agricultural policy (19 percent – including institutional and capacity development, sector adjustment and natural resource management). Forestry (11 percent) and fisheries (6 percent) were the other main beneficiary subsectors. Support to agricultural inputs, a subject that has received considerable attention recently, formed only a minor component (2 percent) of total ODA.

Private enterprise and agricultural capital stock

Without a massive capital input into the agriculture sector in agriculture-based and transforming countries, the world will be unable to meet growing food demand. National public investment must be the primary source of public-sector

TABLE **5**

Average annual rates of ACS growth before and after 1990

	1975-1990	1991-2007
	Percentage	
World	**1.11**	**0.50**
Developed countries	0.60	0.34
Developing countries	1.66	1.23

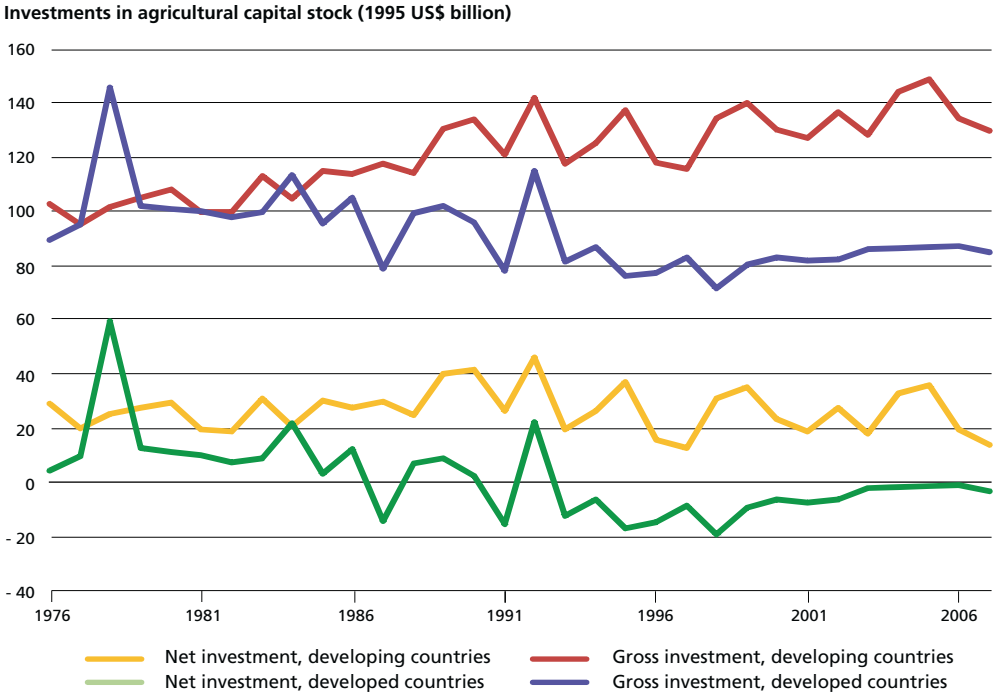
Source: Von Cramon-Taubadel *et al.*, 2009.

development financing, strategically backed by well-targeted ODA. However, globally, agricultural production and marketing is overwhelmingly reliant on private enterprise. Private enterprise in the sector is measured by agricultural capital stock (ACS) – in turn measured by fixed assets in primary agriculture – and this has shown steady growth over the last 30 years, although for most of the period growth has occurred at declining rates (Von Cramon-Taubadel *et al.*, 2009). There has also been a convergence between developing and developed countries, with developing countries showing consistently positive rates of ACS growth across regions and time (although South Asia has recorded a sustained reduction in growth rates since the early 1990s). Worldwide, the average annual ACS growth rate in both developed and developing countries dropped from 1.1 percent between 1975 and 1990 to 0.5 percent between 1991 and 2007 (see Table 5). Disturbingly, ACS growth is lowest in countries with the highest prevalence and depth of hunger. In absolute terms, Von Cramon-Taubadel *et al.* (2009) estimated that gross investment in ACS in developing countries totalled US$130 billion in 2007 (in 1995 dollars), which is equal to about US$142 billion in 2009 dollars (see Figure 21).

Importantly, however, the availability of ACS per agricultural worker has outstripped the rate of ACS growth in sub-Saharan Africa and South Asia, leading to average annual reductions in the ACS per worker in agriculture of 0.44 percent and 0.26 percent, respectively, between 1975 and 2007. In the Near East and North Africa as well as in East and Southeast Asia, population growth has eroded but not completely outweighed growth in the ACS, while in Latin America and the Caribbean a declining rural population has led to a rising ACS per worker, which is also consistent with the growth of capital-intensive agriculture in the region. In sub-Saharan Africa, therefore, despite a projected increase of nearly 300 percent in agricultural output by 2050, revenues per person continuing to work in agriculture will not rise significantly, largely because of the expected increase in the agricultural labour force, which is projected to nearly double by then. When combined with the outlook for capital stocks and the land available per agricultural labourer (Table 6), it appears that the poverty reduction potential of the labour-intensive capital-saving forms of small-scale agriculture likely to prevail in sub-Saharan agriculture will be limited by the fact that too many farmers will have to share too few revenues.

FIGURE **21**

Gross and net investments in the agricultural capital stock, developing and developed countries (1976-2007)



Source: Von Cramon-Taubadel *et al.*, 2009.

A provisional analysis (Schmidhuber, Bruinsma and Boedeker, 2009) indicates that investment requirements for primary agriculture and its downstream industries in developing countries over the 44-year period from 2005-07 to 2050 amount to almost US$9.2 trillion (2009 dollars), 57 percent of which is for primary agriculture and 43 percent for downstream support. Within primary agriculture, about one-

TABLE **6**

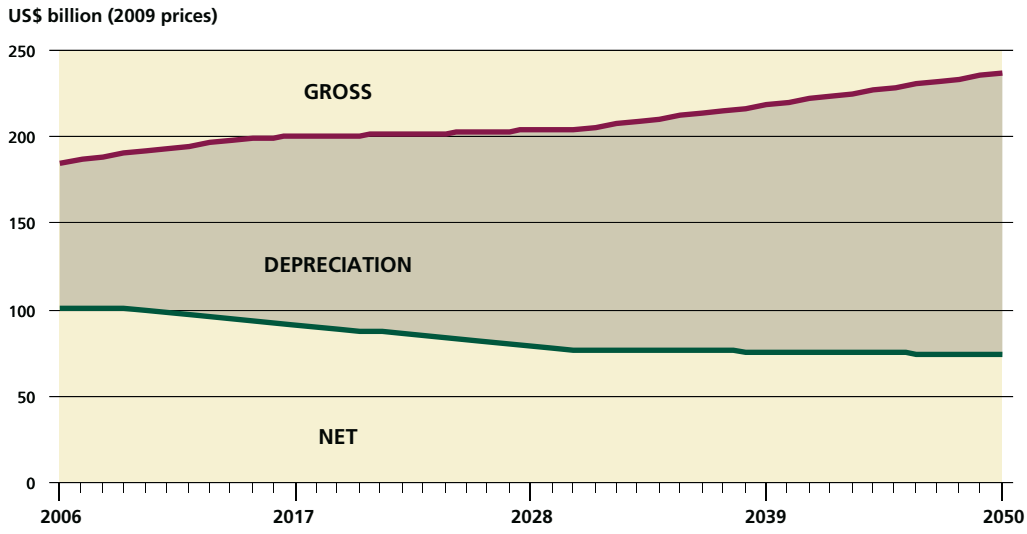
Patterns in agriculture production in sub-Saharan Africa

	2005	2030	2050	2050/2005
Agricultural labour force (millions) by region	206	310	376	1.83
Capital stock per worker (in 2009 US$1 000)	2.78	2.62	2.77	1.00
Harvested land per agricultural labourer (hectares)	0.86	0.68	0.63	0.73

Source: Schmidhuber, Bruinsma and Boedeker, 2009.

FIGURE **22**

Total annual investment requirements in developing countries



Source: Schmidhuber, Bruinsma and Boedeker, 2009.

quarter of all capital needs are projected to be for mechanization and almost one-fifth (18.5 percent) for the expansion and improvement of irrigation. Some 60 percent, or US$5.5 trillion, will be needed to replace existing capital, while 40 percent, or US$3.7 trillion, will be growth investments and thus net additions to existing capital stock. Over time, the share of investment in primary production is expected to fall in relation to investment in downstream value adding. The rates for such change, however, will vary substantially between regions over time, with the higher growth in downstream activities being in sub-Saharan Africa, where food systems are least mature and growth reflects a progressive shift away from a dependence on primary production.

A notable aspect of the study by Schmidhuber, Bruinsma and Boedeker is that annual net additions to the capital stock (growth investments) show a distinct decline over time, falling from about 55 percent of the total in 2006 to just 30 percent in 2050 (Figure 22). This reflects a declining incremental production need as a result of slowing population growth and increased food and fibre satiation levels of per capita consumption; a countervailing move to more capital-intensive production systems and increased substitution of labour by capital; and a progressive improvement in total factor productivity (TFP), which is expected to be positive for developing countries as a whole, although variable across regions.

Foreign direct investment

Foreign direct investment (FDI) in agriculture is expected to play an increasingly important role in achieving agricultural growth and poverty reduction. The FDI

share of the global supply of international investment has risen from 1 percent in 2001 to around 20 percent today. However, a substantial proportion of FDI involves mergers and acquisitions, which is well down from its 2007 peak and is projected by the OECD (OECD, 2010b) to have declined by around 8 percent in 2010: this on top of a 19 percent decline in 2008 and a 43 percent decline in 2009. The G20 countries are the source of about three-quarters of the world's FDI and, in 2010, about 20 percent of G20 investment flowed to emerging economies. Almost 50 percent of the outward investment of emerging economies, equivalent to about 40 percent of the parallel G20 investment, went to other emerging economies. Should this trend expand, it could have important development benefits for emerging economies and implications for the implementation of good investment practice.

UNCTAD's *World Investment Prospects Survey 2009–2011* found that local market size and growth were the most frequently cited determinants of investment location, with the emerging economies of China, India, Brazil, the Russian Federation, Indonesia, Viet Nam, Poland and Thailand favoured by investors. Access to international or regional markets was also a priority, with preferred emerging markets including China, the Russian Federation, Brazil, Mexico and Viet Nam. The set of factors contributing to the quality of the overall business environment came a clear second to market size and growth, with only developed countries identified in this category. Other location determinants, such as labour costs, presence of competitors, and access to natural resources and capital market were cited less frequently. Cheap labour was cited for investing in developing countries, mostly in Asia, such as China, India, Viet Nam, Indonesia and Thailand. Indonesia was identified for access to natural resources, while Brazil and Viet Nam's investment incentive programmes also attracted prospective investors.

The inflow of FDI into agriculture amounted to approximately US$3 billion per year by 2007, compared with US$1 billion in 2000 (FAO, 2009i). While this is a substantial increase, it was across both developed and developing economies and represents a very small proportion (<0.15 percent) of total FDI in 2007 and of domestic private-sector investment in agriculture. Agriculture sector investors are primarily from the private sector, but governments and sovereign wealth funds are also involved, either in providing finance and other support to private investors or in making investments directly. In host countries, it is largely governments who are engaged in negotiating investment deals. Current investments differ from the historical pattern of FDI for agriculture in several key respects: they are resource-seeking (land and water) rather than market-seeking; they emphasize production of basic foods, including for animal feed, for repatriation rather than tropical crops for commercial export; and they involve acquisition of land and actual production rather than looser forms of joint venture.

Policy and governance

For FDI to impact on rural growth and poverty reduction, it is essential for countries to have policy frameworks in place that allow them to attract more and better

investment in their agriculture sectors. Sustainable growth in agriculture relies on a wide set of macroeconomic, commercial, social and environmental policies that go well beyond traditional agricultural policies. Instruments such as the OECD *Policy Framework for Investment in Agriculture* provide guidance in investment policy design, investment promotion and facilitation, human resource and skills development, trade policy, environment, responsible business conduct, infrastructure development, financial sector development and taxation. The *Principles for Responsible Agricultural Investment that Respects Rights, Livelihoods and Resources* initiative, involving FAO, IFAD, the World Bank Group and UNCTAD, is another important instrument designed to enhance the positive potential of FDI by avoiding negative effects in recipient countries. The *Voluntary Guidelines on Responsible Governance of Tenure of Land and other Natural Resources* (discussed in Chapter 4) will set out principles and internationally accepted standards for responsible practices, providing a framework for states to develop their own strategies, policies, legislation and programmes that will allow government authorities, the private sector, civil society and citizens to judge whether their proposed actions and the actions of others constitute acceptable practices.

Significantly more resources are required to prevent a further deterioration of the food and nutrition situation in poor and food-insecure countries where coping capacities are challenged. A sustained global partnership is needed, bringing together governments, multilateral institutions, private sector, civil society and NGO actors to mobilize domestic and external resources and significant increases in development financing for food and nutrition assistance, safety nets, and agricultural investments, in particular for smallholder farmers. The CFS is building capacity to fulfil this latter role.

Quantifying investment needs

It is estimated that, in 2007, the level of investment in agriculture was US$189 billion, of which two-thirds (US$142 billion) was private investment. As shown in Figure 23, most investment in agriculture in developing countries, both public and private, is actually funded from domestic sources.

An estimated annual investment of US$279 billion, including US$204 billion in private investment, will be required to meet food demand in 2050. If ODA and FDI increase in proportion to the required amount of private investment, then ODA to agriculture would need to increase to US$12 billion per year and FDI in developing country agriculture would increase to US$4 billion per year. To reduce hunger by half by 2015 and eliminate hunger completely by 2025, FAO estimates that total public investment in developing country agriculture would need to increase to US$120 billion per year. If ODA to agriculture continued to increase in proportion to domestic government expenditures, it would rise to US$20 billion per year. Alternatively, if ODA increased to 0.7 percent of donor countries' GDP, as previously committed, and if agriculture's share of ODA increased to 17 percent, as seen in the early 1980s, ODA to agriculture would rise to US$44 billion per year. However, despite the mounting evidence of food insecurity catalysing civil unrest,

there is scant evidence that ODA will rise sufficiently to meet this challenge. It remains a major challenge for FAO to provide the evidence base and best practice examples that will stimulate the political will to meet these critical ODA targets and the means for its supporting strong sector growth.

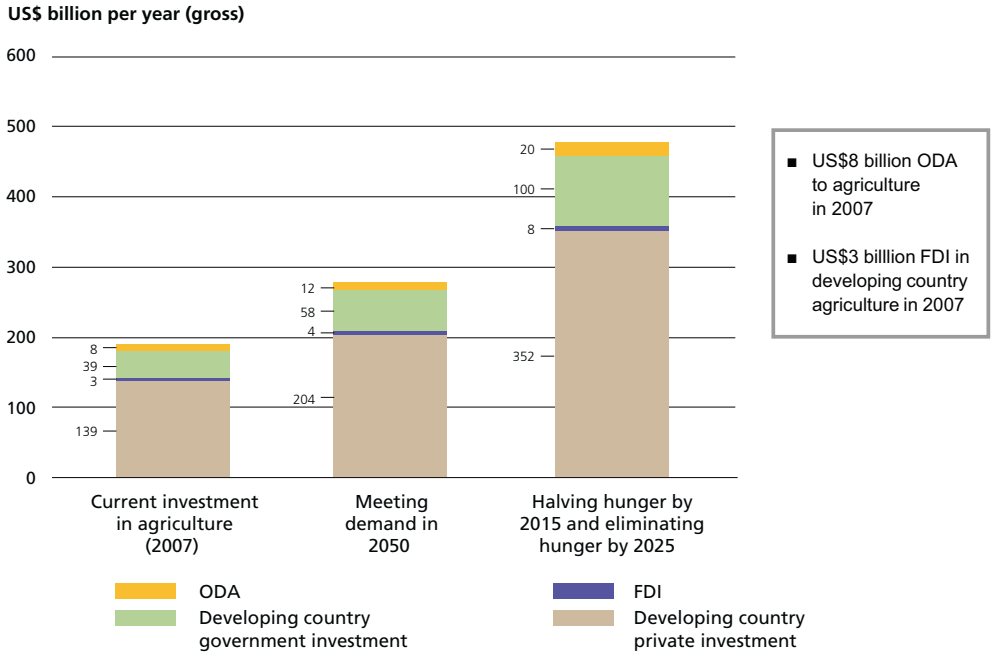
Mobilizing resources and creating a benign investment environment

In 2011, FAO is implementing about 1 500 emergency and technical cooperation projects, with an overall delivery of US$891 million in 2010. A small percentage of these projects are funded from assessed contributions through FAO's Technical Cooperation Programme (TCP) and Special Programme for Food Security (SPFS). The remainder is funded from voluntary contributions. Currently, more than 150 unilateral, bilateral and multilateral resource partners contribute voluntary financing to FAO's programmes.

FAO has faced enormous challenges in recent years in adapting its funding mechanisms to highlight a demanding investment environment, in which mobilization of development resources has become increasingly competitive and where the focus of funding is on infrastructure buildup rather than on the agriculture and

FIGURE 23

Sources of investment in developing country agriculture, including estimated requirements



Note: Estimated increases calculated in proportion to the required amount of private investment to meet food demand.

Source: FAO (preliminary estimates).

rural sectors as such. The situation has been compounded recently by the scarcity of resources resulting from the global economic crisis.

While FAO has been an important participant in the development and implementation of a significant proportion of ODA investment in agriculture worldwide, those investments fall well short of what is required to build a sustainable agricultural economy in the developing world in order to assure global food security and nutrition in 2050. More voluntary funding is critical. Private investment, particularly from domestic sources, will be the primary driver of agricultural growth in the coming decades, and rising public investment – primarily from developing country governments – will be an absolutely essential "pump primer" for expanded private investment. Unless the targeted levels of investment – government, ODA, domestic private and FDI – for ensuring food security are realized in the near future, the prospect of a food-secure world will remain elusive.

To mobilize the necessary resources and ensure an appropriate investment environment, FAO will continue to work closely with national governments, developing capacity for effective policy reform, strategy development and investment planning and implementation. There is ample evidence that sufficient food availability, access, utilization and stability can result in the establishment of an environment in which private-sector investment can thrive in a transparent, accountable and regulated marketplace, backstopped by sufficient and efficient public investment in rural infrastructure, research and development.

Technology development, transfer and opportunities

The development and exchange of appropriate technologies are essential for achieving global food security in the face of the challenges discussed in this book. Furthermore, as consumers place greater emphasis also on the quality and safety of food and the sustainable use of resources in its production and distribution, technologies and systems are all the more important for ensuring adequate controls along the food chain.

Substantial organizational and institutional changes have been taking place in the agriculture sector of most developing countries. Increasing concentration is taking place at all levels, particularly in the retail and processing sectors. Agribusiness enterprises are becoming larger as firms seek economies of scale in food manufacturing, marketing and distribution. Food is increasingly being retailed through formal outlets such as supermarkets rather than through local markets.

While these trends have opened a diverse range of market opportunities within the developing countries themselves and in export destinations, tapping into these opportunities is contingent on meeting very stringent requirements. This poses a major challenge for small-scale farmers, traders, processors, wholesale markets and retailers, many of whom risk being excluded from the benefits of these opportunities if they do not have knowledge of and access to the required technologies.

PHOTO 12
Finished products must meet consumer needs as well as food safety and quality requirements.

Technologies for food security and safety

Technologies used to obtain farm inputs, such as seeds or fingerlings, and to undertake farm operations have a significant impact on the quality of the raw materials that enter into processing and other operations carried out further downstream in the value chain. They also affect the attributes of the final product that reaches the consumer's table. Such technologies include those applied in breeding and feed manufacturing, field equipment that respects environmental sustainability, machinery and farm power for production, and weed, pest and disease control systems.

Technologies for ensuring that processing operations yield finished products that meet consumer needs as well as food safety and quality requirements are an essential aspect of agriculture today. These include: technologies for converting commodities into differentiated finished products that have an enhanced value and meet quality requirements; biotechnologies and other technologies for obtaining specific ingredients and food components such as antioxidants, flavours and functional ingredients; preservation techniques such as pasteurization and drying, which prolong shelf-life and reduce the risk of contamination; packaging technologies to prolong the shelf-life of products while enhancing quality or safety and convenience in culinary use; and technologies for branding, labelling and certification in order to differentiate products, ensuring traceability and compliance with standards and quality requirements.

Well-coordinated logistical arrangements are required along the production-to-distribution chain to meet the requirements of the new market place. This involves cost-effective systems for handling raw materials and intermediate and finished products, as well as ICT systems that provide information on product flows, quality characteristics of products and financial transactions at all stages of the chain. Cold-chain logistics systems, which accommodate perishable products such as meat and horticultural produce and provide needed support along the increasingly elongated distribution chain, have also become more important. The

same is true for traceability systems, which make it possible to follow the progress of products through all stages of production, processing and distribution, facilitating logistics and providing assurances to the consumer of the safety and origin of such products.

Promoting value-adding technologies

The application of science and technology to improve living standards in developing countries has been a primary goal of FAO since its foundation. FAO provides a broad range of technological options for adding value to agricultural raw materials, starting with assessments of the diverse levels of skill, infrastructure and production in member countries, and leading on to technology proposals that are appro-

BOX **18**

On the ground – reducing post-harvest losses in Afghanistan

In the northern region of Afghanistan where more than half the country's cereals are produced, many farmers traditionally store their crops in plastic and fibre bags or in farm buildings that do not have proper flooring, doors or windows, resulting in significant post-harvest losses. In seeking support from FAO, the Afghan Government requested silos for communities and farming households for grain storage. From 2004 to 2006, with funds provided by the Federal Republic of Germany, FAO implemented a project to reduce post-harvest losses by improving household and community storage facilities in seven grain-producing provinces, while at the same time improving the technical capacity of local artisans to construct metallic grain silos.

Technical personnel from the Ministry of Agriculture and NGOs trained 300 local artisans in the manufacture of silos and issued contracts to more than 100 tinsmiths to build metal silos ranging from 250 to 1 800 kg capacity for distribution in local communities. The project also supervised the construction of grain warehouses for community use at 12 sites and trained beneficiaries on how best to operate and manage them.

As a result of using the metal silos to protect their grains from insect, rodent or mould attacks, farmers' incomes increased when their crop losses dropped from 15–20 percent to less than 1–2 percent. In addition, participants could store their grain for longer in the silos, which meant they could wait to sell the stored grain when market prices were higher. The artisans involved went on to set up profitable silo-fabricating micro-enterprises on the strength of the training received from the project.

Source: FAO, 2007b.

priate to the circumstances of the end-user. Scalability, cost-effectiveness, energy requirements and environmental impacts are taken into consideration in all cases.

FAO has found that the efficient transfer and adaptation of small-scale processing technologies tends to be limited by the capacities of the users, who often lack the basic scientific knowledge of the processes and inputs involved and of the processes required for their correct implementation. Basic infrastructure, such as suitably equipped laboratories with consistent working conditions, a constant supply of good quality water and reliable power supplies, are critical elements for the transfer and adaptation of these technologies. It is therefore essential to build institutional capacity for research and development geared towards a better understanding of relevant technologies. Governments need to formulate supportive national policies that promote small-scale agro-industrial development.

In supporting the transfer of small-scale food processing technologies to developing countries, FAO primarily focuses on developing capacity through field projects and training programmes designed to upgrade technical, marketing and management skills. It also advises governments in the formulation of national programmes and policies that support small-scale technologies and fosters technical cooperation among countries.

Value chain approaches

With the transition to market-driven systems and greater reliance on the private sector, interventions to upgrade value-adding processes and strengthen the capacity of various actors to meet market requirements are planned in the context of value chains. This means using systemic rather than disjointed single-point interventions to improve the efficiency of the chain as a whole. It also means recognizing the central role of the private sector and developing strategies that provide economic incentives to all actors in the chain. Some of the key elements of the value chain programmes being implemented by FAO include:

- strengthening and supporting the development of associations, producer organizations and cooperatives that can achieve economies of scale in buying inputs and selling products for their members;
- fostering public- and private-sector cooperation in order to encourage private-sector technology development and transfer, as well as to enhance the effectiveness of private-sector compliance with regulatory frameworks;
- building the capacity of chain partners and reinforcing business services available to them so that they can understand and meet the quality, safety and other requirements of their customers.

FAO's approach also includes strengthening the policies, institutions and support services that create an enabling environment for private enterprises related to food safety regulation; establishing and enforcing grades and standards; supporting product, technology and process innovation; fostering public-private sector cooperation; and attracting FDI as a way of improving access to new technologies.

Environmentally friendly technology

There is increasing pressure to develop technological systems that serve agricultural producers, processors and consumers as well as the environment. Yet rising energy costs, the highly energy-intensive processes needed to obtain products required by consumers, the high level of perishability of agricultural products and the longer distribution chains required to deliver them pose an immense challenge in important areas such as decreasing the carbon footprint used along the production-to-consumption continuum.

Major public and private investments are required for research, development and transfer of technologies for producing the products required by consumers throughout the world. Today's research and extension systems focus mostly on issues related to production systems, for example breeding and agronomy. However research and extension activities should also pay attention to the post-production sections of value chains. At the policy level, attention is also required to develop the institutional framework to support transfer of technologies to the private sector.

Conclusion

As the world has globalized, so have the world's agrifood systems. As a result, national agriculture sectors as well as agro-business must now keep up with and adapt to market liberalization, growth of international trade, increased international financial transactions and capital flows, and advances in information and communication technologies. These developments have highlighted differences between developed and developing countries, as illustrated by the failure of world trade negotiations to agree on agricultural products and markets over the past decades. Developing countries have also been targeted by foreign business interests wishing to purchase or lease large tracts of their land, either for future biofuel production or as a way of "outsourcing" their country's food production.

FAO recognizes the importance of agricultural trade for poverty reduction and food security and supports member countries in issues ranging from trade negotiations to developing land tenure governance guidelines for dealing with potential land sales. The Organization is also increasingly partnering with the private sector, working with agribusinesses as well as their associations and business leaders on a wide range of issues, including value chain and subsectoral development projects and standard-setting activities.

With the increasing pressure on agriculture to produce food, feed and fibre for a growing and changing population while preserving the world's natural resources and mitigating climate change, investments in developing country agriculture are an absolute priority for governments, the development community and private investors. Investments in agriculture, however, have been declining for several years. Moreover, in their efforts to mobilize resources for agricultural development and

create an investment environment conducive to agricultural productivity and food security, FAO and its member countries are facing an extremely competitive and stringent financial resources market, calling for new and innovative approaches.