

# Agriculture's performance, diversity, and uncertainties

## chapter 2

A big question at the time of the last *World Development Report* on agriculture, in 1982, was whether agriculture would be able to provide enough food for the world's growing population. Twenty-five years later it is clear that world agriculture has met the global demand for food and fiber. Increasing per capita production, rising productivity, and declining commodity prices all attest to this success. But adequate global supplies do not mean that countries or households have enough food—purchasing power matters more than availability (see focus C). And the future world supply of food may be uncertain: increasing resource scarcity, heightened risks from climate change, higher energy prices, demand for biofuels, and doubts about the speed of technical progress all have implications for future agricultural performance.

In addition, improved agricultural performance has not been uniform throughout the world. Improvements have yet to stimulate enough growth in agriculture-based countries, especially in Sub-Saharan Africa, to allow them to achieve a sustained structural transformation (chapter 1). Environmental costs have often been high, compromising the sustainability of future production and affecting natural ecosystems and human health.

Poor agricultural performance in some areas relates to difficult agroclimatic conditions or low investments in infrastructure that constrain market access. The agricultural challenge in these less-favored areas is to sustainably intensify production in diverse farming systems, while improving infrastructure and markets.

In the high-potential areas that have led the global increase in food production, especially the transforming countries of Asia, the challenge is different: sustaining

productivity and income growth in the face of declining prices for grains and traditional tropical exports. Rising demand for high-value horticulture and livestock in these rapidly growing economies offers farmers opportunities to diversify into new markets.

This chapter highlights emerging trends, opportunities, and constraints that will drive future agricultural performance in response to four challenges: the potential for a productivity revolution in Sub-Saharan Africa, options for less-favored areas, diversification in favored areas, and global uncertainties. The considerable diversity of agricultural production conditions underlines the complexity of these challenges.

### **Productivity growth in developing countries drove agriculture's global success**

Agriculture's performance has been impressive. From 1980 to 2004, the gross domestic product (GDP) of agriculture expanded globally by an average of 2.0 percent a year, more than the population growth of 1.6 percent a year. This growth, driven by increasing productivity, pushed down the real price of grains in world markets by about 1.8 percent a year over the same period.

### ***Developing countries have led agricultural growth***

Developing countries achieved much faster agricultural growth (2.6 percent a year) than industrial countries (0.9 percent a year) in 1980–2004. Indeed, developing countries accounted for an impressive 79 percent of overall agricultural growth during this period. Their share of world agricultural GDP rose from 56 percent in 1980 to 65 percent in 2004. By contrast, they

accounted for only 21 percent of nonagricultural GDP in 2004.<sup>1</sup>

The transforming economies in Asia accounted for two-thirds of the developing world's agricultural growth.<sup>2</sup> The major contributor to growth in Asia and the developing world in general was productivity gains rather than expansion of land devoted to agriculture. Cereal yields in East Asia rose by an impressive 2.8 percent a year in 1961–2004, much more than the 1.8 percent growth in industrial countries (figure 2.1). Due to rising productivity, prices have been declining for cereals—especially for rice, the developing world's major food staple—and for traditional developing-world export products, such as cotton and coffee.

### *Better technology and better policy have been major sources of growth*

Since the 1960s, rising cereal yields have been driven by widespread use of irrigation, improved crop varieties, and fertilizer (figure 2.2). Although crop improvements have extended well beyond the irrigated areas to embrace huge areas of rainfed agriculture, Sub-Saharan Africa has not participated in this agricultural success.

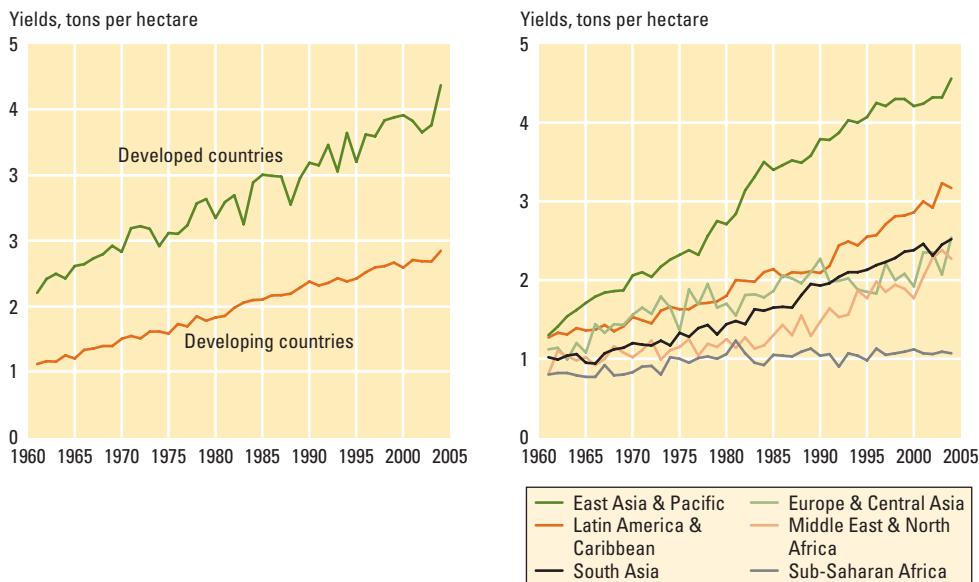
For millennia Asian agriculture has been intensified through irrigation, which

continued to expand through the 1990s and into the 2000s. Today 39 percent of the crop area in South Asia is irrigated, 29 percent in East Asia and the Pacific, but only 4 percent in Sub-Saharan Africa.

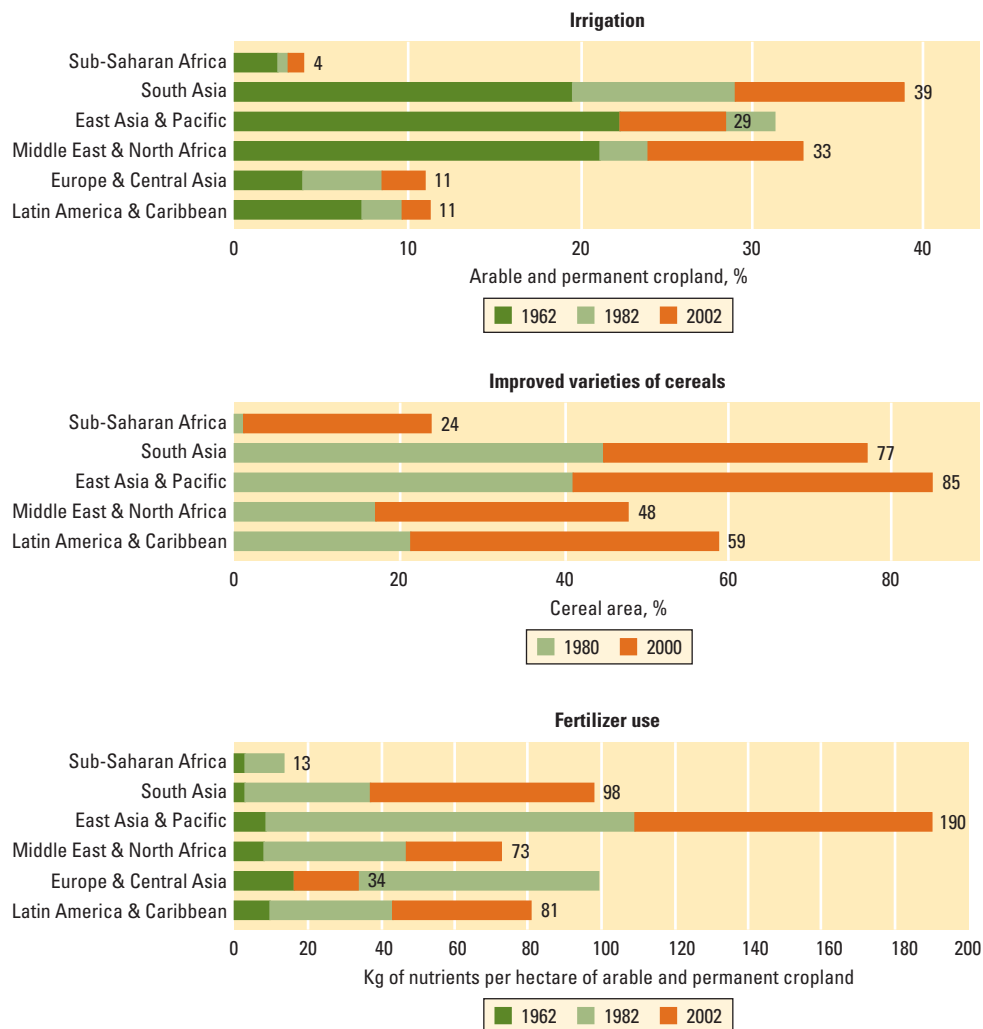
Modern crop varieties of cereals began to be widely adopted in the 1960s. The area devoted to improved varieties has continued to expand, and by 2000 they were sown on about 80 percent of the cereal area in South and East Asia, up from less than 10 percent in 1970. After a late start, Sub-Saharan Africa is also expanding the use of improved cereal varieties, which covered 22 percent of the cereal area there in 2000.<sup>3</sup>

Chemical fertilizer use has also expanded significantly in most of the developing world, except Sub-Saharan Africa. The developing-country share of global fertilizer use has risen from about 10 percent in the 1960s to more than 60 percent today. Asian farmers are the major users, with use up sharply from an annual average of 6 kilograms per hectare in 1961–63 to 143 kilograms per hectare in 2000–02,<sup>4</sup> more than in developed countries. Higher fertilizer use accounted for at least 20 percent of the growth in developing-country agriculture (excluding dryland agriculture) over the past three decades.<sup>5</sup>

**Figure 2.1 Cereal yields rose, except in Sub-Saharan Africa**



**Figure 2.2 Modern inputs have expanded rapidly but have lagged in Sub-Saharan Africa**



Sources: Evenson and Gollin 2003; FAO 2006a.

Livestock expansion has also contributed to the high agricultural growth rates. Livestock is one of the fastest growing sub-sectors in developing countries, where it already accounts for a third of agricultural GDP.<sup>6</sup> Production of meat has doubled over the last 15 years, led by a 7 percent annual increase in poultry production.

The combination of these breakthroughs produced steady growth in total factor productivity (TFP), especially in Asia at 1–2 percent a year.<sup>7</sup> TFP growth was responsible for half of output growth after 1960 in China and India, and 30–40 percent of the increased output in Indonesia and Thailand, greatly reducing pressure on increasingly scarce land.<sup>8</sup> Investments in science,

roads, and human capital from the 1960s, combined with better policies and institutions, were the major drivers that made the agricultural productivity gains possible.<sup>9</sup>

Decompositions of productivity gains consistently point to investment in research and development (R&D) as major sources of growth.<sup>10</sup> Hybrid rice alone is estimated to have contributed half of the rice yield gains in China from 1975 to 1990.<sup>11</sup> Improved varieties contributed 53 percent of total factor productivity gains in the Pakistan Punjab from 1971 to 1994. Even in Sub-Saharan Africa, the impact of R&D has been identified as important in its (limited) productivity growth.<sup>12</sup> Infrastructure, especially roads, has also been

an important factor in agricultural growth in Asia. In India, investments in rural roads contributed about 25 percent of the growth in agricultural output in the 1970s, with high payoffs.<sup>13</sup> Investments in human capital—improved education, health, and nutrition—have repeatedly been shown to increase aggregate productivity.<sup>14</sup> One study for Sub-Saharan Africa found a significant positive impact of calorie availability on agricultural productivity, providing evidence of the interdependence of malnutrition, hunger, and agricultural growth.<sup>15</sup>

Policy and institutional changes are also likely to have been major sources of productivity growth, although few studies have explicitly quantified the impacts. One such study is the well-documented impact of the household responsibility system in China, in which institutional and policy reform was the dominant factor promoting agricultural growth and reducing rural poverty during 1978–84.<sup>16</sup>

Despite this progress, long-term productivity growth could have been higher and ecosystem and health costs reduced if the environmental costs of modern technology had been avoided. As much as a third of the productivity gains from technical progress in China and Pakistan have been negated by soil and water degradation, and this does not include the offsite pollution costs.<sup>17</sup>

### Growth across regions and countries has been uneven

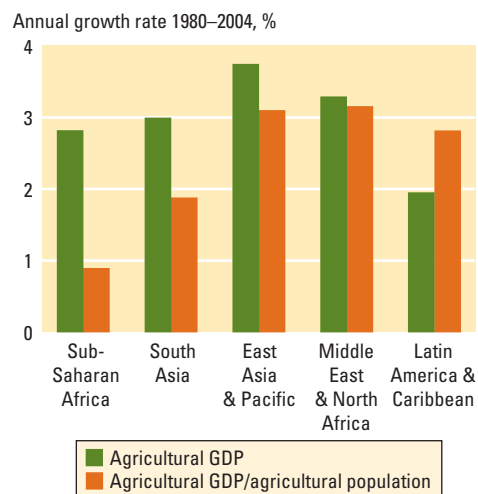
The progress in agricultural growth in developing countries has been dominated by the significant gains in Asia, especially in China. Growth in Sub-Saharan Africa has averaged nearly 3 percent over the past 25 years, close to the average for all developing countries. But the growth per capita of agricultural population in Sub-Saharan Africa (a crude measure of agricultural income) has been only 0.9 percent, less than half that in any other region and well below the star performer, East Asia and the Pacific, at 3.1 percent. Latin America had lower agricultural growth than Sub-Saharan Africa, but with Latin America's declining agricultural population, the growth per capita of agricultural population has averaged a healthy 2.8 percent a year (figure 2.3).

In most cases, countries with high growth rates of agricultural value added per capita of agricultural population—such as China (3.5 percent annual growth rate), Malaysia (3.1 percent), and Vietnam (2.4 percent)—were also good performers in rural poverty reduction (see focus A). But Brazil (5.3 percent annual growth rate) and Pakistan (2.4 percent) have been less successful in reducing poverty, mainly because of the highly unequal ownership of and access to productive assets such as land and irrigation water.<sup>18</sup>

The distinguishing feature of Sub-Saharan growth is the high variability among countries and over time. Over the past 25 years, only Nigeria, Mozambique, Sudan, and South Africa maintained agricultural growth rates per capita of agricultural population above 2 percent a year, while seven countries had rates below 1 percent a year and another six countries had negative per capita growth. Many countries had significant periods of negative growth associated with conflicts or economic crises.

The growth rate of agricultural GDP per capita of agricultural population for the region was close to zero during the early 1970s and negative through the 1980s and early 1990s. But with positive growth rates in the last 10 years, this trend has been reversed, suggesting that the stagnation in

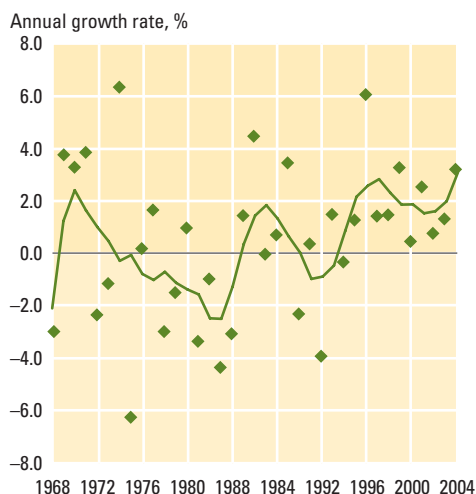
**Figure 2.3** Growth in agricultural GDP per agricultural population is lowest in Sub-Saharan Africa



Sources: FAO 2006a; World Bank 2006y.

**Figure 2.4 Stagnation in Sub-Saharan African agriculture may be over**

(Growth in agricultural GDP per capita of agricultural population in Sub-Saharan Africa)



Sources: FAO 2006a; World Bank 2006y.

Note: Line is for data smoothed by locally weighted regressions.

Sub-Saharan African agriculture may be over (figure 2.4). Improvements in agricultural performance coincide with better macroeconomic policies and higher commodity prices (chapter 1). But food production is still lagging (box 2.1).

Another characteristic of Sub-Saharan Africa is the generally poor yields of food staples, even in the most recent period. The green revolution breakthrough in cereal yields that jump-started Asia's agricultural and overall economic growth in the 1960s and 1970s has not reached Sub-Saharan Africa, where the adoption of productivity-enhancing inputs has been low (figure 2.2). There are many reasons for this: dependence on rainfed agriculture, diverse food crops, poor infrastructure, policy discrimination against agriculture, and low investment (box 2.1).

### Differences in performance reflect different underlying conditions

The different performances of countries and regions in part reflect the huge diversity of agricultural production systems—their agroclimatic potential, their population density, their infrastructure. Many of these

factors can now be readily quantified and mapped against agricultural areas and populations using geographical information systems.

### Both agroecological conditions and market access matter

Agricultural potential, especially that of rainfed agriculture, is highly sensitive to soil quality, temperature, and rainfall. Two-thirds (1.8 billion) of the developing world's rural population lives in areas with favorable agroecological potential—that is, irrigated areas (42 percent of the rural population) or humid and semihumid rainfed areas with reliable moisture (26 percent of the rural population) (map 2.1 and figure 2.5).<sup>19</sup> But one-third (820 million people) live in less favored rainfed regions, characterized by frequent moisture stress that limits agricultural production (arid and semiarid areas of map 2.1). Although these less-favored areas account for 54 percent of the agricultural area (45 percent of the cropped area), they produce only 30 percent of the total value of agricultural production. Latin America, the Middle East and North Africa, and Sub-Saharan Africa all have fairly high shares of rural population in these moisture-stressed areas.

Performance also relates to access to markets and services. Rural areas by definition are spatially dispersed, which affects the costs of transport, the quality of public services, and the reliance on subsistence production. In developing countries 16 percent of the rural population (439 million people) lives in areas with poor market access, requiring five or more hours to reach a market town of 5,000 or more (map 2.2). About half the agricultural area in these remote regions has good agricultural potential but lacks the infrastructure to integrate into the wider economy. In Sub-Saharan Africa and the Middle East and North Africa, the percentage of rural population with poor market access is much higher, more than 30 percent (figure 2.5). In South Asia, only 5 percent live in remote areas, and 17 percent in East Asia and the Pacific. Poor market access reflects low investments in infrastructure, often due to low population density (box 2.2).

## BOX 2.1 The green revolution in food staples that didn't happen: Sub-Saharan Africa's variegated palette

The expansion of food production has taken quite different courses in Asia and in Sub-Saharan Africa, where increases in food staples were achieved largely by expanding the area cultivated, as shown in the figure below.

**Population density—low?** To some extent the extensification in Sub-Saharan Africa reflects differences with Asia in population density and land availability. The population density of 29 persons per square kilometer in Sub-Saharan Africa is only one-tenth that in South Asia. Yet population densities in many areas of Sub-Saharan Africa have reached levels at which growth through land expansion under rainfed conditions is no longer sustainable. When population density is adjusted for land quality, densities in much of Sub-Saharan Africa are similar to those in Asia. For example, the land-quality-adjusted population density in Kenya is estimated to be higher than that in Bangladesh.<sup>20</sup>

**Infrastructure—undeveloped.** Sub-Saharan Africa is massively disadvantaged in infrastructure, increasing transaction costs and market risks. In part due to low population densities, there are fewer and less-developed

roads in Sub-Saharan Africa than there were in Asia at the time of the green revolution. Sub-Saharan African countries are small, many of them landlocked, and barriers to trade are relatively high because of high transport costs. As already mentioned, Sub-Saharan African investment in irrigation (4 percent of crop area) is also only a fraction of that in Asia (34 percent of crop area).

**Geography and agroecology—diverse.** Other reasons for the differences in agricultural productivity growth include Sub-Saharan Africa's intrinsically different agroecological characteristics. The main green revolution cereals in Asia were wheat and rice, largely irrigated. Sub-Saharan Africa's diverse rainfed agroecologies use a wide range of farming systems and a broad number of staples (from cassava in west and central Africa to millet and sorghum in the Sahel). What does such heterogeneity in crop production and agroecological conditions mean? In Sub-Saharan Africa improved varieties for many different crops will be needed to increase productivity. Outside technologies often are not directly transferable, and Africa-specific technologies will be required to improve the region's agricultural productivity (chapter 7). Yet the trend for R&D spending was stagnant in the 1990s.

**Fertilizer use—low.** Largely because of poorly developed markets, fertilizer use in Sub-Saharan Africa has stagnated at very low levels, one of the main reasons for the region's low agricultural productivity relative to Asia. On average, Sub-Saharan African farmers must sell about twice as much grain as Asian and Latin American farmers to purchase a kilogram of fertilizer, given its high price.<sup>21</sup> Low volumes, high prices, high transport costs, and undeveloped private input markets are major barriers to fertilizer use in Sub-Saharan Africa (chapter 6).

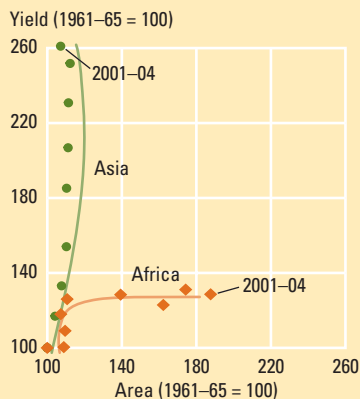
**Soils—degraded.** The combination of shorter fallows, expansion to more fragile land driven by rapid population growth, and a lack of fertilizer use is degrading soils in Sub-Saharan Africa. About 75 percent of the farmland is affected by severe mining of soil nutrients. According to a recent report by the International Fertilizer Development Center, the average rate of soil nutrient extraction is 52

kilograms of nitrogen-phosphorus-potassium per hectare per year, five times the average application of 10 kilograms per hectare of nutrients through chemical fertilizers.<sup>22</sup> Soil nutrient mining is highest in areas of high population density. For example, the estimated annual productivity loss in the Ethiopian highlands from soil degradation is 2–3 percent of agricultural GDP a year.<sup>23</sup> Clearly the decline of soil fertility is a large part of the reason for Sub-Saharan Africa's low yields, so reversing it must be a high priority.

**Policies—historically distorted.** To reduce risks and increase profitability, Asia provided credit, support prices, and input subsidies to farmers. In Sub-Saharan Africa governments also intervened heavily in markets, but agriculture was taxed more than in other regions—and it still is (chapter 4). Although Kenya, Malawi, Zambia, and Zimbabwe initiated maize-based revolutions using hybrid seed and fertilizer, the programs have been difficult to sustain, due to high marketing costs, fiscal drain, and frequent weather shocks. Macroeconomic policies and much lower public investment in agriculture than in Asia have also reduced incentives to private agents and limited supply of public goods such as R&D and roads (chapter 1).

**Turning the corner?** Recent evidence suggests that Sub-Saharan Africa may be turning the corner. There are many local successes in food crop production, such as maize in several West African countries, beans in Eastern Africa, cassava in many countries, market-driven expansion of the use of fertilizer on maize crops in Kenya, and many promising technological innovations in the early stages of adoption (chapter 7). The challenge is how to achieve productivity gains in diverse rainfed systems by coordinating investments in technology with investments in institutions and infrastructure to promote development of input and output markets.

### Expansion of cereal production has followed very different paths in Sub-Saharan Africa and Asia



Source: FAO 2006a.

Note: Each point represents a five-year average, starting with 1961–65 = 100.

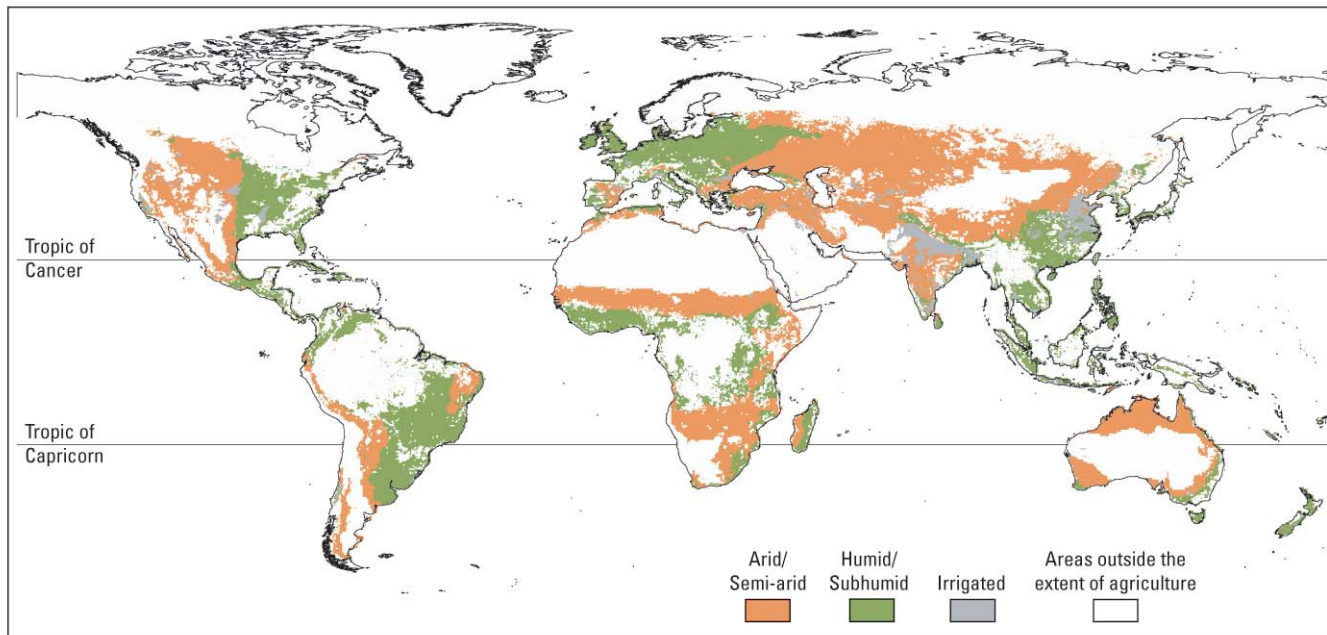
Sources: Borlaug and Dowsell 2007; Cummings 2005; Djurfeldt and others 2006; Harrigan 2003; InterAcademy Council 2004; Johnson, Hazell, and Gulati 2003; Mosley 2002; Sanchez 2002; Spencer 1994.

### Defining less-favored areas

The combination of agroclimatic potential and market access provides a working definition of areas that are favored or less favored for agriculture, at least for market-oriented production. In this *Report*, favored regions

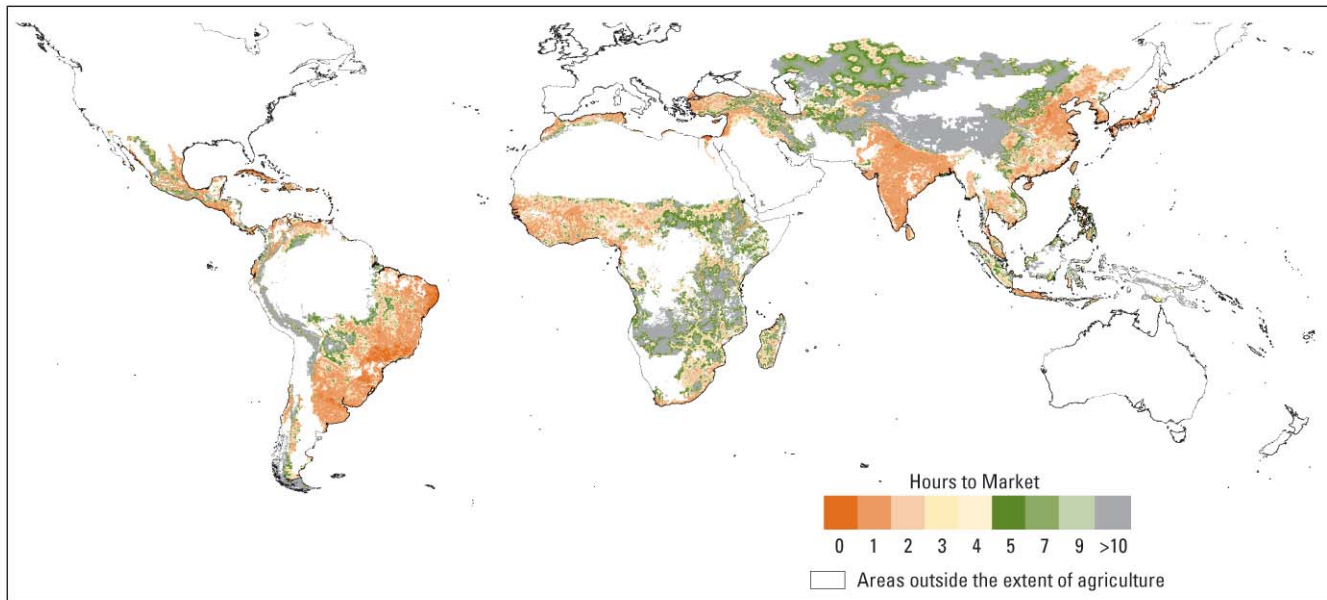
are those that are irrigated or have good rainfall and have medium to high access to markets. Sixty percent of the rural population live in these areas. Less-favored areas are of two types—constrained by poor market access, and limited by rainfall. Almost

**Map 2.1 Agroecological zones in agricultural areas**



Source: Sebastian 2007, based on GAEZ climate data from FAO/IIASA; GMIA irrigated area data from FAO; and cropping and pastureland data from Ramankutty/SAGE.  
 Note: Agricultural areas include those with at least 10 percent irrigated, cultivated, or grazing lands.

**Map 2.2 Market access in agricultural areas of Africa, Asia, and Latin America**

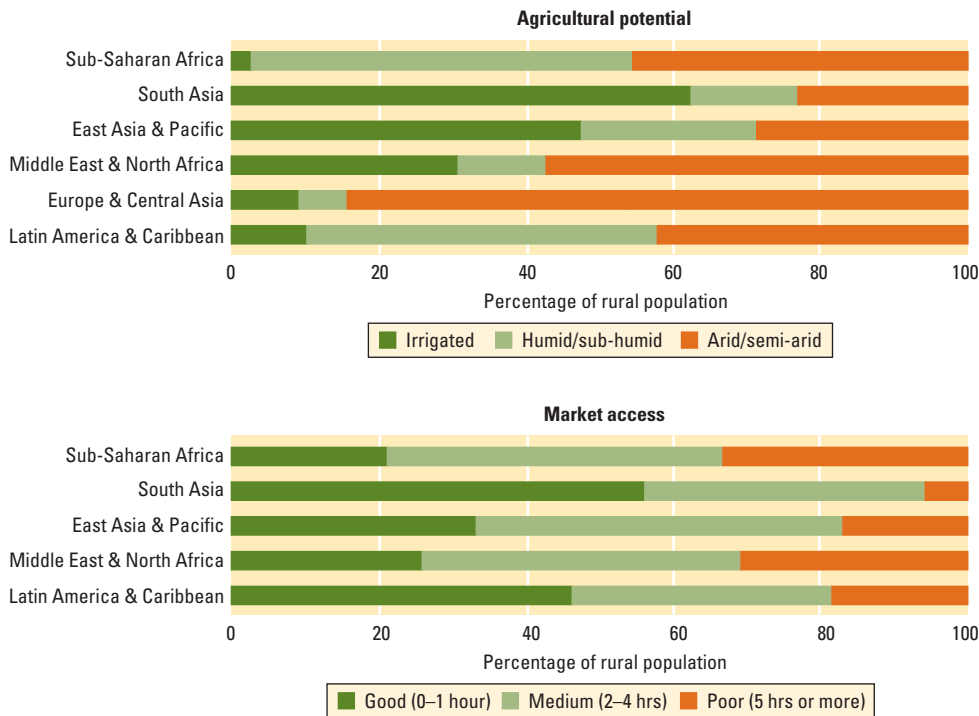


Source: Sebastian 2007, based on market access data from A. Nelson, and extent of agriculture from IFPRI.  
 Note: Agricultural areas include those with at least 10 percent irrigated, cultivated, or grazing lands. Data are not shown for Australia, Canada, Europe, and the United States.

two-thirds of the Sub-Saharan rural population are in less-favored areas with either or both low agricultural potential or poor market access, compared with only 25 percent for South Asia. Of course, many additional elements of less-favored areas should also

be considered, including the fragility of the natural resource base (chapter 8) and social conditions.

These distinctions determine the choice of farming systems and strategies. For example, in Ethiopia a disproportionate

**Figure 2.5** There are big differences across regions in agricultural potential and access to markets

Source: Sebastian 2007.

share of vegetable production is in high-access areas (63 percent of production, but only 38 percent of the rural population), while cereals are concentrated in less-favored areas, whether defined by rainfall or by market access.<sup>24</sup>

These characteristics are not immutable. Investments can convert less-favored areas with low rainfall or poor roads into high-potential areas. The most common is irrigation, which has made some of the world's deserts bloom, transforming agricultural systems and livelihoods. Likewise, investment in transport infrastructure has allowed Brazil's interior states to enter global markets for soybeans and other crops.

For much of Sub-Saharan Africa, poor market access is almost as important a constraint (34 percent of the rural population) as rainfall (45 percent of the rural population). In Ethiopia, 68 percent of the rural population lives in medium- to high-rainfall areas, but farm households are on average 10 kilometers from the nearest road and 18 kilometers from the nearest public transport. The challenge in such contexts

is to sequence cost-effective investments in areas that have low population density and little commercial activity. One option is to focus investments geographically to foster the development of growth poles.

Beyond infrastructure, agricultural investments in new varieties to improve yield stability and in natural resource management can be effective in less-favored areas (chapter 8). Over the long term, investments in human and social capital (education, health, and institutional strengthening) to enhance income diversification and out-migration may be the best option for many areas (chapter 9).

Although the conventional wisdom is that most of the poor are in less-favored regions, overlapping maps of agroclimatic potential and market access with poverty maps indicate that this is not so (see focus A). Although the poverty rate is often highest in more marginal areas, the largest number of poor people live in the more-favored areas. Lagging regions with high poverty rates are even found within countries with rapid economic growth (box 2.3).

### BOX 2.2 Population density and the definitions of “rural”

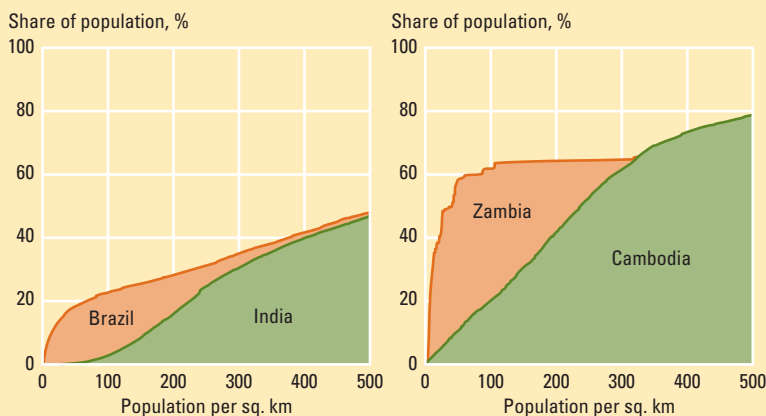
Market access is closely related to population density. Worldwide there is enormous heterogeneity in population densities. In India less than 1 percent of the population live in areas with fewer than 50 people per square kilometer, compared with 20 percent in Brazil and 60 percent in Zambia (see figure below). Zambia’s population distribution is quite uneven, while Cambodia’s is fairly equal.<sup>25</sup> This also means that national definitions of “rural” can have quite different meanings in different countries.

Rural areas can be defined by settlement size, population density, distance to metropolitan areas, administrative division, and importance of the agricultural sector. Brazil uses administrative divisions and reports 19 percent of its population as rural. The Organisation for Economic

Co-operation and Development (OECD) uses population density of 150 people per square kilometer to define rural. Applying this definition to Brazil would increase its rural population to 25 percent. India reports 72 percent of its population as rural, but the OECD definition would reduce that to only 9 percent. Even heavily agricultural areas in India would not be rural under the OECD definition.

Differences in population density and distance to market towns imply very different challenges for infrastructure, service delivery, and rural development. High population density makes it cheaper to provide public goods, such as roads. Low population density increases the cost of such investments but eases constraints of land resources.

#### The distribution of population within a country varies widely



Share below 150 per sq. km:	Share of rural (UN):
Brazil: 25%	Brazil: 19%
India: 9%	India: 72%
Zambia: 65%	Zambia: 65%
Cambodia: 31%	Cambodia: 83%

Sources: Center for International Earth Science Information Network (CIESIN) 2006; data on the share of rural population are from United Nations 2004.

### Opportunities for a new agriculture through diversification

Farmers in areas of good agricultural potential and with access to markets—about 60 percent of the rural population in the developing world—have good opportunities in new markets. By diversifying to higher-value products, they can offset the

decline in prices of cereals and traditional exports.

Changes in consumer diets—brought about by rapid income growth and increasing urbanization—are already driving diversification. Especially in the transforming and urbanized economies, dietary patterns are shifting away from cereals, roots, tubers, and pulses to livestock products, vegetable oils, fruits, and vegetables (figure 2.6). Consumer preferences in industrial countries for specialty products and year-round supplies of fresh produce create global markets for many of them. Horticulture, oilseeds, and livestock are expanding the fastest, with new markets also emerging for feed grains, livestock, and biofuels. Most food products in this new agriculture are perishable, and quality and safety standards are tighter, thus increasing the vertical integration of food systems.

### The horticulture revolution

Fruits and vegetables are one of the fastest growing agricultural markets in developing countries, with production increasing by 3.6 percent a year for fruits and 5.5 percent for vegetables over 1980–2004.<sup>26</sup> During this period, 58 percent of the increase in worldwide horticulture production came from China, 38 percent from all other developing countries, and the remaining 4 percent from developed countries, suggesting that the boom in horticulture is mainly benefiting developing countries. In India, fruits and vegetables were the most important growth sector for crop production in the 1990s.<sup>27</sup>

The horticulture revolution boosts incomes and employment. Relative to cereals, horticulture increases the returns on land about 10-fold. And it generates considerable employment through production (about twice the labor input per hectare of cereals) and more off-farm jobs in processing, packaging, and marketing (chapter 9).<sup>28</sup> Women hold many of these new jobs.

But horticulture also requires producers to adjust. It is management-intensive, with a variety of crops and heavy use of cash inputs and chemicals. It is risky, due to both pest outbreaks and price volatility, and fruit production requires an investment of several years to recoup costs. It can

### BOX 2.3 *Why are there lagging regions in countries with high agricultural growth?*

Even countries with strong overall agricultural growth have lagging regions, where agricultural productivity and household incomes are low. In many cases these regions have lower agricultural potential or poorer market access than other regions in the same country. But lagging areas can also be the result of social processes, with specific territories left aside by public policies or poor governance. The most difficult regions are those that combine poor agroecological endowments, isolation, and social marginalization.

#### **Brazil's northeast: Low agricultural potential next to a breadbasket**

Brazil's agricultural growth of 5.3 percent a year during 1990–2004 was led by agricultural exports from the south and center of the country. Agricultural GDP growth there was impressive—Mato Grosso at 14.8 percent a year, Goiás 6.8 percent, Paraná 6.7 percent, and Mato Grosso do Sul 5.3 percent. But this performance does not reflect the entire country. Alongside a rural Brazil that is a global leader in several agricultural exports is another rural Brazil, with widespread poverty and deprivation affecting millions of people in semisubsistence farming.

The northeast of Brazil has the country's highest rural poverty rates (76 percent) and the largest concentration of rural poor in Latin America.<sup>29</sup> States in the northeast were among the poorest agricultural performers in the country for 1990–2004, some with negative agricultural growth rates (Ceará –4.3 percent a year, Rio Grande do Norte –2.3 percent, and Sergipe –0.5 percent).<sup>30</sup> The northeast's paucity of natural resources and climatic instability (with droughts occurring on average every five years) are accentuated by the fragile equilibrium of its ecosystems and highly unequal

access to land. Nearly two-thirds of its soils are not suitable for farming, a situation only aggravated by centuries of use (particularly for livestock) that degraded soils and limited their capacity to absorb rainfall.

#### **Peruvian Andes: Isolated areas have not participated in rapid agricultural growth**

Recent economic growth in Peru has been driven by the mining and agricultural sectors, with annual growth rates of 7.9 percent and 3.8 percent, respectively, in 1997–2004. Growth in these sectors helps explain why rural areas appear to have done better than urban ones in reducing poverty after the 1998–99 economic crisis. But poverty reduction in rural areas has been unequal across geographic regions.

Rural poverty appears to be most responsive to growth in the coastal regions (elasticity between –0.9 and –1.3), and least responsive in the sierra regions (elasticity between –0.6 and –0.9).<sup>31</sup> This can be explained by the geography of the Andean region, which isolates towns from the rest of the economy. The mountainous terrain increases the costs of road construction. In some areas it is necessary to walk for several hours to get to a market town, health center, or public school. The distance to markets encourages subsistence farming using few purchased inputs, with about 20 percent of agricultural production for personal consumption, labor exchanges characterized by reciprocity, and poor opportunities for non-agricultural income despite the low productivity of the land.

These isolated areas have the highest poverty rates in the country (\$1-a-day poverty rates of more than 65 percent).<sup>32</sup> Even though agricultural income represents more than 75 percent of total income in the Andean areas, these regions did not benefit from recent

agricultural growth, which was largely concentrated in the irrigated coastal regions.

#### **India's Bihar: Meeting the challenges of governance in areas with high agricultural potential**

Well endowed with fertile land and water resources, Bihar has the potential to achieve productivity levels equivalent to the more-developed states of India.<sup>33</sup> But the state's agricultural performance lags seriously behind the country's. Employing 80 percent of Bihar's workforce and generating nearly 40 percent of its GDP, agriculture has performed particularly poorly, declining in the early 1990s by 2 percent a year and growing by less than 1 percent a year since 1995—half the national average.

Bihar's agricultural sector has been plagued by low productivity, slow diversification into higher-value crops, poorly developed rural infrastructure, inadequate investments to expand and maintain surface irrigation systems, small and fragmented farms with widespread illegal land tenancy, little transparency in product marketing, and inadequate public research and extension services. Bihar faces serious challenges to improve growth and strengthen the public administration, service delivery, and investment climate. Government efforts to address the needs of farmers and deliver support services have had little success largely because of an unclear strategy, weak institutional capacity, and little accountability, as well as concerns about security and lawlessness. The cause of these problems: a semifeudal social structure divided by caste. Community involvement and transfers of responsibility in delivering agricultural technology and surface irrigation are enjoying some success.<sup>34</sup>

also inflict considerable harm to the environment: horticulture crops account for 28 percent of global pesticide consumption.<sup>35</sup>

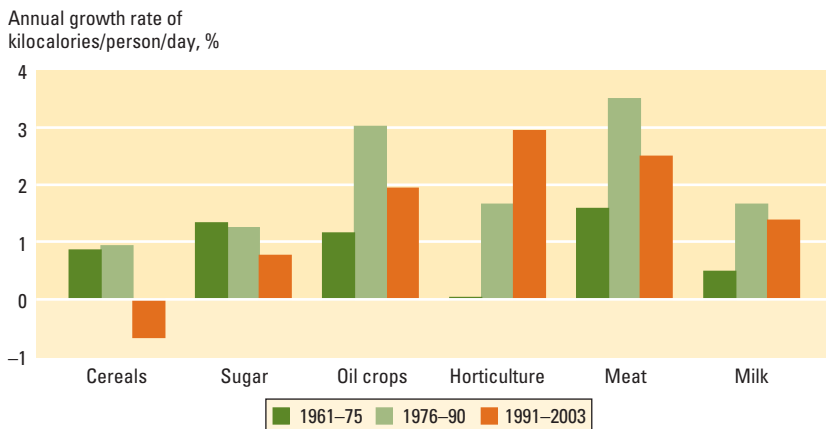
The horticulture revolution, unlike the green revolution, has been driven largely by the private sector and the market. This has implications for the organization of value chains, with specialized agribusinesses and supermarkets increasing their share in these markets, especially in the urbanized countries. Grades and standards make it more difficult for smallholders acting alone to participate in these markets, giving rise to contract farming and collective action by producer organizations (chapter 5).

### *The livestock and aquaculture revolutions*

The livestock and aquaculture revolutions have been most notable in the transforming and urbanized countries of Asia and Latin America, driven by rising demand for poultry, pork, fish, and eggs with increasing incomes. Beef and milk production have also risen steadily in rapidly growing countries. In India the consumption of milk nearly doubled between the early 1980s and late 1990s.<sup>36</sup>

Livestock production is switching from extensive (grazing) to intensive (stall-fed poultry, pigs, and dairy cows), increasing

**Figure 2.6 Per capita food consumption in developing countries is shifting to fruits and vegetables, meat, and oils**



Source: FAO 2006a.

the demand for feed grains, including oilseeds. In developing countries, 28 percent of grain consumption was already used for feed in 2005. But the use of cereals for feed is growing more slowly than the increase in meat production because other feedstuffs, such as oilseed meals and cassava, are substituted for cereal grains, and the share of poultry in total meat production is growing. (Poultry requires only 2–3 kilograms of feed per kilogram of meat, compared with 10 kilograms for beef.)<sup>37</sup>

Aquaculture is the world's fastest growing food-production sector, increasing at an annual average rate of 10 percent since the mid-1980s. Aquaculture now represents more than 30 percent of total food-fish production.<sup>38</sup> More than 90 percent of aquaculture production occurs in developing countries, and China alone accounts for 67 percent of global production. Aquaculture can provide an important source of livelihood for the rural poor, generating income through direct sales of products and employment in fish production and services, especially in processing. In Asia, more than 12 million people are directly employed in aquaculture. In Bangladesh and Vietnam, more than 50 percent of workers in fish depots and processing plants are women, and although salaries are still quite low, they are significantly higher than wages from agricultural activities.

The livestock and aquaculture revolutions are increasing the supply of protein and

providing more diversified diets. But intensive production methods and the growing concentrations of animals near urban and periurban areas of developing countries can increase waste pollution and the incidence of diseases such as tuberculosis and avian flu. The movement of live animals and aquatic products makes the accidental spread of disease more likely. Globalization may further widen the environmental footprint from livestock (box 2.4) and aquaculture, calling for policies to prevent irreversible consequences (chapter 8).

### *Diversifying through export markets*

High-value products also make up a rapidly growing share of international trade in agricultural products. Exports of horticulture, livestock, fish, cut flowers, and organic products now make up 47 percent of all developing-country exports, far more than the 21 percent for traditional tropical products such as coffee, tea, and cotton (figure 2.7). Across a broad range of nontraditional export products, developing countries have been gaining market share—in 2004 they held 43 percent of the world trade in fruit and vegetables (excluding bananas and citrus).

Brazil, Chile, China, and Mexico dominate nontraditional agricultural export markets. But many countries, including some in Sub-Saharan Africa (Kenya, for example), are now gaining shares in selected product markets. The least-developed countries have very limited participation—only Niger is significant, with 2.6 percent of the world's green bean exports by value<sup>39</sup>—but there have been other recent successes, such as cut flowers from Ethiopia. Despite the expansion of nontraditional exports, prices have held up well in real terms. Estimates of the elasticity of export revenues for nontraditional export products indicate there is room for further market expansion.<sup>40</sup>

Even traditional export commodities provide opportunities for entering high-value markets. The markets for premium quality goods such as coffee, organics, and Fair Trade products have grown considerably in the last decade, starting from a low base. The Fair Trade market is most developed in Europe, less so in Japan and the United States. But the market for organic

produce has grown strongly in both Europe (retail sales of \$10.5 billion in 2003) and the United States (\$12 billion).<sup>41</sup> There is considerable scope for expanding exports to these emerging markets (chapter 5).

### Biofuels—a revolution in the making?

Biofuels could be the next revolution. Based on maize, sugar, cassava, oil palm, and other crops, biofuels offer potentially major new markets to agricultural producers. Some countries have been aggressively encouraging biofuel production as oil prices have risen and concerns over energy security and the environment have increased. But current economics, environmental issues, and the prospects of alternative technologies and feedstocks make biofuels' future growth quite uncertain (see focus B).

### Future perspectives: confronting challenges and rising uncertainties

Even if agricultural and food systems have been globally successful over the past four decades, can they meet the likely demand for food over the next 25 or 50 years? Can they accommodate rapid urbanization and changing diets, and will they do this in a sustainable and environmentally friendly way? What are the main uncertainties that might compromise success?

#### A “business as usual” scenario

Projections of global future food supply and demand are always subject to wide margins of error and generally influenced by prevailing market conditions: when prices are fairly high, as they are today, projections tend to be more “pessimistic.”<sup>42</sup> Both the United Nations' Food and Agriculture Organization (FAO) and the International Food Policy Research Institute (IFPRI) have recently released “business as usual” projections to 2025–30 and 2050 that show broadly consistent trends.<sup>43</sup> Such projections are inherently conservative; they assume no major changes in policies (such as trade) or policy responses to market conditions (such as increased investment in R&D induced by higher prices). Projec-

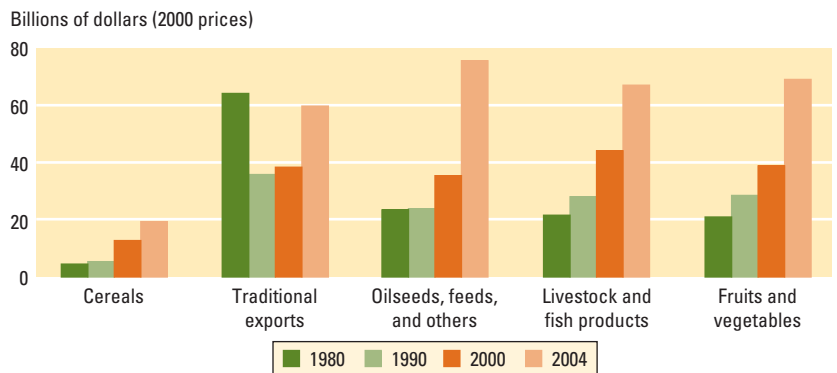
### BOX 2.4 The global environmental footprint of expanding livestock

During the decade 1994–2004, world trade in soybeans doubled. Seventy percent of the global increase in exports went to China, where total meat production rose from 45 million to 74 million tons over the period, generating rapid expansion in demand for feedgrains. Argentina and Brazil responded rapidly to this market opportunity, providing more than two-thirds of the increased global exports of soybeans.

Rapid growth in exports from Argentina and Brazil has been supported by bringing new land under cultivation, often at the expense of forests and woodlands. In the northern Salta region of Argentina, half the area under soybean cultivation in 2002/03 was previously covered by natural vegetation. Much of this area included the highly threatened *Chaco* ecosystem.<sup>44</sup> In Brazil the states of Goiás, Mato Grosso, and Mato Grosso do Sul doubled the

area under soybean cultivation between 1999/2000 and 2004/05 by planting an additional 54,000 square kilometers—an area larger than Costa Rica—much of it displacing ecologically important savanna woodland (*cerrado*) and forest.<sup>45</sup> The mean annual deforestation rate in the Amazon from 2000 to 2005 (22,392 km<sup>2</sup> per year) was 18 percent higher than in the previous five years (19,018 km<sup>2</sup> per year), partly the result of agricultural expansion.<sup>46</sup> Because trees are being burned to create open land in the frontier states of Pará, Mato Grosso, Acre, and Rondônia, Brazil has become one of the world's largest emitters of greenhouse gases. To mitigate the negative ecological impacts, an alliance of private companies, nongovernmental organizations, and the government of Brazil signed a two-year moratorium on buying soybeans from newly deforested land in the Amazon.<sup>47</sup>

Figure 2.7 High value exports are expanding rapidly in developing countries

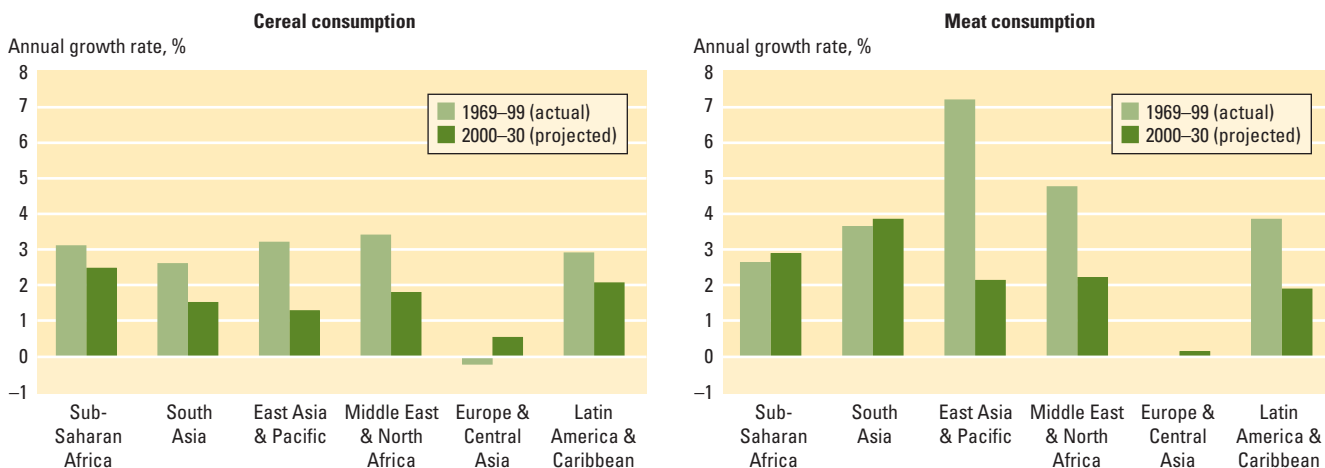


Source: United Nations Commodity Trade Statistics Database (COMTRADE).

Notes: Traditional exports include cocoa, tea, coffee, rubber, tobacco, sugar, cotton, and spices.

tions of the impact of climate change and energy prices are especially difficult given current uncertainties—the IFPRI baseline uses “medium” scenarios for both.<sup>48</sup>

In the IFPRI models, the overall projection is that global food consumption will increase more slowly in the future. Growth in cereal consumption will slow from 1.9 percent annually in 1969 to 1999 to 1.3 percent a year from 2000 to 2030; growth in meat consumption will also slow from 2.9 percent a year to 1.7 percent annually (see figure 2.8).<sup>49</sup> This slowdown reflects

**Figure 2.8 Slower growth in cereal and meat consumption is projected for the next 30 years**

Source: Rosegrant and others 2006b.

a. Includes food, feed, and other uses.

b. No data are available on meat consumption for Europe and Central Asia in 1969-99.

two factors: an overall slowing of population growth to 1 percent a year (nearly all growth is in developing countries), and the medium to high levels of food consumption per capita already attained in some highly populous developing countries (for example, China).

In developing countries overall, per capita consumption of cereals for food will fall slightly; together with continuing trends in the efficiency of converting feed grain to meat, per capita cereal consumption for all uses in developing countries increases by only 0.1 percent a year. Slower demand growth leads to slower growth of cereal production in all regions. Meat consumption also slows sharply, except in South Asia and Sub-Saharan Africa, where meat consumption will increase at a slightly faster rate, but from very low per capita consumption levels.

Despite the slowing growth in consumption, current projections reverse the long-term decline in cereal prices at 1.6 percent a year observed in previous decades. Cereal prices are projected to increase marginally at 0.26 percent a year to 2030 and to accelerate to 0.82 percent a year from 2030 to 2050.<sup>50</sup> The slight upward price trend for cereals is a significant reversal from previous projections—land and water scarcity combined with slower technical progress (discussed below) explain this reversal.

The global projections hide widening supply-demand imbalances in developing countries. Net cereal imports by developing countries of Asia, Africa, and Latin America are projected to increase to 265 million tons in 2030 from 85 million tons in 2000. This reflects continuing high import dependence in the Middle East and North Africa and sharp increases in imports in Asia and Sub-Saharan Africa (figure 2.9).

These trends greatly increase the importance of developing countries in global food markets. The major exporting countries are the developed countries and Brazil and Argentina. Some countries in Europe and Central Asia are projected to become important exporters. Only in Sub-Saharan Africa, with high transport costs and scarce foreign exchange, is the growing import gap a concern for food security. Again, the biggest challenge is in Sub-Saharan Africa, where even in 2030 the average per capita calorie consumption is expected to be around 2,500, less than the 3,000+ in other regions.

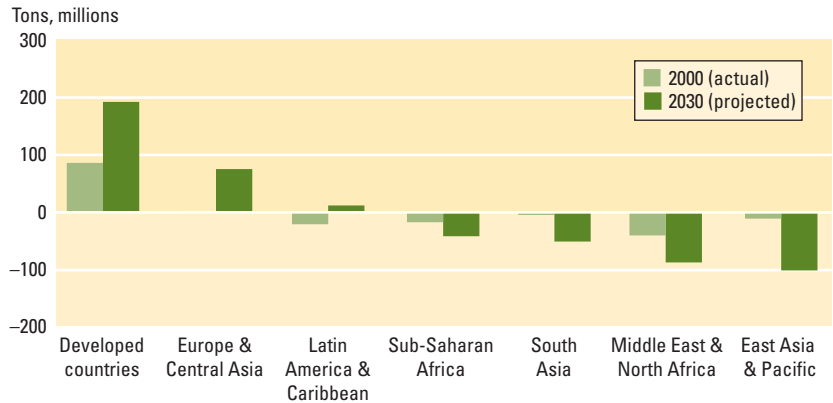
The assumptions underlying these projections show that supply constraints for land, water, and energy; increased climate variability and climate change; and persistent low investment levels in research pose formidable challenges in meeting future food demand. They suggest rising uncertainty and the potential for larger and more frequent shocks to global food prices.

### Looming land constraints

Throughout most of history, agriculture grew by bringing more land under cultivation, driven by population growth and expanding markets. But in the more densely populated parts of the world, the land frontier has closed. In Asia land scarcity has become acute in most countries, and rapid urbanization is reducing the area available for agriculture.<sup>51</sup>

The urbanized countries of Latin America and Europe and Central Asia are relatively land-abundant because of lower population densities and a declining agricultural population (see figure 2.10). In Latin America there is further scope for agricultural land expansion, driven by export markets, but this is often at the expense of cutting subtropical and tropical forests and woodlands.<sup>52</sup> In Sub-Saharan Africa high rural population growth drives expansion into forest or grazing land—creating conflicts with traditional users—or into areas subject to human and animal diseases. Even so, there is considerable room for land expansion in some Sub-Saharan countries, but this will require large investments in infrastructure and human and animal disease control to convert these lands to productive agriculture.

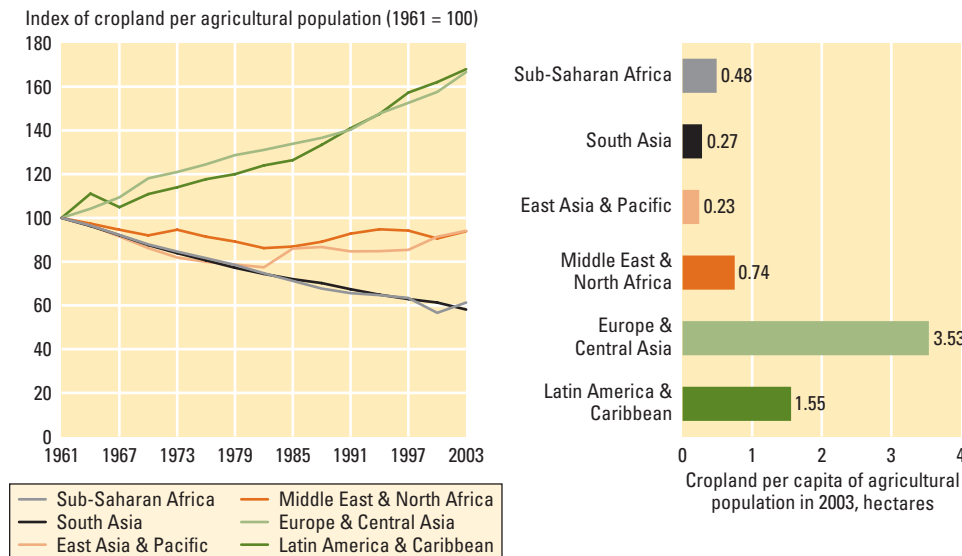
**Figure 2.9** Developing countries will become even bigger markets for cereals exported largely by developed countries



Source: Rosegrant and others 2006b.  
Notes: Negative values indicate net cereal imports, and positive values indicate net cereal exports.

Even land now used for agriculture is threatened. Productivity growth of available land is often undermined by pollution, salinization, and soil degradation from poorly managed intensification, all reducing potential yields (chapter 8). Some sources suggest that globally, 5 to 10 million hectares of agricultural land are being lost annually to severe degradation.<sup>53</sup> Soil degradation through nutrient mining is a huge problem in Sub-Saharan Africa, though much of it is reversible through

**Figure 2.10** Arable and permanent cropland per capita of the agricultural population is falling in Sub-Saharan Africa and South Asia



Source: FAO 2006a.  
Notes: Cropland represents both arable and permanent cropland.

better soil management and fertilizer use (see box 2.1).

### *Acute water scarcity*

Agriculture uses 85 percent of fresh water withdrawals in developing countries, and irrigated agriculture accounts for about 40 percent of the value of agricultural production in the developing world.<sup>54</sup> Without irrigation, the increases in yields and output that have fed the world's growing population and stabilized food production would not have been possible.

Demand for water for both agricultural and nonagricultural uses is rising, and water scarcity is becoming acute in much of the developing world, limiting the future expansion of irrigation. The water available for irrigated agriculture in developing countries is not expected to increase because of competition from rapidly growing industrial sectors and urban populations.<sup>55</sup> New sources of water are expensive to develop, limiting the potential for expansion, and building new dams often imposes high environmental and human resettlement costs.

According to the Comprehensive Assessment of Water Management in Agriculture,<sup>56</sup> approximately 1.2 billion people live in river basins with absolute water scarcity (figure 2.1); 478 million live in basins where scarcity is fast approaching; and a further 1.5 billion suffer from inadequate access to

water because of a lack of infrastructure or the human and financial capital to tap the available resources (chapter 8). The Middle East and North Africa and Asia face the greatest water shortages, although there are pockets of severe water scarcity in all other regions as well.

Large areas of China, South Asia, and the Middle East and North Africa are now maintaining irrigated food production through unsustainable extractions of water from rivers or the ground.<sup>57</sup> The groundwater overdraft rate exceeds 25 percent in China and 56 percent in parts of northwest India.<sup>58</sup> With groundwater use for irrigation expected to continue rising, often driven by subsidized or free electricity, the degradation of groundwater aquifers from overpumping and pollution is certain to become more severe (chapter 8).<sup>59</sup>

Sub-Saharan Africa and Latin America have large untapped water resources for agriculture. But even in Sub-Saharan Africa, almost a quarter of the population live in water-stressed countries, and the share is rising.<sup>60</sup> Even so, there now are many opportunities for economically investing in irrigation in Sub-Saharan Africa (box 2.5), and the irrigated area there is projected to double by 2030.

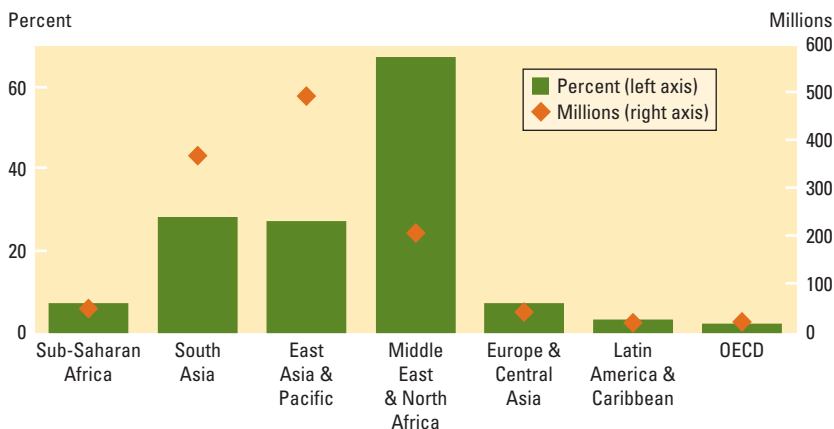
In other regions, the emphasis on water for irrigation has already shifted to increasing the productivity of existing water withdrawals by reforming institutions and removing policy distortions in agriculture and in the water sector (chapter 8). With productivity growth and a modest growth in irrigated area of 0.2 percent annually, irrigated production is projected to account for nearly 40 percent of the increased agricultural production in the developing world by 2030.

### *Uncertain effects of climate change*

Global warming is one of the areas of greatest uncertainty for agriculture. If emissions continue at today's rate, the global average temperature is likely to rise by 2°C–3°C over the next 50 years, with implications for rainfall and the frequency and intensity of extreme weather events.<sup>61</sup> The effects are not evenly distributed. While many regions have already become wetter, parts of the

**Figure 2.11 Water scarcity affects millions of people in Asia and the Middle East and North Africa**

Population living in areas of absolute water scarcity



Source: International Water Management Institute (IWMI) analysis done for the Comprehensive Assessment of Water Management in Agriculture (2007) using the Watersim model.

### BOX 2.5 Substantial potential for expanding irrigation in Sub-Saharan Africa—in the right way

Sub-Saharan Africa has a large untapped potential for irrigation. Only 4 percent of the total cultivated area is under irrigation, with a mere 4 million hectares added in the last 40 years, far less than in any other region.<sup>62</sup> Investment in irrigation projects steadily declined in the 1980s, partly in response to the many failed irrigation investments and partly because

of poorer market opportunities and higher investment costs than in other regions. But with the new generation of better-designed irrigation projects, costs in Sub-Saharan Africa are now comparable to those in other regions, thanks to improvements in institutions, technology, and market opportunities for high-value products (see table below).

These economic returns can be realized only if a significant share of the area is sown with higher-value crops. This underlines the need for complementary investments in roads, extension services, and access to markets. Small-scale irrigation is also showing recent successes, especially in Niger and the Fadama program in Nigeria (chapter 8).

#### Returns on irrigation in Sub-Saharan Africa

	1970–74	1975–79	1980–84	1985–89	1990–94	1995–99
<b>Sub-Saharan Africa</b>						
Number of projects	3	9	11	15	4	3
Cost per hectare (2000 US\$)	4,684	24,496	11,319	7,669	8,287	8,347
Average economic rate of return (%)	10	2	8	16	17	30
<b>Non-Sub-Saharan Africa</b>						
Number of projects	21	66	75	41	49	6
Cost per hectare (2000 US\$)	3,433	4,152	5,174	2,252	3,222	3,506
Average economic rate of return (%)	19	15	15	18	21	17

Sources: African Development Bank and others 2007; Carter and Danert 2007; IFAD 2005a; International Water Management Institute (IWMI) 2005; World Bank 2006t.  
Note: Rates of return on externally financed irrigation projects in Sub-Saharan Africa and the rest of the world (two-thirds of which were in Asia) during 1970–99.

Sahel, the Mediterranean, southern Africa, and parts of southern Asia are becoming drier—and this trend will continue. Water scarcity will increase in many areas, particularly in the already-dry parts of Africa and in areas where glacial melt is an important source of irrigation water.

With moderate warming, crop yields are expected to increase in temperate areas and decline in the tropics. Crop-climate models predict an increase in global crop production in slight to medium warming scenarios of less than 3°C.<sup>63</sup> But the combined effects of higher average temperatures, greater variability of temperature and precipitation, more frequent and intense droughts and floods, and reduced availability of water for irrigation can be devastating for agriculture in many tropical regions (see focus F). One-third of the population at risk of hunger is in Africa, one-quarter in Western Asia, and about one-sixth in Latin America.<sup>64</sup>

The impact of climate change on food prices at the global level is predicted to be small through 2050. Some models predict more substantial effects from climate

change after 2050 with further increases in temperature.<sup>65</sup> But stronger impacts are expected at the regional level. Relative to the scenario of no climate change, agricultural GDP in Sub-Saharan Africa (the region with the highest impact from climate change) could contract by anywhere from 2 to 9 percent.<sup>66</sup>

The major implications of climate change are thus largely for the distribution of agricultural production. In a globalizing world, some of the adaptation can be accommodated by trade, if measures are in place to ensure alternative livelihoods of those most affected. But for much of the tropics, especially areas of Sub-Saharan Africa negatively affected by climate change, trade can only partially fill the gap.

#### High energy prices: pressure on food prices from two sides

Although there is considerable uncertainty about future energy prices,<sup>67</sup> there is little doubt that energy prices will be higher than in the past 20 years and that this will increase agricultural production costs, placing upward pressure on food prices.

On the demand side, the greatest uncertainty is the pace of expansion of biofuels using agricultural feedstocks in response to high energy prices. The magnitude of the expansion of use of feedstocks and its impact on food prices is uncertain. Recent projections indicate real price increases of as much as 40 percent for maize by 2020, with spillover effects on substitute grains (wheat), given rapid growth in biofuels demand.<sup>68</sup> But over the long run, the prices of feedstocks such as maize and sugar cannot rise faster than real energy prices if biofuels are to be competitive, so the impacts are likely to be much lower.<sup>69</sup> Major uncertainties then relate to the price of oil, the technical progress in conversion efficiency of agricultural feedstocks and biomass, and the extent that governments subsidize or mandate biofuel production (see focus B).

On the supply side, much of today's agricultural production is fairly energy intensive, more so in the developed world than in the developing. Estimates by the FAO indicate that 6,000 megajoule (MJ) of fossil energy—equal to 160 liters of oil—are used to produce one ton of maize in the United States. One ton of maize grown in Mexico under traditional methods uses only 180 MJ of energy inputs, equal to 4.8 liters of oil.<sup>70</sup>

Energy is required directly for the operation of machinery and indirectly for fertilizers and other chemicals. Fertilizer prices, for example, are linked to energy prices because natural gas, a primary component in nitrogen fertilizer production, represents 75 to 90 percent of the production costs.<sup>71</sup> In the United States, energy costs accounted for 16 percent of agricultural production costs in 2005, about one-third for fuel and electricity and two-thirds indirectly for energy to produce fertilizer and chemicals.<sup>72</sup> Econometric analyses suggest that U.S. grain prices (which determine world prices) would rise by 18–20 percent of any increase in crude oil prices, not including effects on the demand side through biofuels.<sup>73</sup>

In developing countries, fertilizer costs are a growing share of production costs—18 percent of the variable costs for irri-

gated wheat in the Indian Punjab in 2002, and 34 percent of soybean costs in Mato Grosso, Brazil.<sup>74</sup> Sharply higher fertilizer prices could have far-reaching effects on developing-country agriculture—pushing down fertilizer application rates and crop yields and raising food prices—unless rapid advances are made in tapping nutrient sources that do not depend on fossil fuels, such as biological nitrogen fixation by including legumes in farming systems or biotechnological advances that fix nitrogen in cereals (chapter 7).

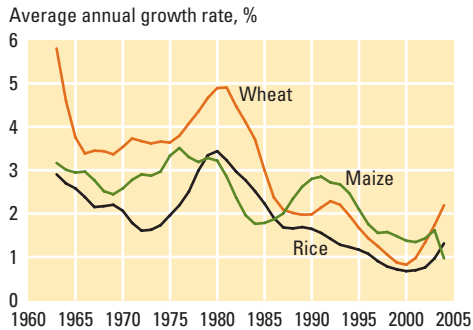
Beyond the farmgate, other energy-dependent food production inputs, such as transport and refrigeration costs, will be affected by higher energy costs. Four percent of U.S. food costs are attributable to transport expenses alone.<sup>75</sup> Long-distance air freight for global food markets may be most affected—aviation fuel represents about 7 percent of the retail price of a basket of high-value products in a U.K. supermarket.<sup>76</sup> These costs are stimulating interest in local food markets in industrial countries to minimize “food miles”; however, there is not always a strong association between the distance that food travels and the combined use of nonrenewable energy in food production and transport.<sup>77</sup>

### *Will science deliver?*

With growing resource scarcity, future food production depends more than ever on increasing crop yields and livestock productivity. But the outlook for technological progress has both positive and negative elements that raise uncertainty. For the major cereals—rice, wheat, and maize—the growth rate of yields in developing countries has slowed sharply since the 1980s (figure 2.12); the easy gains from high use of green-revolution inputs have already been made, except in Africa. Plant breeders continue to increase the yield potential of wheat by about 1 percent annually, but less for the world's major food crop, rice.<sup>78</sup> Slowing of R&D spending in many countries raises concerns about the pace of future gains (chapter 7).

Historically, a significant part of yield gains has been achieved by narrowing the

**Figure 2.12** Growth rates of yields for major cereals are slowing in developing countries



Source: FAO 2006a.

Note: Data smoothed by locally weighted regressions.

gap between average farm yields and the experimental yield potential of the crop, up to a point where average farm yields reach about 80 percent of experimental yields. China's major rice-producing provinces and much of the wheat and maize produced in industrial countries have already reached this point, so the gap is closing.<sup>79</sup> Other rice-producing areas of Asia are well below 80 percent of experimental yields, and their yield growth has slowed because of deteriorating soil and water quality and imbalanced nutrient use.<sup>80</sup>

Exploitable yield gaps are especially high in medium- to high-potential areas of agriculture-based countries. Onfarm demonstrations using available "best bet" technologies suggest a wide yield gap for maize in Sub-Saharan Africa (figure 2.13). But closing the gaps is a matter not just of transferring these technologies to farmers, but of putting in place the institutional structures—especially well-functioning input and output markets, access to finance, and ways to manage risks—that farmers need to adopt the technology (chapters 5 and 6).

The world is poised for another technological revolution in agriculture using the new tools of biotechnology to deliver significant yield gains (chapter 7). Already 100 million hectares of crops, or about 8 percent of the cropped area, are sown with transgenic seeds (often known as genetically modified organisms or GMOs). But there is considerable uncertainty about

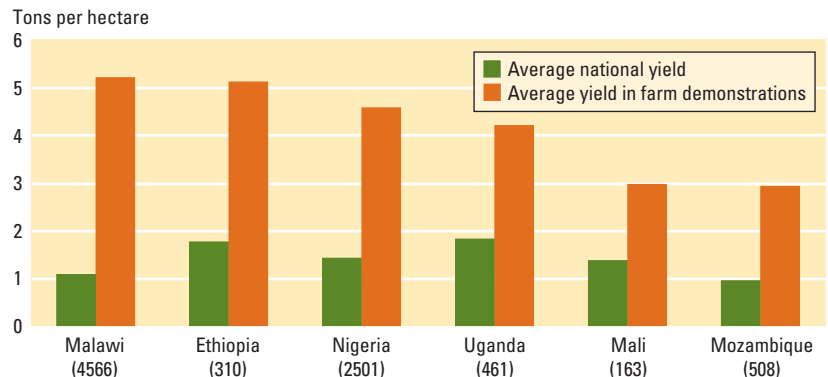
whether this revolution will become a reality for food production in the developing world because of low public investment in these technologies and controversies over their possible risks (see focus E). However, biotechnology applications using genomics and other tools are not controversial, and their declining costs and wider application should ensure continuing yield gains through better resistance to disease and tolerance for drought and other stresses (chapter 7).

### *The bottom line: a more uncertain future?*

Future trends could be accentuated if several adverse outcomes eventuate. High energy prices combined with more biofuels production from food crops could lead to large food crop price increases through effects on both supply and demand. Global warming could occur faster than expected and add to water shortages, hitting irrigated agriculture with lower yields and increasing risk in rainfed agriculture. Rapid income growth in Asian countries with limited land and water resources could lead to a surge in food imports that, combined with higher energy and fertilizer prices, drive up food prices. Or, all three could happen together.

Interdependence also implies likely tradeoffs between poverty, food security, and environmental sustainability. For example, land constraints can be relaxed in many

**Figure 2.13** Exploitable yield gaps are high for maize in Africa



Source: Sasakawa Africa, personal communication.

Notes: Number of plots in parentheses. Open pollinated improved varieties in all cases except Nigeria, which uses hybrids. Data for 2001 for Ethiopia, Mozambique, Nigeria, and Uganda; 2002 for Malawi; and an average of 2001, 2002, and 2004 for Mali.

regions in response to rising prices, but only at significant environmental cost.

Because of these uncertainties, global, national, and local production shocks could become more frequent. Countries will need to increase their capacity to manage shocks through production risk mitigation (better water control or drought-tolerant varieties), trade, and insurance (chapter 5). Countries with rising incomes will be best able to manage these shocks because higher food prices will have less impact on real incomes. The least-developed countries would be hit hardest.

### *A growing divide among regions?*

Differences in agricultural performance among countries are projected to persist and even deepen under a business-as-usual scenario, especially between the agriculture-based countries and the rest. Within Sub-Saharan Africa, continuing rural population growth greater than 1.8 percent a year in some countries adds to already serious pressure on available land.<sup>81</sup> Together with poor agricultural resources and a high dependence on domestic agriculture, the risks of food insecurity in such landlocked countries as Burundi, Ethiopia, and Niger will greatly increase unless massive efforts are mounted to intensify production on existing land.<sup>82</sup> IFPRI projections highlight the close link between agricultural productivity and nutritional outcomes in Sub-Saharan Africa—and the urgency of increased investments to reach the Millennium Development Goal of cutting hunger by half.

### **Conclusion—a continuing production challenge**

Does success over the past three decades in meeting rapidly growing food demands mean that food production is no longer a problem? The review of food and agricultural production trends and challenges in this chapter suggests four reasons why the production problem still belongs on the development agenda.

The first is the lagging performance of agriculture-based countries, especially in Sub-Saharan Africa, relative to population

growth, in a context where food production is important for food security (chapter 1). With limited tradability because of the types of food consumed and high transaction costs, the need for Sub-Saharan Africa to feed itself based largely on its own production remains a stark reality. Poor performance is a source of food insecurity only partially compensated by food imports and food aid.

Faster growth of agricultural production in Sub-Saharan Africa is also essential for overall growth and poverty reduction in the region, as seen in chapter 1. The recent progress in accelerating growth in Sub-Saharan Africa must be sustained in countries already experiencing rapid growth and broadened to (often conflict or post conflict) countries that have not yet participated.

The second reason for a continued focus on agricultural production is the poor agricultural performance across all country types in areas with difficult agroclimatic conditions or inadequate infrastructure that constrains market access. In these regions, livelihoods depend on agricultural production, either as a source of income or for food for home consumption. The challenge is to improve the productivity of subsistence agriculture, diversify to new markets where possible, and open opportunities for nonfarm work and migration as pathways out of poverty (chapter 3).

The third reason is that even high-potential areas that led the global increase in food production (such as the transforming countries of Asia) are facing a triple production challenge. They must sustain productivity and income growth in the face of declining prices in grains and traditional tropical exports, they must seize the opportunity to diversify in high-value horticulture and livestock in response to rapidly growing domestic and international demand, and they must reduce the environmental footprint of intensive crop and livestock systems.

The last reason is more speculative, but still important. Even at the global level, future agricultural success may be compromised by greater resource scarcity, heightened risks from climate change,

higher energy prices, competition for land between food and biofuels, and under-investment in technical progress. For the first time since the world food crisis in the 1970s, global models predict the possibility

of rising food prices. The world food supply requires close monitoring and new investments to speed productivity growth, make production systems more sustainable, and adapt to climate change.