CHAPTER 5

Transforming Institutions on Agricultural Land

The previous chapter focused on people living in remote, low-density settlements on fragile lands, and how, with new institutional improvements, they can better manage their portfolio of assets to increase productivity and sustain critical ecosystems. Chapter 5 is about people living in areas with commercial agricultural potential, either in frontier areas where market-driven agriculture is newly emerging, or in areas closer to larger and increasingly urban markets. These areas will help feed the growing and increasingly higher-income world population. This chapter focuses on the management of and interaction of assets such as land and water and the environment; how to help the poor get better access to land and water; and the importance of asset distribution for the development of good institutions (as described in chapter 3)—especially in near-market areas where intensification can generate considerable equitable growth. Population in rural areas totals 3 billion people, and more than half of them live in areas with commercial agriculture potential (see figure 1.1). Some of these people will migrate to cities, and many will live in areas that will be reclassified as urban when the areas' densities increase. The total number will remain in the range of approximately 1.5 to 2 billion people over the next three to five decades. Despite widespread concern over the past 20 to 30 years about food shortages, the rural developing world has exceeded expectations in food production (box 5.1). Will past trends continue, or is there a real cause for concern? For the world to make a smooth transition to relative population stability 50 years from now, its rural areas will have to meet a range of challenges.

Chapter 5 addresses the key development challenges for rural transformation over the next 30 to 50 years:

- *Eliminate rural poverty and strengthen rural-urban linkages—including preparing outmigrants for a productive urban life.*

As discussed in chapter 4, rural populations are expected to grow in most low-income countries. In much of the world, the combination of subsistence food production and cash earnings in the hands of poor people is not enough to yield an adequate diet. About 820 million people lack access to enough food to lead healthy and productive lives, and about 160 million children are seriously underweight for their age.[1] Some 2 to 2.5 billion rural people will become urban residents between now and 2050. Whether their families have land, water, or education before they urbanize is critical to their future, the future of the cities they move to, and the quality of their societies' institutions.

- *Intensify agricultural production and manage land and water to feed a growing and increasingly urban population.*

Over the next 30 to 50 years, rural areas will have to feed an additional 2 to 3 billion people globally, and substantially improve the diets of the 2.5 to 3 billion people living on less than $2 a day. That will require tilting institutional rules to move assets into the hands of smallholders, halting nutrient mining, reducing soil erosion, and adopting agricultural practices that restore soil fertility. It will also require sharing rural land and water to serve the expanding urban population and meet environmental needs.

Box 5.1

More food, greater intensity of land use, fewer farmers per urban resident

Global food availability has increased. Global food availability per capita is at an all-time high, with variations among countries and regions. Doubling grain production and tripling livestock production since the early 1960s, the world's farmers now provide about 2,700 calories per person a day. India and China, widely considered two decades ago to be Malthusian disasters in the making, satisfy their own demands for cereal. For the developing world rising incomes enabled increased consumption of meat and poultry. And despite growing demand for grain, the prices for maize, rice, and wheat came down 50 percent or more over the past 20 years. Perhaps most important, the proportion of children who suffer from malnutrition fell sharply—from 45 percent in the 1960s to 31 percent in the late 1990s—though not yet sharply enough.

Agriculture has intensified. For most of the world, reduced availability of agricultural land has induced a transition from land-increasing to yield-increasing technology. Africa and South America are the clear exceptions; they both have large remaining areas of unexploited land. However, that land may not be very productive. Although the trend in South America is toward intensification, the extensive margin continues to expand into the Amazon forest. In Africa there are pockets of intensified production, but the larger story is one of new frontiers of crop production opening areas previously devoted to communal grazing of livestock—and of shortening the fallow period under shifting or bush-fallow cultivation. In the more marginal areas these changes have created new problems (as noted in chapter 4).

Many countries have made the transition from rural to urban human settlement, with fewer farmers feeding more city folk. In developing countries in the 1960s, there were three farmers per urban resident—today, there is one and one-half.

Source: Pinstrup-Andersen and others (1999); Rosegrant and others (2001); Crosson and Anderson (2002).

- *Get ahead of the agricultural frontier to control wasteful land conversion.*

The expansion of agricultural land has taken a large toll on the world's repository of biodiversity, with one-fifth of tropical forests cleared since 1960. The remaining biodiversity is concentrated precariously—more than one-third of it now confined to 1.4 percent of the world's land.[2] Some new agricultural land is of high quality and yields important local benefits in agriculture. But much of the newly converted frontier provides little opportunity for the advancement of locals, despite imposing large national and global social costs in GHG emissions and the loss of biodiversity and amenity resources.

This chapter argues that although the rural "sector" has done well in meeting aggregate food needs, it has done less well in meeting the broader needs of the rural population and preparing many for an urban future. It also highlights issues surrounding the conflicts and complementarities between promoting rural development and protecting the environment. For both, good institutional rules are critical. Because of this focus, the chapter covers issues dealing with property rights in land and water, and intellectual property in agricultural knowledge. It does not try to give a complete, or even a balanced, treatment of the problems of rural development. The purpose is to illustrate the importance of thinking more deeply about the institutional rules that govern behavior and support policies, and how they might be improved.[3]

The main message of the chapter is this: Countries should, where still possible, give a high priority to creating egalitarian endowments of land, water, and human capital for its people as they make the transition from rural to urban human settlement. The smooth emergence of land and water institutions is of fundamental importance to a country—because the rules sanctioning property ownership determine the later character of the state and society. Countries that have distributed rural property equitably before urbanizing have developed more egalitarian and democratic societies than those that put assets in the hands of relatively few rural elites. Put another way, countries with rapidly growing populations that have concentrated land in the hands of the few have urbanized prematurely, educated few, and developed extremely inegalitarian societies. Experience and research show that creating widespread land ownership is critical to the later development of inclusive institutions.

Land and water constraints

Food production increases are slowing. Land is becoming increasingly degraded. Scarcities of land and water are more evident. These problems are best addressed by thinking of them not as problems of global resource scarcities but as problems of poverty among plenty.

Global food abundance, yet hungry poor

The prevailing view among agricultural economists is that the world food problem is one of insufficient purchasing power in the hands of poor people, not

of global constraints on aggregate food production—even with an expanded global population. The aggregate data support this view, but some poor regions have too little food. And it is true, as many point out, that annual increases in food production have been falling. But annual increases in demand are falling faster. Evidence at the global level—that the growth of yields (as opposed to production) is slowing—is extremely weak.[4]

What is incontestable is that a slowdown in food demand relative to production—much of it inappropriately subsidized in OECD countries—has depressed food prices to record lows. With an ever-larger portion of the world's people fed well, rising world incomes induce smaller increases in food consumption. Falling rates of population growth are also slowing the growth in food demand.[5] With higher incomes, food consumption patterns do change. But simulations of the world food economy suggest that even a rapid increase in meat consumption in China (underway) and India (less likely) would not significantly alter the balance of world food supply and demand.[6]

In short, food will continue to be abundant at a reasonable price for those people with the income to purchase it. Eliminating hunger tomorrow, however, will require the same solution as eliminating hunger today—raising the productivity and incomes of poor people. And here the world must do better. For the more than 70 percent of the world's poor people who live in the countryside, this means increasing their ability to produce food to consume and food to sell in markets.[7]

Land degradation—also a poverty problem

It is widely reported that erosion, salinization, compaction, and other forms of soil degradation affect 30 percent of the world's irrigated lands, 40 percent of rainfed agricultural lands, and 70 percent of rangelands. The effect of this degradation on overall productivity so far is limited, in part because cultivators bring new lands under cultivation. Cumulative global productivity loss due to land degradation over three decades has been estimated at 12 percent of total production from irrigated land, rainfed cropland, and rangeland. This yields an average annual rate of productivity loss of 0.4 percent.[8]

The underlying degradation estimates have weaknesses, however, because most attempt to estimate losses through time without data on degradation through time.[9] Empirical studies based on actual time-series data on soil samples (taken throughout China and Indonesia over 50 years) find no overall loss of agricultural soil depth or quality for China or Indonesia.[10] Time-series data for 1971–93 from the India and Pakistan Punjabs, by contrast, suggest that intensification of land and water use has resulted in resource degradation that is lowering overall productivity growth. For Pakistan these data indicate that resource degradation has reduced overall productivity growth from technical change, education, and infrastructure investment by one-third.[11]

Studies based on cropping patterns and fertilizer use in Africa indicate that failure to replace the soil nutrients removed through cropping (nutrient mining) is grave, widespread, and poverty induced.[12] All but three countries in Africa show negative balances of nutrients of more than 30 kilograms of nitrogen, phosphorus, and potassium per hectare annually.[13]

African farmers have traditionally practiced bush fallow and shifting cultivation to maintain production, as decreasing soil nutrients begin to affect yields. This practice is becoming unsustainable as rising population density shortens the fallow period, which lowers fertility. So more land is needed in cultivation each year, partly because of higher population and partly to offset the effect of a decline in yields. Poverty-stressed farmers face three choices, with mixed outcomes:

- Expand into forests, permanent pasture, hillsides, or wetlands.
- Continue to intensify labor inputs on existing land.
- Complement labor on existing lands through the use of inorganic and organic fertilizer and land and water conservation infrastructure, such as grass strips, anti-erosion ditches, hedgerows, bunds, and terraces.

The first puts farmers on a collision course with other land users, such as cattle herders, commons holders, and biodiversity reserves. It also begins the vicious cycle of land degradation anew, condemning farmers to work on increasingly marginal lands (because of agronomic conditions, disease, and distance from markets). The second is unsustainable in the absence of new fertility-augmenting soil management, hastening the downward spiral of falling yields and shorter fallows.[14] The third choice has been pro-

hibitive in the past because it requires that farmers assume additional risk in the form of purchased inputs.[15] As discussed below, new adapted techniques are becoming available that can improve soil fertility using resources naturally available in Africa.[16] These techniques offer the promise of breaking out of this downward spiral.

Land and water: Serious regional scarcities globally abundant

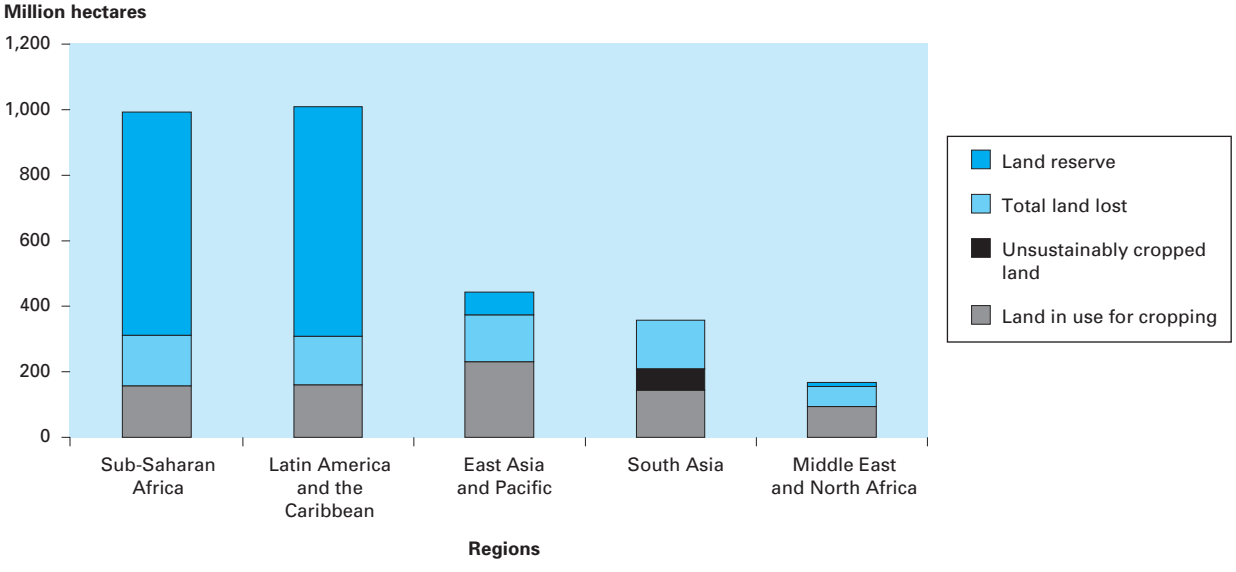
Land and water, now globally abundant, are projected to remain adequate throughout the 30- to 50-year time horizon of this Report—even while meeting the needs of a growing population and improving nutrition.[17] But the aggregate picture masks serious local and regional water and land shortages in all continents—as well as a lack of financing and institutional capacity to develop and sustain Africa's water resources potential. The World Commission on Water predicts that water use will increase by 50 percent over the coming 30 years and that 4 billion people—half of the world's population—will live under conditions of severe water stress in 2025.[18] Conflict over land and water will worsen, especially in areas already suffering from water stress in South Asia and the Middle East and North Africa. In addition, battles are looming between direct economic use and environmental needs. And in many urbanizing semiarid regions, conflict between high-value (usually urban) use and low-value irrigation will worsen.

Land availability. Additional land available in the developing world is of three types (figure 5.1):[19]

- Land in use for annual and permanent cultivation
- Land lost or no longer usable economically for cultivation
- Land reserve still unused but suitable for sustainable agriculture.

"Lost" land has been either consumed by urban sprawl or degraded beyond the point of economic recovery.[20] Globally, agricultural land has been lost through degradation at the rate of about 0.5 percent a year—and from new infrastructure at 0.1 percent a year. Severe degradation comes from water erosion (particularly in Southeast Asia and Central America), soil nutrient mining (particularly in Africa), and salinization (particularly in some areas with large irrigation schemes). Note that almost as much land has been lost (303 million hectares) as is now in use (307) in Africa and Latin America. Some of this is from shifting "slash and burn" cultivation pat-

Figure 5.1
Regional variations in land scarcity



Source: IBSRAM (2001).

terns (based on nutrient mining) and may recover after an extended fallow period.

The land that is available (and tillable) varies widely from region to region. Latin America and Africa stand out as having extremely large reserves of tillable land: 700 million hectares and 680 million hectares, respectively. At least 45 percent of the 1,400 million hectares of reserve land is in forests. East Asia and the Pacific and the Middle East and North Africa have little additional tillable land. And South Asia is already farming soils that are not sustainable for cultivation.

Much of the potentially tillable land in Africa is either not accessible for commercial agriculture, is subject to human or animal disease, or is already being used for animal grazing. In Latin America, new land is mostly in the Amazon, predominantly uneconomic to exploit. But some of it is potentially economic and therefore the subject of considerable dispute between environmentalists and rural development interests. Clearly on both continents this remaining uncultivated land has extreme limitations relative to land already under production, from the agronomic perspective and relative to markets. Much of it can be farmed only at high environmental cost.

Water availability. Like land, water resources are also unequally distributed around the world.[21] Africa and Latin America again have large unexploited water resources. According to the International Water Management Institute (IWMI), in Africa only South Africa has exploited more than 20 percent of its potentially usable water resources, and in Latin America only Cuba (48 percent) and Mexico (27 percent). Despite the modest exploitation of water resources in Africa and Latin America, future irrigation development is expected to be limited. Most good sites for irrigation—flat, close to water, near good markets—have already been developed.

Data from IWMI reveal China as the most water-stressed country in East Asia, exploiting 44 percent of its usable water (in the aggregate) and projected to exceed 60 percent by 2020. Primary withdrawal of more than 60 percent is widely considered by water experts to exceed the environmental carrying capacity of a river basin system. Although China's aggregate use appears still to be reasonable, it has several basins that are severely stressed environmentally, and it faces a serious groundwater overdraft in the North China Plains. According to IWMI data, withdrawals already exceed environmental limits in Afghanistan and Pakistan and will exceed limits in India by 2020. Irrigation already exceeds recharge rates in India's northwest plains (the major site of its green revolution). In the Middle East and North Africa only Morocco has unexploited water resources. All the rest have exceeded environmental limits, and many are mining groundwater aquifers (figure 5.2).

Africa is relatively well endowed with water resources. It has only 1–3 percent of its agriculture under irrigation, compared with two-thirds in Asia. The potential for expansion in Africa is limited, however, because more than 60 percent of the irrigation potential is in humid regions, where, because of high rainfall levels, irrigation would be at most supplementary to well-managed rainfed agriculture. In many of the regions where irrigation is most needed more than 60 percent of the potential renewable water resources are already exploited, and most of the highest potential areas are already under irrigation.[22]

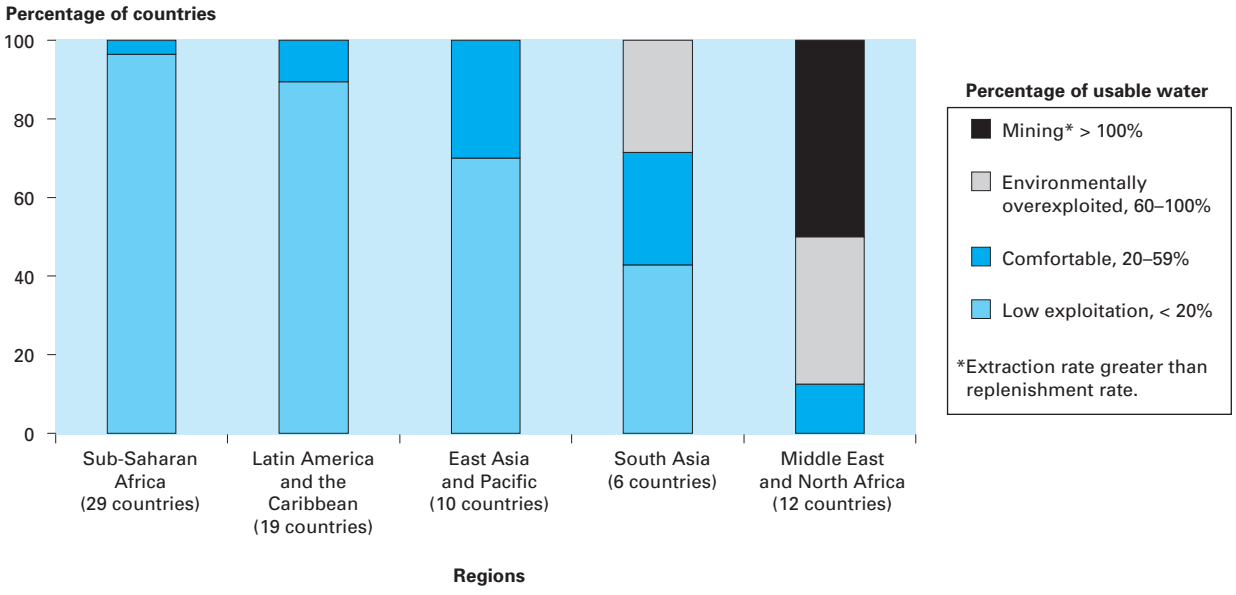
Figure 6 in the Roadmap shows the projected water scarcity worldwide in 2025 grouped in three categories: physical water scarcity, economic water scarcity, and little or no water scarcity.[23]

Eliminating rural poverty and preparing outmigrants

The social challenge of the rural sector over the next 50 years is enormous. Not only must it feed the world and prepare some 2–2.5 billion people to become productive urban citizens but it can also create the preconditions for the evolution of responsive, inclusive local and national institutions (as discussed in chapter 3).

For poor developing countries with large agricultural sectors, rural growth has a powerful effect in pulling people out of poverty.[24] In rural economies, the more equal the incomes and assets, the more powerful the growth effect in poverty reduction.[25] As inequality increases, the linkage of growth to the poor weakens, and in the most unequal of rural economies, growth tends to bypass poor people completely. The quality of rural development is thus a basic determinant of the quality of the future social development of a country. Countries that let rural incomes and assets become concentrated in the hands of a few find it extremely difficult to lift poor people out of poverty later (box 5.2). They have painted themselves into a corner.

Figure 5.2
Regional variations in water scarcity



Source: IWMI (2001).

Breaking the poverty cycle and preparing outmigrants

The conditions to break the poverty cycle and bring the rural poor out of poverty are overwhelmingly associated with increasing rural-urban interactions and more intensified use of existing agricultural land. In more dense rural areas with towns, credit markets are more apt to exist, and land is more likely to qualify for collateral. Higher farmgate prices associated with better roads and proximity to urban markets, and more opportunities for spreading risk, encourage higher-input agriculture. This in turn leads to greater value produced per unit area and generally to more off-farm jobs in food processing, transportation, and in the agricultural service industries. A more diversified economic base, dynamically linked to farm towns—and eventually cities—provides more stability of incomes throughout the economy. Education and health services can also be provided more efficiently.[26]

The first pillar of rural-led economic growth that reaches poor people is a "virtuous employment multiplier" and a transition to urban life through rural nonfarm jobs.[27] Driving the virtuous employment multiplier is the tendency of the rural poor to consume goods of predominantly local origin, produced by people who are also poor. This sets up a chain of increased demand and incomes that cascades through the hands of poor people in the rural and urban sectors. An extra dollar of income in the hands of a poor farmer might lead to 50 cents worth of demand for products and services from other rural poor, 40 cents of demand for products produced by poor urban residents, and only 10 cents of demand for products produced in the formal urban sector or imported from abroad. In the hands of a rich farmer, nearly the whole dollar escapes the economy of poor people.

The second pillar of rural-based economic growth is the training effect of rural nonfarm employment. Besides allowing the rural family to diversify income sources and reduce risk, rural nonfarm employment is an important stepping stone to urban skills. A young rural man or woman who gets a job with the fertilizer or farm implement dealer makes a smooth transition to a rural town economy—developing the urban skills and often the opportunity to later move to the city. This process of transformation and growth has the added benefit that it leads to greater support for schools. As parents observe children in the com-

Box 5.2
Poverty, equitable growth, and path dependency

Inequality reduces economic efficiency and traps societies in bad development paths through inequality-perpetuating institutions in three ways:

- Inequality reduces the participation of poor people in political processes, both directly and indirectly. This in turn reduces the likelihood that poor people have access to education, health care, and other services that would contribute to growth.
- Inequality can hinder the establishment of independent and impartial institutions and the enforcement of binding rules, because they might reduce the benefits of the privileged.
- Inequality makes it easier for the wealthy to hold out in political bargaining, either directly or through capital flight. It therefore makes it more difficult for societies to respond quickly and optimally to external shocks.

Each of these effects prevents the emergence of institutions that would distribute incomes, assets, and opportunity more widely.

Source: Binswanger and Deininger (1997).

munity successfully negotiating the rural-urban dynamic, they place a higher value on better education.

Governance and the distribution of rural assets

As chapter 3 showed, path dependency arises when institutional rules lock countries into bad development paths that prevent them from meeting future challenges. For example, the sharpest drops in growth after the economic shocks of the 1970s were in countries with divided societies and weak institutions for conflict management.[28] Similarly, the recent stagnation in Argentina and the República Bolivariana de Venezuela can be traced to an inability to settle distributive conflicts. Investigations into the determinants of growth have consistently found a negative relationship between initial inequality (usually unequal distribution of income or wealth in the rural sector) and subsequent growth.[29] This effect can be traced through the short and medium terms, as discussed above in the context of the virtuous employment multiplier, as well as through the very long term (relevant for the 30–50 year time horizon here). As discussed in chapter 3, differences in inequality in wealth, human capital, and political power stemming from colonial experiences account for much of the variation in the records of growth of North and South America.[30] While in North America, early settlement experience led to a virtuous cycle of inclusive institutions, in Latin America inequality and exclusive institutions became the rule (box 5.3).

Increasing the value of smallholders' assets

Urbanization has been rapid over the past several decades, and in many countries, especially countries in Latin America, most rural residents have already migrated to the cities without physical or financial assets or human capital. At the same time, institutions have not evolved to include them in the development process. In Asia and Africa, however, most people still live in the countryside. And it is from these countries that a substantial part of the 2 to 2.5 billion increase in urban populations expected in developing countries by 2050 will occur. In these countries a strategy to enhance the range of assets to which rural people have access would simultaneously strike a blow against rural poverty, stimulate an inclusive orientation in institutional evolution, and prepare migrants to become good urban citizens.[31]

Water control is critical to ensure and minimize climatic risk—and to allow farmers to safely invest in increased production. Unlike Asia, where 30 to 35 percent of agricultural land is irrigated (producing two-thirds of the agricultural output), Africa irrigates only 1 to 5 percent of its agricultural land (depending on the classification of traditional water management).[32] Without mechanisms to control risk, on-farm investment will be restricted to intensifying labor inputs. Farm and landscape-scale investments may be needed to enrich soil nutrients and organic matter, to protect fields from water and wind erosion, and to regenerate natural vegetation to provide local ecosystem services that also benefit agricultural production. Where investment can take the form of improving water control, and the water-retaining characteristics of the soil, climatic risk may be lowered considerably (box 5.4).

A broad-based attack to help African farmers break out of the vicious cycle of poverty will require increased investment on all fronts, including more attention to low-intensity agricultural techniques and genetically modified crop technology in areas remote from markets. And it will take major public investments in water control, transport, and technological advance aimed at staple food crops.[33]

Box 5.3
Land distribution and path dependency

The powerful impact of initial land allocations on subsequent agricultural development is well illustrated in Brazil. In most of the country in the late 19th century land could be titled only in lots of 4 square kilometers (988 acres) or more—an area much larger than a family could work. Restrictions on subdivision kept landownership highly concentrated. As a consequence, Brazilian agriculture became dependent on wage labor, characterized by relatively low efficiency and investment. Investment and productivity rose only after government subsidies brought about rapid capitalization of the sector.

Land sales were unable to significantly reduce inequality in the size distributions of the holdings. Brazil became a largely urban society without ever having developed a significant presence of appropriately sized family farms. As a result, much of the rural population moved as wage labor to the cities, without assets and unprepared for urban life—and over half the remaining rural population is in poverty. Undoubtedly, the dynamic of this rural-urban transition is a major contributor to Brazil's having one of the world's highest levels of income inequality. Recently, Brazil has invested heavily to overcome this early inequitable start. From 1995 to 2001 Brazil invested more than $10 billion in land reform, settling some 584,000 families on nearly 20 million acres.

In the United States the Homesteading Acts limited to 160 acres the plots that families could acquire. To retain ownership rights, individuals were required to cultivate the plots for a specified number of years. Owner-operated farms dominated agricultural production, with rentals and sales merely reallocating land to more efficient farm families working plots of comparable size. U.S. agriculture became one of the most productive systems in the world—and remains so today.

Based on an agrarian structure consisting predominantly of family farms, the major Southeast Asian economies—Indonesia, Malaysia, and Thailand, following the earlier lead of Taiwan (China) and the Republic of Korea—and China reduced agricultural taxation in the 1970s and started to support smallholders. These countries, in addition to establishing favorable macroeconomic policies, invested in rural infrastructure and social services. They also provided research and extension services and supported viable smallholder credit systems. Agricultural output grew rapidly, and the number of rural households living in poverty fell dramatically.

In 1978 China abandoned collective agriculture and assigned most agricultural land to families, giving each a very small holding. It also sharply increased the prices paid for agricultural goods. Over the next 15 years farm output grew more than 6 percent a year. This dramatic increase in agricultural productivity precipitated China's long-running economic boom and reduction in poverty.

Source: Based on Binswanger and Deininger (1997).

In Africa improved agricultural institutions may depend on first strengthening asset value through water and transport infrastructure and fertilizer (box 5.5). Many countries will follow a two-pronged strategy—encouraging intensification and commercialization through purchased input-intensive agriculture in productive areas near urban markets and transport (and in more distant areas with dense rural populations) and low-external input agriculture in more remote areas. With the predominance of constrained soils, high production levels in Africa will require use of both inorganic fertilizers and inputs to maintain soil organic matter and structure. In peri-urban farming areas where high levels of fertilizer inputs (inorganic or organic) are used, water quality issues may become a concern (as they have become in intensive production areas of Asia and Europe), requiring use of filter strips and other waterway protections.

A soil fertility replenishment approach, developed over the past 10 years by researchers from the International Center for Research in Agroforestry has been adapted by tens of thousands of farm families in Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia, and Zimbabwe. This approach uses various combinations of fallow, phosphorus, and biomass transfers with consistently good results. A program to scale up these practices from tens of thousands to tens of millions of African farm families would cost $100 million a year for 10 years.[34]

How deep institutional structures impede research on the needs of poor smallholders

Genes are already available that could help food production in the poorest countries if they were to be transferred into poor people's crops. These include genes that improve tolerances to salt, aluminum, and manganese in soils; give plants greater resistance to insects, viruses, bacteria, and fungi; enrich beta carotene to correct vitamin A deficiency; create more nutritious oils, starches, and amino acids; and improve fatty acid profiles and digestibility for animals.[35]

Despite this promise for poor people, biotechnology in general and transgenics research in particular have barely begun to be put to work to address the problems of poor people. So far large commercial

Box 5.4
Breaking out through *zais* and *tassas*—low-input traditional technologies

Since the early 1980s a technique for reclaiming degraded land has spread rapidly in Burkina Faso and Niger and was recently introduced into Ghana. This technique—called *zai* in Mossi and *tassa* in Hausa—originated in the Yatenga region of Burkina Faso. It involves digging holes that are 20–30 centimeters deep and filling them with crop residue, household compost, and manure.

Many lateritic soils of the area had become impermeable, sealed by a thin crust, hardened by wind and water. The *zais* attract termites, and their underground tunnels increase water infiltration. Millet is planted in the holes, which protect seedlings from wind damage. The number of *zais* per hectare varies from 12,000 to 25,000. Digging that hectare takes about 60 days (averaging five hours a day) in the dry season when work demands are low.

This technique has tripled yields and greatly reduced yield loss in dry years. On the central plateau of the Yatenga some 100,000 hectares have been restored, promoted by Projet Agro-Forestier (funded by the Oxford Committee for Famine Relief), and the German-funded Projet Agro-Ecologie. In many cases farmers spontaneously adopt the technique after seeing the results on others' fields.

The reaction of visiting Ghanaian farmers to what the Burkanabé had accomplished bears noting:

> "We are very much blessed and yet we are complaining of our poor soils. A large proportion of our soils we have even discarded as 'dead' but, to our surprise, such soils are being used here [in Burkina Faso] to produce something even better than we are doing on our best soils."

The *zai* is a response by farmers to population and climatic stress. The Yatenga region of Burkina Faso has some of the highest population densities in the country. Earlier versions of the *zai* were used in the Yatenga prior to the 1950s, but on a much smaller scale. They were abandoned in the 1950s and the 1960s because rainfall was much above average and the water harvesting properties of the *zai* were not needed. Re-emerging in the drought of the 1960s and 1970s, they began to be rapidly adopted following improvements in the techniques around 1980 by Yacouba Sawadogo, a farmer from the village of Gourga. The role of donors in dissemination, especially through field visits and farmer trials, has been critical.

Source: Reij, Scoones, and Toulmin (1996); Millar (1999); Meitzner and Price (1996); and IFAD (1999).

Box 5.5
Breaking out through fertilizer: the next green revolution?

During the 1960s the fundamental cause of declining per capita food production in Asia was the lack of short-statured, high-yielding varieties of rice and wheat. Asian food security was only effectively addressed with the advent of improved germ plasm. Then other key aspects that had previously been largely ineffective (enabling government policies, irrigation, seed production, fertilizer use, pest management, research and extension services) came into play in support of the spread of the new varieties. The need for soil fertility replenishment in Africa now is analogous to the need for the "Green Revolution-type" germ plasm in Asia three decades ago, a belief that is supported by two of the "fathers" of the Green Revolution: Norman Borlaugh and M.S. Swaminathan.

Source: Sanchez and others (2001).

plantings of transgenic crops have been restricted to Argentina, Canada, and the United States, with other countries planting less than 2 percent of the world total.[36] This is partly because much of the research supporting this technology is locked into patents held by a small number of multinational, vertically integrated life-science organizations, which have had little commercial interest in working on crops with limited markets, or funding research for the needs of poor producers. It is also because the rules that make this technology available worldwide—about the sharing of proprietary knowledge, products, processes, and genes—are being defined in U.S. courts, based on U.S. case law. The other high-income countries are catching up, but the developing countries, where needs are greatest, are being left behind.[37]

The use of modern biotechnology (genetic engineering) in agriculture has left the world sharply divided, though not always along predictable lines.[38] Some applications generate little controversy, such as marker-assisted genetic selection. Others, such as transgenic organisms, cause much concern. Comfort with the new technology is determined in large measure by a society's comfort with its scientific and food safety institutions, as well as its feelings about emerging concentrations of economic power in multinational life-sciences corporations.[39] Poor farmers and poor consumers have not yet been given significant voice in the decisions on agricultural use of these new technologies.

The current controversies over biotechnology result from twin revolutions in science and in property rights:

- *A scientific revolution* in understanding the structure of genes and regulatory gene sequences (genomics) and in bioinformatics has created an unprecedented opportunity to improve the characteristics of plants and animals, either through more rapid and efficient marker-assisted breeding or through the insertion of new genes into plants by genetic transformation.
- *An institutional revolution* in the coverage of intellectual property rights (IPRs), especially in the United States, has resulted in rapid growth of the private sector in crop genetics.

These revolutions have generated associated concerns about food and environmental safety, and ethical and equity consequences, all within a context of society's lagging institutional capacity to keep up, especially in the developing world. These concerns have a foundation in related earlier experiences (see box 5.6 on pesticide stockpiles in Africa).

Transgenics and developing countries. The slow progress in applying transgenic research to the problems of poor farmers is due to the exclusionary aspect of IPRs, as well as issues of biosafety, food safety, consumer choice, trade, and the publicly funded research network. Solutions to these complex issues are all playing out against a backdrop of globalization-related uncertainty that leaves many people unsettled about their incapacity to control their lives and their environment.

Deepening IPRs have created a revolution in agricultural science and a race for (exclusive) property rights for agricultural and biological knowledge. This race has led to greater concentration of the life-sciences industry, including massive buyouts of seed companies in all countries. These global giants raise

Box 5.6

Science, technology, and institutions to solve the challenges of nature: obsolete pesticide stockpiles in Africa

Science and technology are important tools to address the forces that damage livelihoods and affect quality of life. To take advantage of these tools requires effective supporting institutions. In Africa, weak institutions, unable to regulate and distribute pesticides, have left a legacy of dangerous, obsolete pesticide stockpiles.

In agriculture, insects and other pests have a potentially devastating impact on crop yields throughout the world. One of the most dramatic examples is locust infestation in Africa. To address this and other pest infestation over the past 40 years, the donor community has provided loans, grants, and other transfers to cover the procurement of pesticides as important components of agricultural projects. However, for this action to be successful, ministries of agriculture, port authorities, transport and handling networks, storage agencies, shopkeepers, extension agencies and farming communities need to know how to manage the timely purchase, transport, storage, application, and disposal of these chemicals. If this coordination is done well, the chemicals contribute to well-being. If not, they become a social and environmental liability.

Coordination problems combined with misguided advice or ineffective development assistance from donor agencies and pesticide manufacturers have resulted in a stockpile of more than 50,000 tons of extremely toxic and now obsolete pesticides, some dating back 40 years, and tens of thousands of tons of severely contaminated soils that have to be shipped out. An estimated 30 percent of the pesticide waste is believed to be made up of highly persistent organic pollutants (POPs), which have seeped into the water tables and oceans, and which are moving around the globe through ocean currents, contaminating the food chain of many marine species far from Africa's shores. The stockpile problem went from being a local problem to being a local and global problem, with shared responsibility among all parties. African countries do not have the specialized industrial facilities to dispose of the pesticides, hence the stockpiles need to be collected and transported back to hazardous waste disposal centers in industrial country locations, mainly Europe.

Donor agencies underestimated the institutional prerequisites necessary for the correct application of pesticides, which would have allowed African countries to realize the beneficial effects while minimizing the negative impacts. Donors have also underestimated the difficulties in mobilizing global action to address the problem. At the initiative of the FAO and a few other donors, modest clean-up activity began nearly a decade ago, but has moved slowly. Less than 5 percent of the estimated stockpiles have been disposed of, and new additions of obsolete pesticides continue to accumulate faster than the disposal rate. Recognizing that a gradual, piecemeal approach would not solve the problem, in December 2000 two NGOs (WWF and Pesticides Action Network, or PAN U.K.) launched the idea of major clean-up actions under an "Africa Stockpiles Program." The 15-year program, estimated to cost $250 million, would be donor funded and managed in cooperation with the partners and member governments. The program includes country level inventories, clean-up and disposal, and extensive technical assistance to avoid recurrence of the problem. The challenge now is to coordinate the process among the different parties involved.

Source: GEF, Africa Stockpile Program; interviews with World Bank staff, 2002.

fears about biosafety and food safety, heightened by tragic institutional failures in the areas of feed, food, and drug safety in Europe.

Who has the greatest need to access these new agricultural technologies? The rural poor in developing countries. The precautionary principle tells us that we should err on the side of caution, look at alternatives, and ensure a fully transparent and democratic process. Applying this principle suggests doubt about the need for genetically modified organisms (GMOs) in high-income countries, where oversupplies of food and low food prices are associated with subsidies of $360 billion a year. It will certainly lead to a different decision in countries in Africa, where the rural poor depend critically on one or two crops grown under precarious conditions.

Poor people need a stronger voice in international discussions of these matters, and science and governments must find mechanisms to improve the quality of the debate. This requires sorting more clearly what is known in current science from what is not, so that the political process can act more effectively on what is not known. If informed, representative stakeholders decide to move forward with genetic engineering, that would also require credible and independent monitoring—and systems to identify and intervene early, when unforeseen problems arise. The worldwide problems with invasive species should serve as a warning on the need for due diligence in introducing new organisms to nature.

The twin revolutions in science and property rights have created challenges and opportunities for public research institutions, life sciences departments in universities, national agricultural research institutions, and the international agricultural research centers of the CGIAR. The opportunity is that stronger IPRs have unleashed an extremely dynamic race for exclusive property rights in agricultural knowledge. And public research is in the race.

The race has generated new agricultural knowledge at an unprecedented rate. But the challenge is twofold. First, how can research be channeled to benefit poor people in developing countries, who really need it? And second, how can this be done in a period of declining public financial support for public agricultural research? This situation calls for new public-private research—and new institutional models for regional cooperation.[40] Ensuring that this research reaches poor people also calls for a considerably strengthened public sector role in doing and directing basic research.

Proprietary agricultural science and the dominance of the private sector. The dominance of the private sector in agricultural bioscience is relatively new. As long as farmers could replicate improved plant and animal varieties in the field, there was little scope for the private sector to recapture the costs of investment in improved varieties. So, to promote the public interest in higher yields and food quality, the public sector has traditionally borne the bulk of agricultural research spending. It was only with the introduction of hybrid technology in the 1930s that the private sector became interested in investing in crop biology. Why? Because hybrid varieties lose their high-yielding characteristics if seeds harvested from them are used for planting. Farmers who want the benefits from high-yielding hybrids must purchase new seeds every year if they want to maintain high yields. This makes it possible for seed companies holding the parent lines to appropriate the benefits from research-induced increased crop yields.

Incentives for private-sector agriculture R&D were strengthened in 1980 when the U.S. Supreme Court decided that although patent protection could not be extended to naturally occurring living things, it should apply to living organisms that had been altered by human intervention.[41] Later interpretations extended this coverage to new processes, which may or may not give rise to a new product. The 1995 Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement has further established an international institutional framework of minimum standards for international trade involving intellectual property, including for proprietary agricultural processes and products.

Three factors explain the private sector's dominance:

- *The deeper protection of intellectual property*, which allowed firms to move into more basic research, traditionally left to the public sector.
- *The race for property rights* among firms and between firms and the public sector, strongly influenced by eager capital markets.
- *The weakening of taxpayer support for public sector agricultural research.* Indeed, with annual agricultural subsidies in excess of $300 billion, glutted world markets, and record low prices, the case for

public support of agricultural innovation was, for many taxpayers, weak. The prevailing mood has become "leave it to the private sector."

A divided public. Support for the application of transgenics to the food needs of poor people has been nearly unanimous among the major agricultural development institutions.[42] Even so, discussion of the use of transgenics to address the development needs of poor people has been heavily influenced by public concern, especially in Europe, and the use of transgenic agricultural technology has been overwhelmingly geared to the needs of large, mechanized agriculture.

In Europe consumer groups, led by Greenpeace and Friends of the Earth, have driven genetically modified foods off the shelf—and subsequent domestic production and imports of genetically modified products have largely halted.[43] In a European Commission survey 56 percent of the respondents felt that genetically modified food was dangerous.[44] Similarly, consumer groups and NGOs prevented genetically modified soybeans from entering Brazil, despite the support of the minister of agriculture and the head of the national agricultural research agency, EMBRAPA; local and international NGOs have also led resistance in China, India, and Kenya.[45] In North America, by contrast, the public attitude is optimistic about the promise of modern biotechnology, though with concern over possible environmental effects.

Clearly the perception of risk differs strongly between scientists and the public in Europe, and between the general public in Europe and North America. Caught in the middle are the rural poor, especially those on dry or degraded lands who could most benefit from the new technology.

Explaining the differences in perceptions of risk. The differences in risk perceptions between North America and Europe appear to be due in large measure to differences in their confidence in their life-science institutions to accurately pick up risk signals and to communicate them to the public. These differences have a base in experience. While North America has had no catastrophic failure in the food and drug protection system, Europe has experienced numerous failures, especially over the past decade. Rightly or wrongly, the U.S. public's confidence in its food and drug safety institutions has been constantly reinforced. Beginning with Thalidomide at the end of the 1950s, it has avoided the food and drug tragedies that occurred elsewhere.[46] This confidence has enabled the U.S. Food and Drug Administration (FDA) to resist industry pressure to reduce its scrutiny of new products.[47]

Europe, by contrast, has been buffeted by a series of food and drug safety issues, precisely as genetically modified foods were beginning to enter the market. "Mad cow disease" (bovine spongiform encephalopathy, or BSE), suspected of killing at least eight people and leading to the slaughter of herds in Britain worth $5.5 billion, rocked public confidence in government and the agri-food industry's credibility and capacity.[48] According to a British parliamentary report released in February 2000, BSE created a "crises of confidence" in both science and government.[49] It was observed that British citizens were more likely to trust science they see as "independent," with university scientists ranking at the top and government at the bottom. The rest of Europe has also suffered recent crises of confidence in government's ability to protect them. France suffered from government failure in its scandal over AIDS-tainted blood, which infected 3,600 people receiving blood transfusions in the mid-1980s. Belgium, too, experienced high-visibility food and agricultural scares in the 1990s.[50]

European distrust of government food-protection institutions has led to demands to be directly informed and directly involved. Given this desire, the precautionary principle (box 5.7), widely supported in Europe, has three attractive characteristics. First, it slows the commercialization of new crops. By putting a greater burden of proof on promoters to show that new organisms will not create environmental or food hazards, the precautionary principle,

Box 5.7
The precautionary principle

- When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.
- The proponent of an activity, rather than the public, should bear the burden of proof.
- The process of applying the precautionary principle must be open, informed, and democratic, including potentially affected parties. It must also involve an examination of the full range of alternatives, including no action.

Source: Adapted from The Wingspread Consensus Statement on the Precautionary Principle (http://www.sehn.org/ wing.html).

as implemented in some national laws, slows the approval process and allows more time for the public to become informed. Second, the principle calls for more transparency in environmental, food, and health-related public sector decisionmaking. Third, where substantial scientific uncertainty exists, it requires that decisions be made through an informed political process. References to precaution have been adopted in the Cartagena Protocol on Biosafety, which regulates the shipping of certain genetically modified organisms (referred to in the protocol as "living modified organisms") across national borders.

Poverty and the precautionary principle

The precautionary principle requires analysis of the alternatives to introducing new technology and organisms, not just the risks inherent in their use. In Africa, in many marginally viable agricultural areas, the range of alternatives is currently minimal. For farmers in these areas, modified crops that can better survive prolonged drought, or that improve diets through micronutrient enrichment, may be among the few critical options, to be supplemented with investment in farm- and landscape-scale soil and water improvements.[51]

Efforts to improve the lives of farmers in arid and semi-arid borderline areas through conventional breeding programs have had limited success. Crop breeders have had limited success in either raising the yields of robust but low-yielding millet or getting improved resistance to moisture stress from fragile but higher-yielding hybrid maize. Both these objectives have resisted traditional breeding programs but have become credibly feasible with genetic modification.[52] The precautionary principle requires weighing the alternatives and the costs and benefits of helping these farmers. As noted above, the development community supports a broad consensus that alternatives that can be adopted on a large scale are few and that risks from transgenics can be managed. The challenge is to focus research and promote knowledge sharing for improving "orphan crops"—crops important to poor people but that have not had the benefit of significant research because of limited market potential.

Disentangling the elements. The ethical, moral, and social dimensions of biotechnology challenge society's institutions at all levels, from the field to the planet. They challenge notions of property and property rights institutions, the national and international institutions responsible for biosafety, the institutions concerned with food safety and consumer choice, the rules for international trade, and the organization and role of public sector research (table 5.1).[53]

For biosafety, food safety, and consumer choice and trade, active sensing mechanisms are in place, largely through NGOs and formal and informal networks. The Internet has greatly increased the power of networking. Mechanisms to balance interests are weak across all five dimensions. Much greater attention is required to frame the debate so that the public can better understand the benefits and risks by making independent positions, agreed on by scientific leaders, accessible to the public. Implementation of institutional remedies in each of these areas is taking place within a global context, and frameworks are emerging to forge international agreements. Because these frameworks often do not reflect satisfactory consensus at the national level, their implementation path can be expected to be rocky.

More importantly, to successfully introduce more science and technology into neglected areas of developing country agriculture, a long-term commitment to the development of agricultural knowledge and supporting institutions must be in place—particularly in Africa (see box 5.8).

Intensifying the use of land

Creating more dynamic, input-intensive agricultural communities in near-market areas, where price incentives make intensification attractive, requires sustained effort on several fronts.[54] First, conditions must be established to activate the land market and make land affordable to smallholders. Second, smallholders must have access to credit to make the holding a viable economic unit. And third, smallholders must have enough protection from risk to be able to afford investing in yield-increasing inputs, such as fertilizer and improved seed.

Three activities are important to move additional land into the hands of smallholders: clarify and adjudicate property rights, improve the functioning of land sales and rental markets, and where necessary, redistribute land through land reform.

Clarify and adjudicate property rights as land scarcity dictates. Countries making the transition from communal to more individual forms of land ownership need to set up a legal framework that permits evolution of land rights toward individualized

Table 5.1
The capacity of institutions to sense problems, balance interests, and implement solutions

	Where we are in identifying problems	Where we are in balancing interests	Where we are in implementing solutions
Problems with intellectual property rights regime	Innovators (especially in pharmaceuticals) felt investment threatened by weak property rights. Legal costs of innovative research now a barrier for public sector researchers. Concern about effect of strong IPRs on concentration in life sciences industry.	IPR debates not well accompanied or understood by public. Minimum standards of IPRs established in the Uruguay Round. Menu of acceptable IPR options large.[55] Many developing countries and NGOs believe that IPRs, based on Western concepts of law, are unethical or impractical in developing countries.[56]	IPR implementation varies widely, as a function of national income.[57] IPR implementation will strengthen as countries become potential exporters (to meet intellectual property (IP) standards of importing countries).
Biosafety	Old concern over invasive, exotic, wild species. *Nature* documents Bt-maize pollen threat to Monarch butterflies.[58] Monsanto sued for Bt "creep" into organically grown neighboring crops. Subsequent research shows low threat to Monarchs under field conditions.[59] Genetically modified crops found poorly competitive outside of cultivated conditions for which designed.	Developed countries have minimal voice regarding tradeoff of biosafety risk against food security. Arguments are inaccessible to lay public. Precautionary principle accepted in Cartagena Protocol on Biosafety, but mechanisms to resolve disagreement weak.	United States screens GMOs using same standards as non-GMOs. U.S. Department of Agriculture (USDA) responsible for implementation—except for Bt products which must also clear EPA. European legislation tends to require screening hypothetical risk. European public pressure halts new approvals in 1998.
Food safety and consumer choice	No documented cases of human health problems from eating commercially marketed GMOs. Normal testing catches potential allergy problem. Scientific opinion in Europe and the United States agrees: "there is no problem with GMOs over and above any other food."[60]	European public pressure pushes a "strong precautionary principle" requiring screening for hypothetical risk. U.S. Academy of Science declares no scientific basis for tougher screening processes for GMOs than non-GMOs. European preference for non-GMOs drives down price of GMO crops. U.S. corn acreage in GMOs falls. Liability concerns arise for pollen contamination.	U.S. FDA applies the same standards of food safety as for non-GMO crops.[61] EU adopts labeling based "on consumers' right to know." GMO food safety low priority in developing countries compared with clean water and uncontaminated meat.
Trade	Developed country consumer and environmental groups question trade in GMOs. Concerns related to globalization-related "loss of control" and multinational industry concentration, as well as to specific food and environmental safety issues. Industry concerned with disguised protectionism and theft of IP.	Contradictory positions. World Trade Organization (WTO) requirements, based on Uruguay Round (SPS agreements), require restrictions to be based on scientific assessment of risks. Cartagena Protocol on Biosafety, endorses "precautionary principle"—that "lack of scientific certainty due to insufficient relevant scientific information and knowledge" should not prevent states from banning imports.	Protocol establishes Biosafety Clearing-House to exchange information on living modified organisms and to assist countries to implement. Calls for assistance from developing countries in capacity building.
Public research investment	With food abundant, prices low, and agricultural subsidies high, developed countries' support for public agricultural research is weak.	Difficulty balancing (a) "pure research," (b) research on improving the productivity of crops without significant commercial markets, but of importance to poor people, and (c) research on yields for major staples where yields are approaching genetic maximums.	Must develop national and international public sector research programs that (a) are oriented toward clear national objectives, and (b) complement (through partnerships), and do not duplicate other public sector and private sector activities.[62]

Box 5.8
Institutional commitment and African agriculture: lessons from Asia and South America

The current pessimism about a continent's ability to feed itself has been seen before—in Asia. The pessimists were proved wrong about Asia. But it took a long-term, coordinated commitment to agricultural research, extension, and agricultural higher education. These are the lessons to be learned from the Green Revolution in Asia and South America.

"Asia's development experience reveals that a bleak economic future for Africa in the 21st century is not foreordained. There are scores of cracked crystal balls in economic forecasting. Even Nobel Laureates such as Gunnar Myrdal can widely miss the mark. Myrdal was pessimistic about Asia's development prospects in the late 1960s because of corruption, 'soft states,' rapid population growth, and the gloomy prospects for agriculture. But Myrdal failed to anticipate Asia's Green Revolution, which was taking root at the same time that his book, *Asian Drama,* was rolling off the press in 1968. The rapid spread of Green Revolution wheat and rice varieties in Asia in the late 1960s and early 1970s, and China achieving the fastest rate of agricultural growth in the world from 1980 to 1995, highlight the perils of economic forecasting." Even Bangladesh, long considered a "basket case," has recently emerged as an agricultural success story. In Latin America, Brazil and Chile have become aggressive competitors in global food markets.

What these countries have in common is a long-term commitment to agricultural research, extension, and higher education—to the development of what Carl Eicher has labeled the "Agricultural Knowledge Triangle." The time for the successful development of agricultural knowledge is measured in decades, not years, and requires long-term national and donor support. The complexity of agricultural systems in Africa have foiled attempts to "jumpstart" a Green Revolution in Africa. Success in Africa will require local adaptation, piloting, and dissemination. Where agricultural institutions are strong, success has been achieved. Zimbabwe's Green Revolution in maize, which led to a reliable maize surplus and generated maize exports for 19 of 21 years during 1970–91, was based on 28 years of indigenous research, which in 1960 produced the high-yielding maize variety SR-52. Unfortunately the technological leadership that made this possible has been allowed to erode.

The long-term commitment required to develop agricultural knowledge institutions does not resonate comfortably with today's aid climate. Today's climate favors rapid "results on the ground," and prefers direct field involvement, often through NGOs. Donors are right to demand accountability for aid resources. But experience shows that there is no shortcut to agricultural knowledge. Sustained agricultural progress in developing countries will require a long-term commitment from donors and partnering with local agricultural research extension and higher education institutions.

Sources: Carl Eicher, *Institutions and the African Farmer,* CIMMYT Economics Program third distinguished economist lecture. On the Web at http://www.cimmyt.org/Resources/Publications/cat-log2001/PubCat2001-Economics.htm; *Zimbabwe's Maize-Based Green Revolution: Preconditions for Replication,* World Development, vol. 23, no. 5, pp. 805–808, 1995.

tenure as the need emerges with increased commercialization and land scarcity. Where tenure arrangements have been severely disrupted by civil strife and war, collectivist land reform, or land-grabbing by influential individuals (Bolivia, Cuba, Ethiopia, Honduras, Nicaragua, Tanzania, Uganda, and Vietnam), an approach is needed that adjudicates among overlapping claims and establishes clear ownership rights at minimum cost.

Where insecurity of tenure already affects incentives, land titling should be initiated. Area-based titling is important where the insecurity results from attempts by the powerful to wrest land from the less powerful. Under these conditions an "on-demand" program may increase the ease of land grabbing, and an area-based system is more appropriate. An example would be the rehabilitation of an irrigation scheme in Somalia—where land values will increase greatly with improved water access and where the rule of law is tenuous, exposing those less powerful to loss of land to individuals with strong political connections or power positions.[63] Experience in Bolivia, El Salvador, Peru, and Thailand demonstrates that area-based titling can be accomplished by introducing titling in combination with a mechanism for dispute resolution.

An on-demand approach can be justified under four conditions. Commercial agriculture is just beginning to emerge as a profitable enterprise for the most innovative and progressive producers. Traditional community values and norms are still strongly enforced. Local political power in the formal governmental structure is constrained effectively by traditional political structures and traditional authority. And national administrative systems extend the rule of law to the local areas.

Under these conditions the emerging entrepreneurial commercially oriented producers may need more security of ownership than the majority of farmers who are still largely subsistence producers. For example, the emerging entrepreneurial group may need access to formal credit markets, which

typically requires greater security of ownership. Under such circumstances an area-wide titling project would be expensive and inefficient because the cost would exceed the benefits for most parcels. Further, it may be possible to use the political strength and local support of traditional authorities to certify boundaries in an equitable manner without area-wide titling. Communities of exactly this type exist in many areas in central and western Uganda.[64]

Improve the functioning of land sales and rental markets. Restrictions have often been placed on operations of land markets to compensate for failures in credit and risk markets—and for policies that raise the price of land above its expected value in agricultural use, such as the use of agriculture as a tax loophole, and agricultural credit subsidies directed to large land owners. These restrictions on tenancy and sales contracts typically reduce the willingness of landlords to make land available to smallholders through sales or rentals and so should be removed. Underlying market failures must be addressed directly. Taxing land can reduce the incentive for large landholders to hold unproductive land (box 5.9). A lump-sum local tax on land has the advantage of maintaining incentives to produce, and it provides revenue to local governments. In addition, by capitalizing local amenities in land values, a local land tax establishes a direct link between tax levels and benefits received by taxpayers.[65]

Depoliticize land reform and stress sustained productivity and poverty reduction. Because many land reforms have taken place in response to political crises, with little sustained commitment to making the smallholders' farms productive, the outcomes have often been disappointing.[66]

Transforming a large farm into a workable set of smallholder enterprises requires a new pattern of production, subdivision of the farm, and construction of infrastructure.[67] So, realizing the productivity benefits of redistribution requires a shift from ad hoc political objectives to productivity and poverty-related objectives. Brazil, Colombia, and South Africa are implementing a new model of "negotiated" land reform. Although it is too early to draw definitive conclusions, initial evidence is encouraging. Key elements of this approach are:[68]

- Emphasize sustainable poverty reduction through elaboration of integrated farm projects by poor people (which are then supported by a land purchase grant).
- Decentralize execution and integrate into development objectives at the local level, with an overarching emphasis on beneficiary training and human capital formation.
- Involve the private sector in project development, financing, and implementation.
- Work to build and maintain a broad-based constituency, including landowners, rural workers' unions, agribusiness, and agricultural research and extension.

Box 5.9
Weakening the interest of landholders in unproductive land

In 1995 Brazil transferred collection of its land tax from the land reform agency (INCRA) to the ministry of finance. With this change, the tax began to be seriously assessed for the first time. In addition, Brazilian Federal Banks began foreclosing on bad debt collateralized by land, and land prices fell because of Brazil's entry to the Southern Common Market (MERCOSUR) and the ending of hyperinflation (which had led to a flight to real assets).

These events began a process of weakening the interest of landowners in holding unproductive land. With this weakened interest it became possible to mount a major campaign against irregular holdings. In the past few years INCRA reclaimed more than 50 million hectares of irregular holdings. Of these holdings 10 million hectares in the Amazon region were turned over to the Brazilian Institute for the Environment to create protected areas. The rest became available for redistribution. According to the minister of land reform, there is now no constraint on land available to be distributed to Brazil's landless. The constraint is budgetary resources required under the Brazilian Constitution to help land reform beneficiaries set up workable production units.

Source: World Bank staff.

Intensifying the use of water

With water scarcity rising, markets tend to emerge—formal or informal, legal or illegal, peacefully or through violence. And the tendency will be for water to go to its highest-value use given the infrastructure in place. Although this provides some comfort, because the scope for improving efficiency of water use through better pricing is great, the institutions underlying those markets will determine the social cost of the transition to markets and the efficiency and

equity of infrastructure put in place to make water transport and water markets possible.[69]

As for land, emerging legal protection of property usually confers rights on the first users. But gaining truly secure property rights is more complicated with water than it is for land. Physical distance and different legal and administrative jurisdiction (states, regions, nations) complicate agreements between upstream and downstream users. Guaranteed quantities become meaningless as quality is degraded. And the complexity of hydrologic systems and unpredictability of climate make "ownership" a contingent concept. For these reasons, property rights in water have emerged only in situations of scarcity, and the nature of the rights varies according to the water basin's peculiarities.

The competition for water has two stages: one for access to cheap water and one for rights to water. The competition for access takes the form of competition for property rights for land that is well endowed with water (box 5.10). This means purchasing good, easy to irrigate land; land above shallow aquifers; or land on which the government can be persuaded to provide low-cost water. In each case rights to water are less of an issue—in the early stages—than rights to land. Only as water scarcity emerges in a second stage, often from conflict with urban or public use, does the irrigator seek to convert traditional uses of water to property rights. This principle of prior appropriation—the squatter's rights to water—tends to be accepted in most settings.

Prior appropriation has pluses and minuses. A plus is that it tends to reward entrepreneurial behavior and investment in productive resources. A farmer who fears losing rights to water is much less likely to invest in land leveling and irrigation infrastructure than a farmer who is sure that water will continue to be available. Communities also prefer to see investment and economic activity than to see a resource lying idle.

There are two minuses. First, prior appropriation sharpens inequalities in incomes and assets by rewarding those with the initial capital to invest. Second, unless well administered, it leads to a destructive race for property rights and loss of environmental services of water.

Nonvoluntary redistribution of existing water use and associated rights has been proposed but found to be impractical—both in industrial countries such as Australia and the United States—and in developing countries with strong central governments such as Mexico (where redistributing water rights would, in the words of a prominent reformer, "require a revolution"). It is also problematic even in developing countries with a strong redistributional mandate (for example, South Africa). The benefits of formalizing the de facto rights of water users, and working with these users to manage the resource in a sustainable manner, have in most cases been judged to outweigh the drawbacks of reinforcing existing inequities.[70]

If the settlement of rights becomes protracted, negotiation strategies of individual claimants will lead to a wasteful drawdown of the resources—and to premature investment. A property rights regime that does not allocate rights expeditiously not only risks wasting water, but also leads to uneconomic infrastructure designed to "lock in" water claims before other claimants do so—often years if not decades before it is justified by emerging demand. For example, pressure for a 2,000-kilometer conveyance system taking water from the San Francisco River to Brazil's northeast—even though most of the urban demand justifying the project will not begin to

Box 5.10
The race for water—and land—and the displacement of the poor

In some arid regions of Sub-Saharan Africa, land rights are less important than rights to use water at specific locations such as an isolated waterhole. Rights to graze land might be open to the entire community or even several communities, but rights to water were restricted. Control over the water meant de facto control over the land, just the reverse of the frontier setting of the Americas. So having a water right was far more important than having a right to graze the land.

With the advent of a modern technology—the borehole well—the constraints to grazing were suddenly relaxed, and it became possible for wealthy or powerful individuals to gain access to land and grazing opportunities through implementation of the new borehole technology. The tribal lands grazing policy (TGPL) program in Botswana promoted private ownership of grazing land and borehole water points under the theory that individual ownership would provide incentives to maximize the returns from grazing, maintain or improve the quality of the range, and increase the rate of herd offtake and national income. The result was that many of the private ranches came to be owned by wealthy individuals, and grazing, hunting, and gathering opportunities for poor people declined.

Source: Richard Barrows, personal communication.

emerge for more than 10 years—comes in part from a concern to guarantee Brazil's poor and arid northeast a claim on the San Francisco's limited water. Similar pressures exist between states in India.[71]

The environmental use of water will not be protected without specific institutional intervention. In the absence of protective institutions the environmental use of water is priced at zero—every other use will establish a prior claim. If estuaries and freshwater ecosystems are to be maintained, institutional solutions have to be put in place to take into account the public goods nature of water.

What are the major institutional issues for rural communities in controlling the race for water? The first, "institutional" principle for water resource management, is that water management should be carried out at the lowest appropriate level—and be as participatory as possible. The second, "ecological" principle requires the holistic management of water, including management of watersheds and guarantees of maintenance of environmental values. And finally the third, "instrument" principle requires that water be managed as an economic resource. Widely known as the Dublin Principles, for the 1992 Dublin conference where they were first developed and agreed on, these are the three principles that water specialists agree that water management must respect.

Picking up signals of environmental decay. Water problems are environmental and economic. Signals of environmental decay are picked up by rural communities as a gradual loss of fisheries and the recreational and aesthetic value of water, as well as the quality and supply of water for domestic use, and the presence of water-borne human diseases. These signals are often missed or interpreted incorrectly. If environmental flows are to be protected, basin-level expertise must be mobilized prior to the emergence of economic conflict for water. The economic signal is a growing disparity among the values of water in irrigation and in urban and industrial uses. For groundwater the early signal of a problem is falling levels, often noticed by local communities with shallow drinking water wells long before it becomes a problem for irrigators.

Balancing the interests of all of water's claimants. Balancing competing water interests requires a consensus on the technical nature of the problem. This requires basin-level expertise. It is critical that environmental flows be established early. If environmental needs emerge only after economic conflict is already emerging, the problem of balance becomes much more controversial. The function of a water agency is to provide quality analysis and technical information about the hydrological characteristics of the basin, including analysis of alternative water sharing, trading, and pricing scenarios.

Interests need to be balanced where they conflict—the Dublin institutional principle. Where problems are local, such as managing an irrigation district, and the actors homogeneous, communities typically find mechanisms to resolve the conflict.[72] Conflicts among widely differing claimants—for example, the irrigation district and urban water supply, with the hydropower dam an added complication—require basin-level mediation. Water parliaments, or a similar institutional structure representing all basin stakeholders, become essential. Water parliaments must have technical backstopping from a strong and respected water agency (box 5.11).

Box 5.11
Water parliaments in France

Since 1964 water policy in France has been made at each of six major hydrographic levels by a *comité de bassin,* an authentic river basin water parliament. The number of seats varies from 61 to 114, with the composition fixed by ministerial order and comprising three groups:

1. Users, qualified local dignitaries, and representatives of socioprofessional groups (40–45 percent of seats).
2. Representatives of the regional authorities (*régions, départements, communes;* 36–38 percent of the seats).
3. Representatives of the state (19–23 percent of the seats).

This organization deliberately limits the influence of the state and reflects the desire to promote the role and responsibility of the different actors—users and elected representatives—in each basin and to encourage them to reach agreement. The basin committee must give its approval on fees and the basis for their calculation.

The basin committee's executing agency is the water board *(agences de l'eau),* an administrative public body under the responsibility of the state. It has a dual role:

- Taking part in the financing of general works in the basin.
- Carrying out water-related research studies.

Source: Chéret (1993).

Executing arrangements to share water. Action requires either sharing available water better or building new infrastructure to bring in additional water, or increasing the flow and quality of water through rainwater harvesting and landscaping improvements. Water management institutions have historically developed to address allocation of existing flows; much more attention is needed to enhance institutional action on water production and use efficiency. Water, even in industrial countries, tends to be very poorly allocated.[73] So the scope to share water better, without resorting to new sources of supplies, is generally great, but incentives have to be in place. Where the number of competing users is relatively small, ad hoc solutions can be sought. For example, the water utility can purchase high-efficiency irrigation devices for the irrigation district (such as the Imperial Valley, California). Or the utility can pay the farmers not to irrigate at all (California water market and others). As the number of players increases, or as all easy solutions become exhausted, water markets become most efficient for water allocation and coordination.

Water basin commissions, or water agencies, must be established to open the dialogue for win-win opportunities in water sharing. Eventually water markets will emerge through this process of ad hoc negotiation and comparison of value.[74] Water markets ensure that water in each basin gets to its highest value use. They also ensure that price differentials clearly signal the potential benefits of augmenting flows through dams, reservoirs, or interbasin transfers.

Moving to market allocations of water requires two important acts, however. First, property rights must be assigned: it must be decided who will have to pay whom for water. Second, environmental allocations must be made—how much water has to be set aside to maintain environmentally critical flows in the basin? The market will not make these decisions. The first must be determined by existing law and prevailing notions of fairness, and the second through a combination of technical and political criteria.[75] In the absence of appropriate balancing mechanisms, many major rivers stop flowing into the ocean or inland lakes.

Water markets will eventually price low-value users out of the market. This can have two bad outcomes. If the community of low-value users is strong, well represented, and politically strategic, it can block market reform—delaying or even preventing badly needed improvements in water allocation. If they are weak, they risk losing their economic base without clear alternatives, as irrigation water becomes priced out of their reach.

But if the rule of prior allocation were to assign property rights to rural users, the transition to market allocation would be greatly smoothed. When local farmers are owners of the water, they are unequivocally made better-off by the market-induced increased value of the water. They have a range of choices; they can continue farming as they were, sacrificing the income they could get by selling water; or they may upgrade by investing in water-saving irrigation equipment and higher-value crops and sell the surplus water created; or they may decide to sell all the water and invest in alternative livelihoods. Similar property rights would have to be assigned to institutions protecting the environmental services of the basin.

Getting ahead of the frontier

What drives the expansion of the agricultural frontier into different wildernesses? Poverty and opportunity. In this section the forest frontier is discussed. But the pattern also applies to the conversion of wetlands, grasslands, and other agriculture—or wilderness—boundaries. The settlement in the eastern Amazon of Brazil has been shaped by Northeasterners fleeing periodic droughts. Western settlements, by contrast, tend to be populated by smallholders who sold farms in southern Brazil during the booming land market of the mid-1970s and early 1980s to seek opportunities by buying cheaper land in the Amazon, often gaining 5–10 hectares of land in the Amazon for every hectare sold in the south.[76] Similar stories of expansion into the forests of Indonesia, Malaysia, the Philippines, and Thailand have elements of poverty-induced flight and profit-driven opportunity.[77] The frontier's expansion highlights the importance of institutions to address a race for property rights.

Many forests were originally claimed by local communities, but these claims were granted to governments during the colonial or postcolonial period. While governments have often faced great difficulties in managing these (often huge areas of) forest, lack of local rights and economic benefits from

forests have reduced local incentives to protect them. The past 15 years have seen a major shift in forest tenure in developing countries back to local communities and indigenous peoples, such that 14 percent are now owned by communities and indigenous groups, and another 4 percent are still publicly owned but reserved for exclusive use of communities and indigenous groups.[78] This shift in forest ownership, plus the dramatic shift in many forest-scarce countries to tree growing on farms, means that commercial forest product and ecosystem service markets could potentially contribute much more in the future to rural livelihoods than they have in the past, particularly with reforms in market policies.[79]

The process of conversion to agriculture usually begins with logging. As roads advance and markets develop, forests become worth seizing. In Asia and Latin America there are typically waves of logging, successively removing more valuable to less valuable trees, followed by the burning of residual noncommercial trees, and finally the establishment of large, commercially oriented ranches or farms. In Africa the closed forest is more likely to be converted to smallholder farms. These are nonetheless often commercially oriented (chapter 8, figure 8.1).

Rational occupation of the frontier and conservation of its biodiversity require better national governance and policies. Project interventions to improve community welfare are well meaning and potentially useful, but they do not address the scale of the problem.[80] Countries need first to rein in unregulated logging, which catalyzes conversion and degradation and appropriates rents to private individuals that belong to the public or to indigenous people. It is technically feasible to do this, but more influential vested interests can resist change. Large-scale logging often benefits government leaders or other powerful interests—sometimes for personal gain, but often because the forest provides an off-budget source of revenue for projects.[81]

The people and wildlife of the world's great transfrontier forests—the western Amazon, parts of the Congo Basin, Siberia, and New Guinea—are protected, only partially and for the moment, by their inaccessibility. These are the last places where large ecosystem processes represent preindustrial experience, and they are home to many indigenous people, plants, and animal species. Today they are also subject to increasing threats. Roads built for oil and gas development, for extraction of mahogany, or for military purposes can open these regions to encroachment—and often wasteful exploitation by loggers, ranchers, and farmers—and to destructive fires. The combination of conversion and sloppy logging provides a deadly recipe for forest fires: open canopies leading to dried-out soil, highly flammable logging waste on the ground, and escaped land-clearing fires.[82] The catastrophic forest fires in Indonesia in 1999 caused $7.9 billion of damage to the Indonesian economy and additional health and tourism damage to neighboring countries.[83] Without intervention these areas are likely to experience, over the next 5 to 50 years, the social and environmental problems of earlier frontiers.

The frontier trap. The race for frontier property creates a sharp disparity between what is good for an individual landholder and what is good for society. First, the rancher or farmer opening new land is unlikely to take into account the loss of biodiversity and carbon storage (box 5.12). Second, holdings at the extensive margin tend to be associated with low density and transient communities—raising the costs and lowering the quality of government services and creating little opportunity for building human and social capital. So an extensive and predatory agricultural economy either has a sharply higher cost to the state to provide equivalent human services, or has

Box 5.12
The Amazon rancher's decision to deforest

Pasture in the Amazon often degrades beyond economic use in some 10–15 years. The rancher then has to decide whether to restore the pasture through plowing, fertilizing, and planting new pasture grasses or to plant on newly deforested land. The decision depends largely on the relative cost of new land (net of sales of commercial value logs) and the cost of fertilizer and limestone to reclaim degraded land.

In intensifying areas where the cost of new land is above $300 per hectare, farmers will generally choose to reform pasture. But where land values are between $20 and $100 per hectare, farmers find it more profitable to deforest new land and abandon degraded pasture. By a conservative estimate of the value of the carbon storage, the value of a hectare of Amazon forest in sequestering carbon is over $800. So, although deforestation generates value to the rancher of less than $300 and costs society more than $800 in lost carbon storage benefits, no national or international arrangement has yet succeeded in developing institutions to influence the rancher's decision.

Source: World Bank estimates.

services that are poor, leading to a corresponding loss in human potential.

Weak institutions to support communities and protect biodiversity

Whatever the motive driving settlement onto new lands, important institutional and economic conditions are constant. First, the combination of abundant, inexpensive land and high-cost agricultural inputs (owing to high transport costs and poorly developed markets) creates economic pressure for land-extensive techniques. These include mining the soil nutrients and failing to control soil erosion. Second, government and governance are weak, with much of the frontier population involved in unilaterally staking out claims to forested land. Third, the loss of valuable biodiversity and contribution to global warming do not enter the economic calculation of farmers opening new land.

Under these conditions rapid farm turnover and transience for poor people are nearly inevitable. Poor people lack assets—collateral, access to credit, access to other, nonfarm sources of income, and urban skills—to navigate formal sector input and output markets. As a result a speculator or entrepreneur will almost always, sooner or later, make a purchase offer that the poor homesteader cannot refuse—generally under distress, such as crop failure, death of a family member, or illness.[84] Some poor families escape poverty through repeatedly settling new lands, improving them, and selling out and moving on as the frontier advances. Many more stay locked in perpetual poverty.

The process through which poor people occupy and gain squatters' rights to land, and later sell out to entrepreneurial agents is repeated in many forms and settings. In the *pa boei* system in the Chon Buri hinterland in southeast Thailand, poor small farmers are paid by local entrepreneurs to establish homesteads on federal forest land, with agreements that the land will be turned over to the sponsor after three to five years.[85] Whether formally arranged in advance or resulting from distress sales or different implicit discount rates, this pattern of poor people gaining informal property rights through clearing the forest, and later selling out to the entrepreneurial agent, is common throughout the developing world.[86]

This cycle of transience is embedded deeply in both the educational and social status of the poor settler and the institutional environment of the extensive frontier. Education is rudimentary at best, so the poor homesteader, lacking education and urban skills, has few alternatives. To make matters worse, the predominantly low-input and low-population-density pattern of frontier expansion sharply limits off-farm opportunities. So poor settlers lack insurance and risk-management alternatives, except selling the farm and migrating farther out on the frontier. This generates a destructive cycle for the poor and for forests.

Although social capital might be substantial in frontier settlement areas—especially in settlements where immigrants have moved together from the same community—the capacity to pool risk through collective action is low. Since nearly all poor settlers are engaged in the same activity, they are all subject to the same risks of pests, drought, sickness, and are unable to self-insure as a group.

Getting institutions ahead of the frontier

Most remaining large wilderness areas are in remote areas of low agricultural potential. In these areas measures to remove land from the land market—by establishing parks, indigenous reserves, or biological reserves—reinforce complementary efforts by the national authorities to encourage more intensified production on lands already under cultivation. Setting this land aside has important public benefits. It protects critical ecosystems, and it reinforces economic forces to intensify land use closer to markets. To the extent that it closes the frontier and raises land prices (reflecting decreased land abundance), it discourages nutrient mining, stabilizes communities, and promotes intensified land use. Park creation, the focus of most conservation projects, has achieved considerable success: 13 percent of the world's lowland rainforest is already protected.[87] Such parks can be effective, especially when guards are present and local people are involved or compensated.[88]

Financing the maintenance of protected areas is a concern everywhere. Frequent criticism has been voiced about "paper parks," without adequate infrastructure or staffing. But recent research shows that the mere designation of parks has an important impact on future settlement patterns.[89] Where protected areas are established well ahead of the frontier's advance, a light official presence is enough to stop intruders. Over the next 30 to 50 years, the pressure on the frontier is going to increase initially and then abate as global population stabilizes, and

higher incomes and education create better job opportunities. Avoiding irreversible losses during this ebb and flow will likely have a high payoff for future generations.

Major institutional needs to establish protected areas ahead of the frontier

The major institutional needs are (a) pick up signals of biodiversity loss; (b) balance interests of communities with biodiversity protection; and (c) execute activities to protect biodiversity.

Pick up signals of biodiversity loss. Signals of ecosystem or species loss are difficult to identify locally because the loss is often a part of cumulative effects on a much larger scale. Warning signals of biodiversity loss, such as forest conversion, are being increasingly monitored by government environmental agencies and universities. Specialized monitoring organizations, such as Global Forest Watch, increasingly play a vital role. The Global Environment Fund has been instrumental in developing biodiversity assessments and action strategies in many countries.

Initiatives to promote transparency can help catalyze change. The combination of voice for forest dwellers, better communications technology, and advances in remote sensing means that forest activities are now more visible than before. NGOs and reform groups in government can use this information to call for greater accountability on how logging is conducted and how forest revenues are used. Transparency in the award of concessions and in monitoring concessionaire performance are important steps toward better forest regulation. Recent efforts in Cameroon show both the challenges and the benefits in moving toward transparency (chapter 7, box 7.10).

Balance the interests of communities and developers. Ultimately though, these tools can be applied only if there is popular consensus on regional development strategies and support for policies that set up the necessary incentives and disincentives. Provinces and nations need to debate, for instance, the desirability of intensifying and upgrading rural road networks in densely populated rural areas while restricting the construction of new roads in areas important for biodiversity but poorly suited for agriculture. There are few good examples of this kind of large-scale land-use planning, which goes far beyond the discredited technocratic approach to zoning. It is an area where international resources may be crucial in helping to facilitate domestic agreement on biodiversity-friendly, economically sensible, and socially sustainable regional development approaches. But the agenda has scarcely begun to take shape.

Box 5.13
Brazil: getting ahead of the frontier

One hundred forty million hectares of the Brazilian Amazon, or 28 percent, are in protected areas—national parks, biological reserves, extractive reserves, or indigenous reserves. Analysis based on satellite imagery and field surveys to detect signs of occupation, forestry potential, and high biodiversity values shows that without competitive use, 46 million new hectares (9 percent of the Brazilian Amazon) could be put into biodiversity protection and 70 million hectares (14 percent) into national production for sustainable forestry.

If this were to come about, more than half the Amazon would be dedicated to either preservation or sustainable forest use. Government has pledged to put a representative 10 percent of the Amazon forest (41 million hectares) into new protected areas through the WWF–World Bank Forest Alliance program. And it is developing a National Forest Program to strengthen the forestry system, creating new national forests. The long-run goal is to create a mosaic of land use to control the advance of the agricultural frontier, support communities through sustainable activities, and ensure a strategic buffer for areas of high biodiversity value.

Source: Veríssimo and others (2000).

Experience shows that balancing interests in creating individual parks, protected areas, and forest production reserves is much easier than building consensus on more comprehensive zoning. This is largely a matter of getting far enough ahead of the frontier that development pressure has not yet emerged. Once the protected or reserve area is a going concern, little presence is required to keep it intact.

Even so, setting aside land beyond the frontier will generate resistance from development interests and from local traditional communities. By providing both economic and environmental benefits, a land-use pattern based on a "mosaic" of land use—a mix of production forests, extractive reserves, indigenous lands, and fully protected areas—can help build a constituency of environmentalists, foresters, and forest dwellers, including indigenous peoples (box 5.13). Large protected area initiatives, by contrast, unaccompanied by job-creating alternatives, face formidable politics.

Execute ecosystem protection activities. Areas beyond the frontier can be protected through biological reserves, indigenous reserves, extractive reserves,

or production forests. International resources are helping governments sustain land use and protect biodiversity. For example, with the goal of putting a representative 10 percent of all forest ecosystems into fully protected status and 200 million hectares into certified production forest, the World Bank and the WWF are working with governments and local NGOs to create parks and to create and certify sustainable logging reserves.[90] Brazil's pilot program to conserve the Brazilian rain forest, jointly financed by Brazil, the Netherlands, and the G7, has set the standard for NGO and local people's participation in forest protection activities.

Technical solutions are at hand to ensure the rule of law in areas of difficult access, in part owing to rapid technological advances. Brazil's Proarco and Amazonia Fique Legal programs have shown the technical feasibility of detecting large-scale illegal deforestation through coordination of remote sensing and ground-based inspection. Using satellite detection the state of Mato Grosso has moved vigorously to prosecute illegal deforesters. Brazil and Indonesia have used the Internet to post the location and identities of lawbreakers.[91]

Conclusion

This chapter reviewed some key development challenges for rural areas over the next 30 to 50 years: get ahead of the frontier with biodiversity protection and environmentally and socially sustainable activities in frontier areas; intensify agricultural production; and manage land and water to generate growth, eliminate rural poverty, and prepare outmigrants to be productive urban citizens.

Getting ahead of the frontier

In many countries the frontier's advance reflects a failure in land tenure policy, and the race for property rights leads to excessive farm sizes, underutilization of land, and lack of opportunity in the more favorable areas nearer cities. It also creates incentives to open new land on the frontier.

The results are nearly all negative. First, because of distance, cost, and transience, the ability of governments to provide for human development on a frontier is extremely limited (and thus, frontier people are the big losers). Second, the low cost of land at the frontier leads to extremely extensive agriculture. As long as biodiversity and carbon values are not taken into account in the farmer's decision to open new land, the environmental costs are high. Third, there is a high probability that marginal frontier land being opened up today will be abandoned as uneconomic in the future. This is becoming more evident now than ever, as global food projections indicate little need for additional land to meet anticipated growth in population and incomes.[92]

Getting ahead of the frontier with parks, reserves, and production forests helps end this cycle of transience and low-value land conversion. It stabilizes the frontier economy. It provides incentives for more intensive development nearer to cities. And it reduces needless loss of biodiversity.

Intensifying agricultural production

Intensifying agricultural production and increasing overall agricultural productivity is critical in much of the developing world, in response to rising populations and food demand. It can also be highly desirable. It can reduce pressure for expansion in wilderness areas and remaining areas of natural habitat within settled regions (in conjunction with conservation initiatives)—thus reducing pressure on biodiversity. It increases the food available to the cities and it leads to dynamic rural-urban linkages. Higher population density and strong rural-urban linkages make investments in health and education more effective in rural areas, increase the potential for off-farm employment, and help farmers accept risk and innovate. These arguments all support a tenure policy promoting relatively small, owner-operated farms.

In areas closer to rural towns and cities, nonfarm rural employment will be a powerful force for diversifying income, allowing greater risk and investment. It can also act as a stepping stone for the rural worker to enter productive urban employment. Rental arrangements should thus be encouraged to allow young "starter" farmers access to land and often to credit. Shareholding arrangements, effective for starter farmers to share risk with the landowner, should not be discouraged.

Eliminating rural poverty and preparing outmigrants

In poor developing countries with large agricultural sectors, growth led by the agricultural sector has a powerful effect in pulling people out of poverty, especially when the incomes and assets of the rural sector are somewhat equal. Smallholders with assets develop voice and become political players. History

has shown that this generates an inclusive development path that helps countries face later challenges. But getting assets into the hands of smallholders requires good land and water policies. These policies also enable poor people to get access to opportunities for building their human and social capital.

The value of assets is enhanced through agricultural research directed to poor people, and through better agricultural institutions. In Africa improving agricultural institutions may depend on strengthening the asset value first—with water control and transport infrastructure, and with a concerted program of fertility enhancement. A reasonable estimate for the cost of a program to scale up currently successful models is $100 million annually for 10 years. Many countries will follow a two-pronged strategy that encourages intensification and commercialization. This strategy would also promote intensified research to adapt staples for high-input agriculture in productive areas near urban markets and transport, and encourage minimal chemical fertilizer supplements for low-input agriculture in more remote areas.

This strategy will require reforms in both developing and developed countries, however. The developing-world farmers produce in a world market where world agricultural prices are depressed some 12 percent by tariff barriers and agricultural subsidies worldwide—but mainly in industrial countries. For many farmers in high-transport-cost developing countries, this may translate into a difference in farmgate prices of 50 percent or more.[93] Similarly, developing countries' farmers suffer from lack of agricultural knowledge. As noted in chapter 4, only 28 percent of public and private agriculture research and development is applied to tropical agriculture. Sustained agricultural progress in developing countries will require a long-term national and donor commitment to the agricultural "knowledge triangle"—agricultural research, extension, and higher education. A development strategy based on strengthening rural institutions and a strong smallholder sector will also facilitate eventual migration to cities. As will be discussed in chapter 6, cities must also be prepared to deal with new migrants.