FOCUS 4

PROMOTING SUSTAINABLE DEVELOPMENT IN LESS-FAVORED AREAS

EDITED BY JOHN PENDER
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"A 2020 VISION FOR FOOD, AGRICULTURE, AND THE ENVIRONMENT" IS AN INITIATIVE OF THE INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE (IFPRI) TO FEED THE WORLD, REDUCE POVERTY, AND PROTECT THE ENVIRONMENT.

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A 2020 Vision for Food, Agriculture, and the Environment
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Promoting Sustainable Development in Less-Favored Areas

Overview

John Pender and Peter Hazell

Focus 4 • Brief 1 of 9 • November 2000

Poverty, low agricultural productivity, and natural resource degradation are severe interrelated problems in less-favored areas of the tropics. Less-favored areas include lands that have low agricultural potential because of limited and uncertain rainfall, poor soils, steep slopes, or other biophysical constraints, as well as areas that may have high agricultural potential but have limited access to infrastructure and markets, low population density, or other socioeconomic constraints (see figure). In other words, less-favored lands may be less favored either by nature or by man.

According to a recent study by the Technical Advisory Committee of the Consultative Group on International Agricultural Research, nearly two-thirds of the rural population of developing countries—almost 1.8 billion people—lives in less-favored areas, including marginal agricultural areas, forest and woodland areas, and arid areas. These areas include most of the semiarid and arid tropics of Africa and South Asia, mountain areas in South America and Asia, much of the highlands of East and Central Africa, hillside areas in Central America and Southeast Asia, and large portions of the humid tropics of Africa and Latin America. The available evidence suggests that most of the rural poor in developing countries live in these less-favored areas. Low agricultural productivity and land degradation are severe in these areas. Cereal yields of less than one metric ton per hectare are common, and deforestation, overgrazing, soil erosion, and soil nutrient depletion are widespread.

Classification of Favored and Less-Favored Areas

Access to infrastructure and markets	Agricultural potential: High	Agricultural potential: Low[b]
High	Favored areas	Less-favored areas
Low[a]	Less-favored areas	Less-favored areas

[a]Socioeconomic constraints
[b]Biophysical constraints

The conventional wisdom in policy circles has said that strategies for development in developing countries should emphasize public investments in favored areas. Many experts have believed that returns to investment would be greatest in favored areas and that increased food production and rapid economic growth in these areas would ensure food security and allow people to migrate out of less-favored areas, reducing poverty and pressure on the resources in such areas.

This conventional wisdom is being increasingly challenged. Despite large investments in favored areas and rapid urbanization in most countries, rapid population growth continues in less-favored areas. Poverty and resource degradation have worsened in these areas, while investments in favored areas have faced diminishing returns and increased social and environmental problems. The threat of famine is severe in many less-favored areas, and resource degradation appears to be contributing to this threat.

Although less-favored areas often have an absolute disadvantage in producing many types of crops compared with favored areas (that is, productivity is lower than in favored areas), they usually have a comparative advantage in some type of agricultural production or in nonfarm activities (that is, production is profitable given alternative uses of the land and labor of people in these areas). The diversity of situations in less-favored areas can allow them to exploit their different comparative advantages, provided that necessary investments in infrastructure and institutions are made. Increasing evidence suggests that investments in less-favored areas can yield relatively high rates of economic return and significantly reduce poverty in some countries. Anecdotal evidence also suggests the possibility of reducing resource and environmental degradation alongside economic growth and poverty reduction. However, the evidence on such strategies is still very limited.

IFPRI commissioned this set of policy briefs to assess the potential of achieving sustainable development in less-favored areas and to suggest the technology and policy strategies needed to realize this potential. Although there are large gaps in knowledge about the underlying causes of the problems facing less-favored areas and the appropriate strategies to address them, several key lessons emerge from these assessments:

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1. *Less-favored areas offer opportunities for socially profitable investments.* Brief 5 cites research showing high returns to various kinds of public investment in lower-potential areas of China and India (in many instances higher than returns to investments in favored areas), in terms of both economic growth and poverty reduction. Investments in agricultural research and development, education, roads, and irrigation had greater incremental impact in less-favored areas in these countries, in part because the opportunities for investment in these areas had been neglected.
2. *The success of alternative investments in less-favored areas depends upon differences in comparative advantage across these diverse areas.* Given the variety of situations in less-favored areas, no one-size-fits-all strategy is likely to succeed everywhere. Three factors are particularly important for determining comparative advantage: agricultural potential, access to markets and infrastructure, and population density. In less-favored areas having high agricultural potential but poor market access—as in much of humid West Africa, parts of the East African highlands, and the Southeast Asian uplands—high-value nonperishable perennial crops such as coffee, cocoa, or oil palm often have a comparative advantage. Areas with low crop production potential are likely to have comparative advantage in extensive livestock production, particularly if they are far from markets and not densely populated, as in much of semiarid West Africa and the Altiplano of the southern Andes. In remote areas where population densities are greater, mixed-crop livestock production is more important, even where crop production potential is low, as in parts of the East African highlands. Areas with low crop production potential but good access to markets—as in periurban areas of semiarid India and other low-potential areas—are likely to have a greater comparative advantage in forestry, intensive livestock production, or nonfarm activities. Development strategies will be more successful if they recognize and build upon such comparative advantages.
3. *Strategies for developing and disseminating technologies must take into account the special characteristics and demands of less-favored areas.* A high degree of diversity in biophysical and socioeconomic conditions is one of the main challenges. Other challenges may include susceptibility to droughts, pests, diseases, temperature extremes, and other risks; the fragility of land and other resources; remoteness from markets and services; and the subsistence orientation of farmers in these areas. A technological strategy should therefore be participatory and demand driven, stimulating and building upon farmer innovation and adapting to local circumstances. Technologies that help reduce risks (by increasing tolerance to drought, pests, or frost, for example) and conserve and improve resources may be more effective than those that simply promote high yields in response to high levels of inputs.
4. *Sustainable and profitable technologies are needed to conserve and efficiently use scarce water, control erosion, restore soil fertility, and increase the supply of useful biomass.* Such technologies are often labor or land intensive (such as terrace building) and may be unattractive to farmers where labor costs are high or where land is scarce. Labor- or land-saving technologies such as improved fallows during a short rainy season or agroforestry on farm boundaries may have more potential. In areas with limited rainfall, scarcity of biomass and high demands for alternative uses of biomass (for fodder and fuel, for example) limit the potential of many organic approaches to land management. In such circumstances, technologies and policies for conserving water and profitably increasing the production of useful biomass (such as promotion of woodlots) should have high priority.
5. *Strategies for less-favored areas will be most effective if they are linked to the development pathways that have comparative advantage in particular circumstances.* Small-scale irrigation development is likely to yield the highest returns in areas with good market access and otherwise suitable soil conditions, since this can enable high-value crop production as well as intensified food crop production. Road development is likely to have the highest returns in densely populated areas with good agricultural potential but limited market access, by enabling marketing of high-value commodities and inputs for these. Improved management institutions for common property resources such as community grazing lands or woodlots are critical in many less-favored areas, particularly low-potential areas with limited opportunity to increase crop productivity. Investments in education and training are also important, particularly in low-potential areas with limited market access, where emigration is likely to be an important element of people's livelihood strategies for the foreseeable future.

No single strategy will work in all less-favored areas. However, all effective strategies will require investments in physical, human, natural, or social capital. The key is to identify and implement the appropriate portfolio of such public and private investments for different circumstances in less-favored areas. Achieving this goal requires more than simply new technologies or policies. It requires responsive and effective institutions to mobilize such investments and to ensure accountability, efficient management, and equitable distribution of benefits. Progress is being made in this direction as a result of recent trends toward decentralization and improved governance in developing countries. Still, the challenges remain great, even if potentially profitable strategies are identified. ■

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PROMOTING SUSTAINABLE DEVELOPMENT IN LESS-FAVORED AREAS

TECHNOLOGIES FOR THE EAST AFRICAN HIGHLANDS

FRANK PLACE

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The East African highlands consist of areas above 1,200 meters in Burundi, Ethiopia, Kenya, Rwanda, northern Tanzania, and Uganda. They occupy about one-fourth of the land area in East Africa and are home to 53 percent of the population of these countries. Rural population densities in the East African highlands are the highest in Africa (well over 500 per square kilometer in areas). As a consequence, farm sizes are small throughout the highlands, averaging around one hectare. Most of the highlands have favorable rainfall compared with the rest of Africa. Rainfall averages over 1,000 millimeters per year in most of the highlands, and many sites have two growing seasons ("bimodal highlands"). There are a variety of soil types, though most are clayey with relatively good stability. As a consequence, most of the highlands are considered to be medium- to high-potential areas and are expected to be major breadbasket regions. Topography of the highlands varies widely, often within small geographical areas. Much farming takes place on steeply sloping land.

A large range of agricultural crops is found in the highlands, especially in the bimodal highlands, where cash crops such as tea, coffee, dairy, sugar cane, fruits, and other horticultural crops are common. In the drier zones, these crops are less profitable and less common. The chief food crops are maize, banana, beans, teff, wheat, sorghum, cassava, and potatoes. Individual farms in most of the highlands grow a diverse set of crops, regardless of how commercially oriented the farm or region. The highlands attract a good share of regional agricultural research resources. Many countries have strong national research programs, along with international centers and nongovernmental organizations (NGOs) involved in technology development.

KEY ISSUES FOR SMALLHOLDER AGRICULTURE

At the farm level, the core problems are much the same as elsewhere in Sub-Saharan Africa: the complex reinforcing problems of poverty, low agricultural productivity, and natural resource degradation. Poverty is widespread in the highlands and has been exacerbated by civil strife in Ethiopia, Uganda, and especially Burundi and Rwanda. Actual crop yields, especially of food crops, fall much below their potential. Low agricultural productivity is related to poverty, which leads to use of inferior seeds, lack of irrigation, lack of fertilizer use, and increased pests and diseases. Soil fertility decline through nutrient depletion and soil erosion is pervasive. Major pests and diseases have recently expanded, including coffee wilt, potato blight, cassava mosaic, and striga and stem borers in maize.

PROSPECTS FOR IMPROVED AGRICULTURAL TECHNOLOGY IN THE HIGHLANDS

The types of technologies that are feasible and effective depends on the agroclimatic environment. It is useful to distinguish two highland zones: (1) high-potential areas with bimodal and high average rainfall and soils that are not highly acidic, and (2) low-potential areas, mainly the drier highland areas. A further distinction will be made according to the degree of market access, as this affects the profitability of different technologies.

High-Potential Highlands

Given the wide range of enterprises and the relatively less risky ecological environment in the high-potential highlands, technologies that increase the productivity of existing enterprises are highly beneficial and attractive to small-scale farmers. Such technologies or packages must be low cost, since credit is largely unavailable to smallholders, but farmers have some flexibility with land and labor if good opportunities arise.

Rising productivity may result from technological change related to any of the following areas: improved crop, tree, and livestock germplasm or breeds, better pest and disease control, improved soil fertility, better conservation of soils, and improved water management.

The largest efforts by national research systems, as well as by a number of international research programs, are geared toward improved crop germplasm. Breeding programs have increased yields and improved resistance to pests and diseases: recently released varieties include wilt-resistant coffee, high-yielding maize, and blight-resistant potato. The literature suggests that among smallholders, pest- and disease-resistant germplasm have had more impact than high-yielding varieties. The response of the high-yielding varieties on-farm has been disappointing, owing in part to poor soil fertility.

The Kenyan highlands are Africa's success story with respect to improved dairy cattle. Several projects supply highland communities with high-quality bulls; recipients pay back with calves instead of cash. Growth in dairy production is currently high in Uganda, and the domestic market has high potential for growth in most countries of East and Central Africa. Production of other types of livestock is also growing.

Aside from breeding, other methods have been used to further address pest and disease problems. Two traditional methods, crop rotation and intercropping, are being modified or reintroduced in some cases. Examples include mucuna-maize and faba bean–wheat rotations in Ethiopia. Tephrosia is also being used to ward off moles and insects, and neem products are used to thwart several pests. Most of these technologies have had only localized effects, because scaling them up to wider areas requires considerable informational efforts.

Soil fertility is a major problem. Lack of cash and inefficient markets keep small farmers from using more fertilizer, except for the most profitable crops. As a result researchers are working to identify inexpensive ways of improving nutrient management and organic nutrient production, such as improved fallows, biomass transfer, crop residue management, manure management, and composting. Improved fallow systems have a niche during the short rainy season in the bimodal highlands and are labor saving, whereas biomass transfer, crop residue management, and composting are more labor intensive. There is also a limit on the biomass produced under such transfer systems, but farmers have used them on smaller plots of higher-value crops.

The vast sloping areas of the highlands mean that for long-term sustainability of agriculture, soil conservation is called for. Current solutions range from labor-intensive bench terracing to less labor-demanding natural vegetative strips. Stone walls and perennial tree crop systems also play an important role. Use of soil conservation measures is common in Kenya, where heavy government investment has taken place. However, little diffusion or adoption occurs in the region in the absence of such public investment. Less costly methods such as natural vegetative strips seem to offer more promise.

There is large untapped potential for irrigation in the highlands. Indigenous systems are still found among smallholders on Mount Kilimanjaro, though many are in need of renovation. Most other irrigation has either been set up by governments on a pilot basis or been established by larger-scale commercial farmers. Pump technology is not common and is restricted to wealthier farmers. Simple irrigation techniques for small home gardens are being tested, but it is too early to tell how promising they may be.

Low-Potential Highlands

Low-potential highlands suffer from low and unreliable rainfall, allowing for only a single growing season and limiting the range of profitable enterprises. In areas where markets are functioning reasonably well, expanding the set of income-generating enterprises may be more important than in the high-potential areas since new enterprises can help to reduce farmers' exposure to climatic or market risks.

Much of what was said about germplasm improvement for the high-potential highlands also applies in the low-potential highlands. There is high demand for germplasm that is tolerant of pests and diseases as well as drought tolerant. Examples of farmer adoption of such varieties exist (such as mosaic-tolerant cassava), but drought-resistant local varieties offer strong competition. There is less adoption of higher-grade livestock in the low-potential zone except in areas with good market access, where savings in transport costs can overcome more costly production. Trees offer some potential in this zone because their dense and deep rooting systems normally enable them to provide some products even in drought conditions. Production of wood, nuts, and fruits are examples of attractive opportunities in areas of good market access in this zone.

Low soil fertility is again a serious problem in the lower-potential highlands. The use of mineral fertilizers is lower in this zone because of the lack of cash crops in the farming systems, lower expected payoffs, and higher risks than in high-potential areas. Aside from animal manure, organic methods of supplying nutrients are also more problematic. Biomass transfer, crop residue management, and composting systems suffer from a timing problem, since a single rainy season prevents biomass from being grown in one season for use in the following season. Improved fallows are only feasible in areas where farm sizes are sufficiently large to permit longer-term fallowing. In densely populated low-potential areas, the demand for organic materials for animal fodder or fuel is high, and these materials are often scarce, limiting their availability for soil fertility management.

Soil conservation efforts are needed in the lower-potential zones as well. There is potentially more scope for labor-intensive conservation measures, provided that the work can be undertaken in the off season and that there is a slack labor period at the time. In addition, because they conserve scarce water, soil conservation structures often are more profitable in lower-rainfall areas. Natural or planted vegetative strips may not be as suited to low-potential areas, since they take time to establish and become effective, but they are attractive in some areas. Many farmers do invest in conservation structures in parts of the highlands, but they are often poorly maintained or not widely adopted.

In the drier highlands, water management is an important issue. Where such areas are fed by wetter highlands, population pressure in the wetter areas generates increased competition for water. In other areas individual farmers are pumping water from streams, shallow wells, and small ponds, using simple drip irrigation for small plots and using small microcatchments for single or multiple plants. Some of these technologies are capital intensive and restricted to use by wealthier farmers.

In conclusion, lower and more risky productivity in the lower-potential highlands means that technologies cannot aim strictly at enhancing the profits of existing enterprises. Successful technologies must also reduce risks to farmers. Improved water harvesting and management techniques are key, as are those that can either reduce labor during the rainy season or offer income during the dry season. ■

For further information see *AgriForum,* a newsletter of the Association for the Strengthening of Agricultural Research in East and Central Africa (ASARECA), which can be accessed at www.asareca.org/html/agrfrm.html or by contacting ASARECA at P.O. Box 765, Entebbe, Uganda, or at asareca@imul.com; *SPORE,* a newsletter of the Centre Technique de Cooperation Agricole et Rural (CTA), Wageningen, Netherlands, which can be accessed at www.agricta.org/spore/index.html or by emailing cta@cta.nl; and D. Hoekstra and J. D. Corbett, "Sustainable Agricultural Growth for the Highlands of East and Central Africa: Prospects to 2020" (International Food Policy Research Institute, Washington, D.C., 1995), mimeo.

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PROMOTING SUSTAINABLE DEVELOPMENT IN LESS-FAVORED AREAS

TECHNOLOGIES FOR THE TROPICAL ANDES

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The heterogeneity of the tropical Andes has spawned many systems of agroecological classification, but the criterion that most effectively separates favored from less-favored areas is latitude. Proximity to the equator eliminates seasonal temperature change. In the northern Andes, rainfall is possible in any month of the year. In the southern Andes, both temperature and rainfall regimes are seasonal, and frost and drought determine the length of the growing season and periodically threaten crop production.

Seasonality defines the two great high-altitude grassland systems known as the Páramo and the Puna. The dividing line for these two systems crosses northern Peru at about the latitude of Cajamarca (see figure). We use this point of reference to group the tropical highlands above 1,500 meters into the northern and southern Andes. We briefly discuss technological change in the northern and southern Andes before focusing on the Altiplano, the least-favored production region of the southern Andes.

THE NORTHERN AND SOUTHERN ANDES

In the northern Andes, adequate natural resource endowments of temperature, rainfall, and soils have set the stage for some impressive examples of intensification in response to increasing population pressure and market access. The most outstanding examples are the thriving cut-flower industries in Colombia and Ecuador.

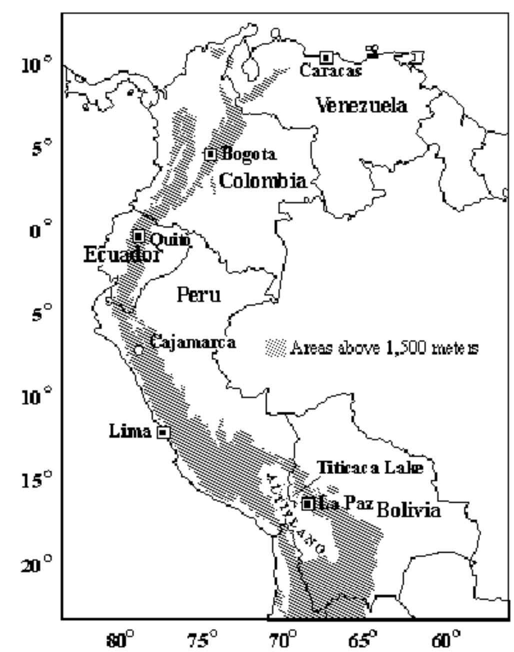
Pests and diseases potentially exact a toll on production in the northern Andes. These threats can be managed, however, by using disease-resistant varieties or more costly but still remunerative inputs. In spite of a moderately high incidence of these biotic stresses, specialized areas of potato production have emerged in the highlands of Colombia and Ecuador where yields of 20 (or more) tons per hectare are common and where it is possible to cultivate rain-fed potatoes throughout the year. In most cultivated regions of the northern Andes, applying inorganic fertilizer pays not only on high-value and fertilizer-responsive horticultural crops but also on cereals.

In contrast to the northern Andes, the rural residents of the southern Andes are significantly poorer than those in other regions of the same countries. In the southern Andes, drought is accentuated by the cyclical occurrence of El Niño.

THE ALTIPLANO

The least-favored production environment in the southern Andes is the Altiplano, a high plains region encompassing Lake Titicaca and extending nearly 800 kilometers from north to south with a width of about 200 kilometers (see figure). Three-quarters of the Altiplano lies between 3,600 and 4,300 meters above sea level. Most land is in unimproved pasture. Potato accounts for the lion's share of value of production among native Andean and introduced crops cultivated on the Altiplano.

THE TROPICAL ANDES ABOVE 1,500 METERS



Conditions for crop production are harsh. Drought, hail, and frost are frequent visitors. Floods can severely damage crops on the relatively fertile, flat perimeter of Lake Titicaca. Degraded soils are common; salinity is endemic in some areas.

The comparative advantage of the Altiplano is in the extensive grazing of livestock, mainly sheep, cattle, and alpacas. Compared with crops, livestock has greater commercial potential because of the availability of frost-tolerant forages, the abundance of rangeland in the drier, colder subregions, and the higher value of meat and fiber that respond to the economic reality of distant markets. But the Altiplano is not the ideal place to raise all species of livestock, especially small nonruminants. For example, guinea pigs, a prized source of meat in the Andes, have better commercial prospects in lower-elevation highland areas where the reduced requirements for maintenance energy are conducive to weight gain.

The importance and relevance of agricultural research is derived from the large number of poor, mainly indigenous peoples, who make up the majority of the Altiplano's 2.2 million residents. About 65 percent of the economically active population is engaged in agriculture. Since the 1970s, seasonal migration of working-age adults has been evolving into permanent emigration to the land-abundant rainforest and the coastal cities. Remittances are low or have not been used to invest in agriculture; therefore, the migration of labor has eroded productive capacity.

The harshness of the environment for crop and livestock production is mirrored by the limited adoption of improved practices and varieties. It pays to apply inorganic fertilizer to potatoes in good years; however, good years are not the norm, and amounts applied are very small. High- and stable-yielding potato varieties widely cultivated in the rest of the southern Andes of Peru have not been able to penetrate into the Altiplano, where native varieties and low-yielding frost-resistant cultivated species prevail.

In the rest of the semiarid tropics, it is possible to transform production potential with irrigation. Not so in the Altiplano, because cold temperatures impede sequential cropping.

Scanty evidence for the uptake of improved technologies may suggest an absence of investment in agricultural research. Indeed, more stability in research could have helped improve impact, and public sector support for extension has been weak. However, since 1970 considerable funds have been allocated to research on Andean commodities. Several hundred theses have been written on "forgotten" Andean crops at agricultural universities, mainly in Peru. Since 1975 one donor has invested in more than 20 development-oriented research projects on or near the Altiplano. Regional scientists and farmers have been trained. Germplasm of Andean crops has been conserved. The research process has improved. Regional and local institutions have been strengthened. But the record on practical impact has been disappointing. Farmers have accepted few technologies. Productivity is flat or fluctuates in response to climatic events associated with El Niño. Moreover, rehabilitation of neglected labor-intensive terraces and raised beds designed to improve production potential in other times has required hefty subsidies to achieve targets.

A few production-oriented projects have also negatively affected production potential. Investment in poorly designed irrigation in the wake of the severe drought caused by the 1983 El Niño event resulted in salinity damage in some areas. Indiscriminate disc plowing to accommodate an increasing demand for quinoa, an Andean grain, has been indicted for accelerating wind erosion.

Nevertheless, there have been some successes in the past, and others are unfolding in the present. Improved temperate dairy breeds have been widely adopted. White clover, alfalfa, and other forage crops have been introduced in limited areas to improve forage quality. The production of alpaca fiber has increased from sire exchange among herds and from community investment in wetland areas for forage. The early acceptance of rustic greenhouses has been encouraging. Revolving funds for the purchase of higher-quality seed of selected native varieties of Andean crops have also met with some success. An export market for quinoa is emerging, and preferences are for white bold-seeded types that grow in the very dry conditions of the southern Altiplano.

Some promising technologies are in the pipeline. Several frost-resistant potato varieties are nearing the release stage in Bolivia. Halophytic plants could markedly improve feed supplies and rehabilitate saline areas. Low-cost shelters for livestock can substantially reduce energy loss during cold nights. Research on cold-tolerant forage crops and on range management of native grasslands also has bright prospects. Advances in information technology featuring computer simulation models built on digital databases and satellite imagery and incorporating GIS techniques are increasingly helping to define problems, evaluate risk, and design technologies.

The generation of new, low-cost, divisible components to improve the management of crops in cold temperatures is one of the foremost priorities in technology design. For instance, some impressive gains have been recorded in marginal production areas of China with the use of clear plastic mulch that has extended the length of the growing season and fueled the so-called White Revolution in maize. Several such techniques that have worked well in the production of crops in cold-growing conditions could be adapted to the Altiplano.

Biotechnology has been widely touted as a means to enhance plant resistances to abiotic stresses such as drought and frost. However, these stresses are poligenic, and few transgenes have been identified. Also, opposition to the use of transgenic varieties of Andean crops in or near the Altiplano, where many of the Andean crops were first domesticated, is strong on the grounds that it may threaten biodiversity. At this time in potato breeding, a more feasible prospect appears to be to increase the market value of frost-resistant cultivated species—that is, enhance the sweetness of bitter potato. Molecular-marker technology will eventually contribute to improving the efficiency of conventional breeding, but the question is when. Private sector investment in plant breeding could also contribute to productivity growth when cost-effective ways for hybridization of Andean crops are found.

Greater market access holds the key to unlocking production potential. Freer trade among Bolivia, Brazil, and Peru will enhance the competitiveness of trout farming and vegetable growing in and around Lake Titicaca. Continued progress in road construction will increase this remote region's comparative advantage vis-à-vis irrigated coastal and rainfed inter-andean valleys. ■

For further information see Luis Argüelles and Ruben Dario Estrada, *Perspectivas de la investigación agropecuaria para el Altiplano* (Lima, Peru: Proyecto de Investigación en Sistemas Agropecuarios Andinos, 1991).

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Promoting Sustainable Development in Less-Favored Areas

Technologies for the Southeast Asian Uplands

Sushil Pandey

Focus 4 • Brief 4 of 9 • November 2000

Uplands in Southeast Asia account for about 50 million hectares with over 100 million people directly dependent on them. Rice is a major food crop in the uplands, and the food security of upland people depends on its production. Total rice area in the uplands of Southeast Asia is estimated to be 4 million hectares. Countries in this region include Cambodia, Laos, Myanmar, the Philippines, Thailand, and Viet Nam. Population density in these countries varies from 20 per square kilometer in Laos to 225 per square kilometer in the Philippines. Uplands are highly heterogeneous with the climate varying from humid to subhumid and the soils varying from fertile to highly infertile. Uplands also include flat to steeply sloping areas. Cultivation practice ranges from shifting to permanent cultivation. The crops grown in the uplands also vary across these environments. Despite this diversity, a general feature of the upland system is that it is inhabited by very poor farmers who grow food crops mainly for subsistence using very few inputs other than labor. Upland areas are often remote with poor access to markets. They are also generally inhabited by ethnic minorities who are often socially and politically disadvantaged.

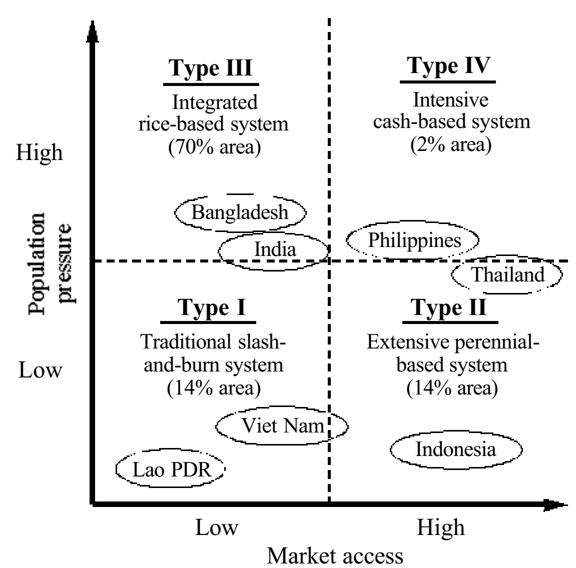
In addition, upland areas suffer from a number of resource degradation problems such as deforestation and erosion. Property rights to land and forest resources are often poorly defined and enforced. In some cases, indigenous systems of land rights are being eroded because of public sector interventions, excessive immigration, and high rates of natural population growth. High population pressure, low agricultural productivity, and resource degradation in the uplands of Southeast Asia pose real challenges for designing development strategies that alleviate poverty in a sustainable manner.

Any strategy for achieving poverty alleviation in upland environments must stimulate growth in agricultural productivity, raise incomes, and conserve resources. Current agricultural productivity is low. For example, the yield for rice, an important food crop in the uplands of Asia, is only 1.1 metric tons per hectare compared with 4.9 metric tons per hectare for irrigated areas. The traditional system of slash-and-burn based on fallow periods in excess of 20 years has been replaced by short fallow—in some cases less than two years—owing to increased population pressure. Technological and institutional interventions to improve the yields of major staples are needed to increase overall food production. At the current low level of income (for example, US$78 per capita per year in the uplands of northern Viet Nam), enhancing food security and alleviating poverty will also require generating additional sources of income, particularly where environmental constraints limit opportunities to increase food production. Finally, various developmental activities in environmentally fragile upland areas must be resource conserving so that long-term growth can be sustained.

TYPOLOGIES OF UPLAND RICE SYSTEMS

A typology of upland rice systems of South and Southeast Asia can be created based on population density and the degree of market access (see figure). In this idealized typology, increasing population pressure pushes farming systems to become more intensive and sedentary. Increasing market access moves the systems toward more commercial production of nonrice crops. In areas with low population pressure and limited market access, the traditional system was shifting cultivation with long natural fallow, but these areas are declining because of increasing population pressure and political reactions against unsustainable slash-and-burn cropping. Integrated rice-based systems, where upland rice is grown in rotation with a range of annual crops in permanent fields, are found in situations with high population pressure but limited market access and are the dominant systems in Asia. In areas with greater access to markets, opportunities exist for development based on

A Typology of Upland Rice Systems



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cash-cropping although food production may still be an important component of the farming systems. Type I, Type II, and Type IV systems predominate in Southeast Asia, while the Type III system is found mostly in South Asia. In both Type I and Type III systems, improving the productivity of upland rice can be an important starting point for addressing the problem of poverty. For other types of upland systems, plantation crops and other cash crops are likely to be the dominant components of farming systems even though rice will remain important for food security.

TECHNOLOGICAL OPPORTUNITIES

The major biophysical constraints to the growth of rice yields in the uplands of Southeast Asia are drought, weeds, blast (a fungal disease), nematodes, and infertile soils, which are deficient in phosphorus and are generally acidic. In addition, soil erosion is an important problem, especially in sloping uplands. While improving rice germplasm will affect the rice crop only, improving soil fertility will help make other crops more productive as well.

Technology research for germplasm improvement at the International Rice Research Institute and collaborating partners in various countries is focused on developing varieties that escape, tolerate, and resist drought. Short-duration varieties that mature before the end of the rainy season escape the damaging late season drought that occurs in some areas. Varieties that tolerate and resist drought are needed for areas where intermittent drought can occur anytime during the growing season. Researchers are studying physiological mechanisms for drought resistance and using molecular tools to identify genes that impart such resistance. While this prebreeding work should ultimately reduce production losses to drought, most of the modern varieties currently being adopted in Asian uplands are shorter-duration varieties that escape drought. The adoption of these varieties has, however, remained somewhat limited because of other constraints including the unavailability of seeds.

Weeds and blast are two other major constraints to the production of upland rice. Manual weeding is extremely labor intensive, but most farmers cannot afford chemicals for weed control. As most of the losses to weeds occur during the early stages of crop growth, rice varieties with high seedling vigor that establish themselves rapidly are being developed to reduce the competitive effects of weeds. Similarly, allelopathic rice varieties that smother weeds through toxic chemical exudates are being evaluated. In addition to these germplasm-based weed control measures, various weed management strategies that combine tillage, crop rotation, and manual weeding are being evaluated.

For tackling soil fertility problems, the focus of research is on understanding long-term nutrient dynamics in upland soils, with particular emphasis on phosphorus. Researchers are also focusing on nutrient management in drought-prone soils, particularly the effects of nutrients on alleviating drought-induced yield reductions. Scientists are developing nutrient management strategies that rely on biological principles of nutrient cycling and assessing how such strategies can complement or substitute for external sources of nutrients. Research has shown that rice can yield three to five metric tons per hectare if adequate quantities of nutrients, particularly phosphorus, are provided in these poor soils. Similarly, technologies for controlling soil erosion are being developed and evaluated. A socioeconomic study of adoption of contour hedgerows for soil erosion control identified several factors, such as the security of tenure, farm size, and educational status of farmers, as critical determinants of adoption. Contour hedgerows were found to be effective in controlling soil erosion and increasing farmers' incomes in places that are more accessible to markets. The use of contour hedgerows for controlling soil erosion has, however, not been widespread as its profitability is somewhat location-specific.

An important technological intervention with high potential for impact in the uplands is agroforestry. A suitable combination of annual and perennial plants can help maintain soil fertility, because perennial crops help recycle nutrients and reduce soil erosion. In addition, perennial plants such as fruit trees can be an important source of cash income to poor upland farmers. The success of agroforestry-based intervention, however, depends on access to markets and the security of land tenure.

AN OVERALL STRATEGY FOR UPLAND DEVELOPMENT

While improved crop and resource management technologies are important for the development of Asian uplands, institutional and policy interventions also play critical roles. Upland areas must develop effective economic linkages with the national economy to enhance food security and income growth. Enabling policy and institutional environments are needed to encourage activities such as horticulture and agroforestry for which the uplands have a comparative advantage. Such policy interventions include development of infrastructure and marketing institutions and reform of property rights institutions. Much of the degradation of upland environments can be arrested or at least slowed through watershed-based development that recognizes the role of community participation in managing various resources within the watershed. Policies and technologies that encourage diversification to exploit the agroclimatic niches that exist in these heterogeneous and diverse environments hold much promise for sustainable poverty alleviation in Asian uplands. ■

For further information see C. Piggin et al., "The IRRI Upland Rice Research Program: Directions and Achievements," IRRI Discussion Paper Series No. 25 (Los Baños, Philippines: International Rice Research Institute, 1998).

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A 2020 Vision for Food, Agriculture, and the Environment

PROMOTING SUSTAINABLE DEVELOPMENT IN LESS-FAVORED AREAS

RETURNS TO PUBLIC INVESTMENT: EVIDENCE FROM INDIA AND CHINA

SHENGGEN FAN AND PETER HAZELL

FOCUS 4 • BRIEF 5 OF 9 • NOVEMBER 2000

Conventional wisdom suggests that the productivity returns to investment are highest in irrigated and high-potential rainfed lands and that growth in these areas has substantial trickle-down benefits for the poor, including those residing in less-favored areas. Even though investing in less-favored lands might have a greater direct impact on the poor living in those areas, it is argued that investments in high-potential areas give higher social returns for a nation than investments in low-potential areas. The logic behind this position is as follows. Investment in high-potential areas generates more agricultural output and higher economic growth at lower cost than in less-favored areas. Faster economic growth leads to more employment and higher wages nationally, and greater agricultural output leads to lower food prices, both of which are beneficial to the poor. Less-favored areas will benefit from cheaper food, from increased market opportunities for growth, and from new opportunities for workers to migrate to more productive jobs in the high-potential areas and in towns. Fewer people will try to live in less-favored lands, and this will help reduce environmental degradation and increase per capita earnings. Migrants may also send remittances back to less-favored areas, further increasing per capita incomes there, especially for the poor.

Many of the expected benefits arising from rapid agricultural growth in high-potential areas have been confirmed through empirical research. Nevertheless, the rationale for neglecting less-favored areas is being increasingly challenged by: (1) the failure of past patterns of agricultural growth to resolve growing poverty, food insecurity, and environmental problems in many less-favored areas; (2) increasing evidence of stagnating levels of productivity growth and worsening environmental problems in many high-potential areas; and (3) emerging evidence that the right kinds of investments can increase agricultural productivity to much higher levels than previously thought in many less-favored lands. It now seems plausible that increased public investment in many less-favored areas may have the potential to generate competitive if not greater agricultural growth on the margin than comparable investments in many high-potential areas and that these investments could have a greater impact on the poverty and environmental problems of the less-favored areas in which they are targeted. If so, then additional investments in less-favored areas may actually give higher aggregate social returns to a nation than additional investments in high-potential areas. In fact, they might offer win-win-win possibilities (that is, more growth, greater poverty reduction, and better environment).

To test this hypothesis, IFPRI recently analyzed the agricultural production and poverty alleviation impacts of different types of investments in high- and low-potential areas in India and China. Unfortunately, the available data did not permit a comparable analysis of the environmental impacts of public investments in these two countries. India and China are good examples to study because, like many other Asian countries, past public investments have been biased toward high-potential areas, and the remarkable productivity gains achieved in those areas (which led them from acute national food shortages to current surpluses) can now be juxtaposed against the lagging productivity and poverty, food insecurity, and environmental

TABLE 1
MARGINAL RETURNS TO INFRASTRUCTURE AND TECHNOLOGY INVESTMENTS IN RURAL INDIA

Investment	Irrigated Areas	High-Potential Rainfed Areas	Low-Potential Rainfed Areas
	(production return in rupees per unit of investment)		
High-yielding varieties[a]	63	243	688
Roads[b]	100,598	6,451	136,173
Canal irrigation[a]	938	3,310	1,434
Private irrigation[a]	1,000	(2,213)	4,559
Electrification[a]	(546)	96	1,274
Education[c]	(360)	571	102
	(number of people lifted out of poverty per unit of investment)		
High-yielding varieties[d]	0.00	0.02	0.05
Roads[e]	1.57	3.50	9.51
Canal irrigation[d]	0.01	0.23	0.09
Private irrigation[d]	0.01	(0.15)	0.30
Electrification[d]	0.01	0.07	0.10
Education[f]	0.01	0.23	0.01

Source: Fan and Hazell 2000 (see suggestions for further reading).
Notes: The numbers in parentheses are negative. In most cases these negative coefficients were not statistically significant.

[a] Return is in rupees per hectare affected by investment.
[b] Return is in rupees per kilometer of road built.
[c] Return is in rupees per worker made literate.
[d] Return is in number of persons lifted out of poverty per hectare affected by investment.
[e] Return is in number of persons lifted out of poverty per kilometer of road built.
[f] Return is in number of persons lifted out of poverty per worker made literate.

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degradation that exist in many less-favored areas. The results provide strong support for the hypothesis that greater levels of investment in less-favored lands are now warranted, at least on growth and poverty alleviation grounds.

RETURNS TO PUBLIC INVESTMENTS IN INDIA

In India the analysis was based on district-level data, and districts were classified into three categories: irrigated, high-potential rainfed, and low-potential rainfed. Districts were defined as irrigated if more than 25 percent of the cropped area was irrigated. Rainfed districts were subdivided into high- and low-potential areas according to their agroecological characteristics. About 80 percent of the rural poor live in rainfed lands as defined here, and about half of those live in low-potential rainfed lands. Using district-level data for 1970–95, an econometric model was estimated to measure the impact of different types of public investments on agricultural production and rural poverty. The model was then used to calculate the impact on growth and poverty of another unit of each type of investment by land type. The results are shown in Table 1.

For every investment, the highest marginal impact on agricultural production and poverty alleviation occurs in one of the two rainfed lands, while irrigated areas rank second or last. Moreover, many types of investments in low-potential rainfed lands give some of the highest production returns, and all except education have some of the most favorable impacts on poverty. These results provide strong support to the hypothesis that investments in less-favored areas are becoming win-win opportunities and that more investment should now be channeled to less-favored areas in India.

RETURNS TO PUBLIC INVESTMENTS IN CHINA

In a similar study of China, three regions were defined: the coastal, central, and western regions. The coastal region is the most fertile, with good rainfall, and can be classified as a high-potential region. The western region is the least developed and has poor natural resources and social infrastructure; it is a low-potential area. The central region falls between the other two and from an agricultural perspective can be considered a mid-potential area. More than 60 percent of the rural poor lived in the western region in 1996, and most of the rest lived in the central region. Using a similar method as for India and province-level data for 1970–97, the agricultural production and poverty impacts of additional investments were estimated for each region (Table 2).

All investments have their biggest impact on poverty in the low-potential western region and their second-biggest impact in the mid-potential central region. The high-potential coastal region ranks second or third for all investments. Most investments also have their highest production returns in either the central or western region, showing that investments in these regions are now win-win strategies. However, the production returns are mostly larger in the central rather than the western region, suggesting that some trade-off exists between growth and equity goals in allocating investments between mid-potential and low-potential areas.

TABLE 2
MARGINAL RETURNS TO INFRASTRUCTURE AND TECHNOLOGY INVESTMENTS IN RURAL CHINA

Investment	High-Potential Coastal Region	Mid-Potential Central Region	Low-Potential Western Region
	(production return in yuan per yuan invested)		
R&D	7.33	8.53	9.23
Irrigation	1.40	0.98	0.93
Roads	3.69	6.90	6.71
Education	6.06	8.45	6.20
Electricity	3.67	4.89	3.33
Rural telephone	4.14	8.05	6.57
	(number of people lifted out of poverty per 10,000 yuan invested)		
R&D	0.97	2.42	14.03
Irrigation	0.15	0.23	1.14
Roads	0.70	2.80	14.60
Education	1.79	5.35	21.09
Electricity	0.92	2.64	9.62
Rural telephone	0.98	4.11	17.99

Source: Fan, Zhang, and Zhang 2000 (see suggestions for further reading).

These results from India and China should not be interpreted to mean that public investment should now be reduced in irrigated and high-potential lands. These areas are the major sources of food for rapidly growing urban populations, and they still offer favorable returns to many investments. But the results do suggest that attractive opportunities exist for reducing poverty through additional investment in less-favored areas and that rather than sacrificing growth, many of these investments actually offer win-win opportunities for achieving more production growth and greater poverty reduction. Similar studies have yet to be done for other regions, and it would be dangerous to extrapolate these results beyond Asia, since many poorer countries, especially in Africa, have not yet invested sufficiently in their high-potential areas to have reached the point of diminishing production returns. ■

For further information see Shenggen Fan and Peter Hazell, "Are Returns to Public Investment Lower in Less-Favored Rural Areas? An Empirical Analysis of India," *Economic and Political Weekly* (April 22, 2000): 1455–1463; and Shenggen Fan, Linxiu Zhang, and Xiaobo Zhang, "Growth and Poverty in Rural China: The Role of Public Investments," Environment and Production Technology Division Discussion Paper No. 66 (International Food Policy Research Institute, Washington, D.C., 2000).

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A 2020 Vision for Food, Agriculture, and the Environment
2020 VISION

Promoting Sustainable Development in Less-Favored Areas

Development Strategies for Semiarid South Asia

John Kerr

Focus 4 • Brief 6 of 9 • November 2000

Home to nearly 300 million people, the South Asian semiarid tropics cover mainly southern interior areas of India and small parts of Pakistan and Sri Lanka. Poverty levels are high and literacy rates low. With productivity greatly limited by low, variable rainfall, lack of irrigation, and poor soils, the semiarid tropics contrast sharply with the irrigated areas of the Indo-Gangetic plain, which was the cradle of the Green Revolution and remains the region's breadbasket. Nonetheless, infrastructure and access to markets and services are relatively good compared with Sub-Saharan Africa, in part because South Asia's high population density reduces the per capita cost of infrastructure. Since nearly all of the South Asian semiarid tropics lie in India, this brief focuses on that country.

Raising agricultural productivity is essential to stimulating economic development, reducing poverty, and protecting natural resources in the Indian semiarid tropics. Three-quarters of the population lives in rural areas, and their livelihoods depend on agriculture. Moreover, agricultural growth can create purchasing power among rural people that generates demand for locally supplied goods and services, helping create jobs off the farm. Raising agricultural productivity also complements natural resource conservation because it requires better management of soil, water, and nutrients.

AGRICULTURAL PRODUCTIVITY

Rainfed agricultural growth is nearly stagnant in the semiarid tropics, and Green Revolution technologies have had little impact. Farmers pursue complex, multifaceted strategies for earning their livelihoods, with a premium on reducing risk. They are keenly aware that new agricultural technologies and natural resource management practices usually incur opportunity costs by competing with one or more of the many components of the farm household economy. Where feasible, farmers in the semiarid tropics have made large investments in irrigation wells to convert small dryland areas into highly productive irrigated plots that now provide a significant share of household food, fodder, and cash needs.

Infrastructure and access to markets also influence rainfed agricultural development. Access to institutional credit sources is limited, and marketing restrictions reduce the profitability of some crops. On the other hand, government policies have made oilseeds more profitable, greatly benefiting farmers in the semiarid tropics. Infrastructure investments have generated marketing opportunities for these crops and also for milk, whose production has flourished under village-based marketing cooperatives.

NATURAL RESOURCE DEGRADATION

Natural resources in the Indian semiarid tropics are subject to various forms of degradation. Soil nutrient deficits are widespread on rainfed land. Farmers have abandoned traditional crop rotation systems because of land scarcity; they also apply less organic matter, which has high value as fodder and fuel. Irrigated plots received most of the available manure and most fertilizer.

Soil erosion is also widespread. Soil conservation programs have had limited impact, mainly because recommended practices were incompatible with existing farming systems. Farmers have indigenous methods to control erosion, but they often fail to adopt these methods because they are not profitable and because of factors such as short-term tenancy contracts and credit market restrictions. Investment is higher on irrigated plots because water management practices also have soil conservation benefits.

Water may be the key to sustainable intensification of agriculture in the semiarid tropics, because farmers manage their soil better on irrigated plots. However, water sources are scarce and subject to degradation. For example, traditional irrigation tanks, or ponds that capture runoff from rainfall, have deteriorated as traditional community management systems have nearly disappeared. Well irrigation skyrocketed after 1980 because of technological improvements, underpriced electricity that makes the marginal cost of irrigation almost zero, and the fact that wells (unlike tanks) can be controlled individually. Underpriced power and open access to groundwater have encouraged overpumping, putting pressure on the semiarid tropics' unproductive, hard rock aquifers. The decline of tanks, meanwhile, reduces an important source of groundwater recharge.

Pastures and forests are extremely unproductive. Analysis suggests that more than 80 percent of India's uncultivated lands produce 20 percent or less of their biological potential. Village pasture and forest lands are largely government owned. Postindependence institutional reforms removed powerful landlords who had acted as gatekeepers to common lands. These reforms improved equity but failed to install an effective alternative management system. Common lands declined in area, productivity, and employment generation, and these changes hit poor people hardest since they depended most on these lands.

ELEMENTS OF A DEVELOPMENT STRATEGY

Four issues are especially significant for development of less-favored lands in the semiarid tropics: technology development, legal and administrative reforms for natural resource management, infrastructure investment, and risk management.

Technology Development

Improved agricultural technology, particularly more productive cultivars, is an important source of productivity growth in rainfed areas. Successfully introducing better agricultural technology will require that agricultural research and extension systems increase

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their focus on clients and appreciate the complex and often location-specific factors that determine technology adoption. For example, plant breeders need to pay more attention to fodder value, grain quality, and drought resistance. Fertilizer recommendations need to be tailored to location-specific agroclimatic conditions and rainfall fluctuations. More attention needs to be paid to improving indigenous soil and water management systems.

Biotechnology may be a source of raised productivity, helping stabilize yields through drought tolerance and pest resistance. Government investment will be needed to apply biotechnology to less-favored areas that the private sector will likely bypass.

Institutional Reforms in Natural Resource Management

Land and water resources could be better managed by reforming outdated laws and bureaucratic procedures.

Uneven access to land can prevent the most efficient allocation of land and complementary inputs such as labor, while insecure tenure inhibits investment in land improvement and conservation. Land access is highly correlated with poverty; households with even the smallest holdings face a much lower risk of absolute poverty than landless households. Opening up lease markets would provide secure tenure to those poor people who can access agricultural land only through tenancy. Similarly, women's legal right to own land needs to be translated into practice to improve their socioeconomic security and help them gain access to institutional credit.

Efficient groundwater management requires developing well-specified, enforceable property rights. This will be extremely challenging, and small-scale experimentation must precede major legal changes. Needed electricity price reforms are more likely to be forthcoming because the current pricing system drains state government budgets.

Watershed management projects aim to harmonize the management of soil, water, and natural vegetation. Major government investments have had limited impact, in part because technocratic approaches have failed to address the fact that watershed development distributes benefits unevenly between upstream and downstream areas yet often requires universal cooperation. Accordingly, social institutions to encourage cooperation and share net benefits are critical to successful watershed development. Some participatory projects, usually managed by nongovernmental organizations (NGOs), have introduced more farmer involvement and more attention to social organization. Government projects have officially adopted the same approaches, but they need to enable staff to work in a more decentralized, participatory way. Also, they should test innovative pilot projects before scaling up to a nationwide level. Some NGOs have purposely invested primarily in villages where people demonstrate a greater propensity for collective action or where there is less need for collective action. This is a sensible strategy for cost-effective use of limited watershed project budgets.

Improving Infrastructure and Marketing Institutions

Past public investments in infrastructure have contributed to agricultural growth and poverty alleviation in both rainfed and irrigated areas. Investments in new roads support agricultural growth and poverty reduction by raising net returns to agriculture and facilitating economic diversification. Returns to all types of government investments are particularly high in less-favored areas, in part because these areas have been relatively neglected in the past. Additional government investment in less-favored areas raises production by more, and brings more people above the poverty line, than does additional investment in irrigated areas.

Operation Flood provides an excellent example of the power of infrastructure and marketing. Launched in 1970, it created multitier milk production and marketing cooperatives throughout India that have succeeded in moving milk from rural producers to urban consumers via collection and processing centers, thus improving food availability and raising rural incomes. India's dense population helped make this approach cost-effective. Even in villages with no motorable road, bicycles move milk quickly to a nearby dairy. Continued expansion of dairy production in the semiarid tropics will require efficient water management to support green fodder production.

Many agricultural commodities remain subject to various marketing restrictions. Marketing costs could be reduced through reforms such as allowing free interstate trade in rice, abolishing stocking limits on private traders, introducing a futures market to help reduce marketing costs, and removing cotton export quotas.

Finally, investment opportunities vary with both agroclimatic and infrastructural conditions within the semiarid tropics. Just as successful dairy development has required at least modest access to irrigation, soybeans and groundnuts both flourished where agroclimatic conditions were particularly suitable. Another factor that distinguishes the semiarid tropics is distance from a large town or city. More remote areas need more employment and may be attractive for labor-intensive industrial development. Villages closer to cities, on the other hand, often specialize in perishables such as cut flowers and fresh produce, and similar opportunities may remain untapped.

Risk Management

Traditional risk management strategies have helped people manage drought risk, but they are costly and ineffective in the event of widespread, major droughts. Government employment schemes help landless people cope with drought, and crop insurance appears to have a favorable impact, but at an extremely high cost to the government. For those who do not grow insurable crops, another form of insurance is needed. It must be affordable; be accessible to all, including the poor; compensate for total income losses; be practical to implement; and be able to be provided by the private sector. Area-based rainfall insurance offers a promising new alternative that in principle can meet all these requirements and could be tested on a limited scale. The government could also invest in early warning drought forecasting to help farmers plan. ■

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DEVELOPMENT STRATEGIES FOR THE EAST AFRICAN HIGHLANDS

JOHN PENDER

FOCUS 4 • BRIEF 7 OF 9 • NOVEMBER 2000

Low agricultural productivity, poverty, and resource degradation are severe and worsening problems facing most of the 90 million people of the East African highlands (defined in this brief as areas above 1,200 meters above sea level in Burundi, Ethiopia, Kenya, Madagascar, Rwanda, Tanzania, and Uganda). Most farm households subsist on farms smaller than two hectares in size and incomes of less than $1 per day, and cereal yields less than one ton per hectare are common. Forests are disappearing, soils are eroding, and soil nutrient stocks are being mined because of expanding cultivation onto marginal lands, declining use of fallow, limited investment in soil and water conservation measures, and limited use of modern or organic inputs. Underlying these proximate causes are many more fundamental factors, including rapid population growth, limited infrastructure and market development, high weather risks, limited farmer awareness of appropriate technologies, land fragmentation, and tenure insecurity, among others. Government policies have a strong but variable influence on many of these factors. For example, market liberalization policies of recent years helped to spur commercialization in areas of high agricultural potential and good market access, but also led to higher fertilizer prices and less fertilizer use by many farmers. They had little impact on remote areas where subsistence mixed crop-livestock production is still the norm.

Given the complex factors and diverse situations influencing agricultural and rural development in the East African highlands, no "one-size-fits-all" strategy will achieve sustainable development throughout the region. Some common elements are necessary for success anywhere, including peace and security, macroeconomic stability, and a competitive market environment. But beyond such necessary conditions is the need for sufficient investment in physical, human, natural, and social capital. Much of what distinguishes successful development strategies in different locations will be differences in the portfolio of such investments.

The appropriate portfolio of investments will depend upon what development pathways have potential comparative advantage in a particular location. A "development pathway" is a common pattern of change in livelihood strategy (for example, intensification of food crop production or rural nonfarm development). Many factors combine to determine comparative advantage of different development pathways. In rural areas, two are particularly important: agricultural potential and access to local or international markets. Agricultural potential determines the absolute advantage (technical efficiency) of producing agricultural commodities in different locations. Access to markets greatly influences which activities have comparative advantage in a particular location, given agricultural potential.

HIGH-POTENTIAL AREAS WITH GOOD MARKET ACCESS

In areas close to urban or foreign markets and having high agricultural potential—such as parts of Ethiopia close to Addis Ababa, much of the central and western Kenya highlands, the Lake Victoria crescent, and much of the eastern highlands of Uganda—there is great potential for profitable production of high-value perishable commodities, such as horticultural crops and dairy products. Realizing this potential requires investments in marketing infrastructure and information, technical assistance oriented toward such commercial opportunities, and development of input and short-term credit markets. For example, dairy development in central Kenya is a major success, stimulated by the large market in Nairobi, development of processing and marketing cooperatives, and introduction of improved breeds of cattle and intensive feeding systems. Commercial production of vegetables is expanding in areas around Nairobi, Addis Ababa, and Kampala, but improved price information and technical assistance focused on commercial opportunities, appropriate use of agrochemicals, integrated pest management, and integrated soil nutrient management are needed. Credit and input markets are poorly developed throughout the East African highlands.

Other development pathways likely to have comparative advantage include intensified food crop production using relatively high levels of external inputs; intensive periurban livestock operations such as poultry, pigs, or aquaculture; and rural nonfarm development, linked to agricultural intensification and commercialization. There are many synergistic linkages among such pathways. Intensified food crop production can increase food security and increase farmers' willingness to take risks in producing high-value crops, while production of high-value crops and nonfarm income can increase farmers' ability to purchase inputs for food crop production. Increased food crop production increases the availability of crop residues that can be fed to livestock, while livestock operations can provide manure that is used to intensify crop production. These synergies imply that the development strategy can be most effective if it addresses the constraints to several development pathways at once.

HIGH-POTENTIAL AREAS WITH POOR MARKET ACCESS

In areas with high agricultural potential that are farther from markets—such as much of the southern and western Ethiopian highlands, central and western Uganda—a comparative advantage exists in producing high-value nonperishable crops such as coffee, as well as in livestock production. Opportunities may exist to intensify food production for local consumption based on limited use of external inputs, but the potential for expanding food sales to external markets is likely limited by high transport costs. As part of a strategy of intensifying food crop production using few external inputs, agroforestry approaches such as improved fallows have been shown to increase soil fertility and crop yields as well as providing other economic and environmental benefits. Complementarities between livestock and crop production can also increase productivity. For example, banana farmers in western Uganda are achieving higher yields by using compost.

A high priority for such areas is road construction and maintenance. Better roads can enable these areas to shift to higher-value production of perishable commodities, as is occurring in many areas near Kampala and Addis Ababa, as well as increasing the profitability of traditional nonperishable cash crops. Until market access is substantially improved, technical assistance programs should promote food security by emphasizing agroforestry, enhanced crop-livestock interactions, and limited use of external inputs. Without adequate food security, farmers in densely populated remote areas may be forced to forgo profitable cash crop opportunities in order to maintain food production. This dilemma reportedly contributed to declining coffee production in parts of Ethiopia in the past. Given the importance of perennial crops in such areas, ensuring clear property rights and adequate land and tree tenure security is also critical. While this may not require formal land titles, investments in trees or other land improvements can be undermined by periodic land redistributions, as have occurred in Ethiopia, or by absentee land ownership, which is common in central Uganda.

LOW-POTENTIAL AREAS WITH GOOD MARKET ACCESS

Areas with low agricultural potential (for example, because of low and uncertain rainfall) but high market access—such as parts of the northern Ethiopia highlands and parts of the "cattle corridor" of western Uganda close to major towns and roads—are not likely to have a comparative advantage in crop production without irrigation. Farmers may pursue intensification of food production for subsistence purposes using low levels of inputs, but strategies should emphasize labor-saving approaches, since labor demand for nonfarm activities is often high in such areas. There is likely to be a greater comparative advantage in intensive livestock production, particularly where adequate feed supplies and water for animals can be assured. This type of development is occurring in western Uganda. There also may be opportunities for forestry and agroforestry. For example, community woodlots are increasingly common in northern Ethiopia, and the potential profits from fast-growing species such as eucalyptus are high, particularly close to urban markets.

A high priority for these areas is investment in irrigation (where suitable) and water conservation structures. The returns to such investments are highest where water is scarce, soil conditions are favorable, and market access is good. Besides enabling intensified crop production, irrigation helps to relieve feed and water constraints to intensified livestock production. Forestry and agroforestry activities also help relax biomass constraints, allowing scarce organic materials such as manure and crop residues to be recycled to the soil, rather than used as fuel or fodder. To facilitate such activities, improvements in institutions for managing common property (especially community irrigation systems, forest, woodlots, and grazing lands) are needed in many cases. Where privatization is occurring, tenure insecurity may arise because of conflicts between traditional pastoralists and sedentary farmers and ranchers, as is occurring in parts of Uganda. Clarifying access rights and developing mechanisms of conflict resolution are important priorities in such circumstances. Other priorities for areas close to markets include investments to facilitate rural nonfarm development, including electricity, telecommunications, education, and vocational training.

LOW-POTENTIAL AREAS WITH POOR MARKET ACCESS

In areas far from markets and having relatively low crop production potential, livestock and high-value forest products (such as resin and honey) may have comparative advantage, while crop production may be improved through better integration of crop-livestock-agroforestry systems. Still, the greatest comparative advantage is likely to be in developing the skills of the population to enable short- and long-term migration to areas of greater opportunity. Investments in human capital (education and vocational training, extension with an emphasis on low-external-input technologies and mixed crop-livestock-agroforestry systems) thus may have the greatest social returns in such settings. However, investments in social capital (improved institutions to protect and manage common property, improved land and tree tenure security), natural capital (such as planting trees and fodder grasses), and physical capital (such as fuel-efficient stoves, soil and water conservation structures) are also important.

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Though different strategies are needed for different types of situations, many investments are broadly needed throughout the East African highlands, such as investments in infrastructure, education, and agricultural research and extension. No region should be neglected, though the emphasis may differ from one place to another. The framework suggested here can serve as a useful starting point for consideration of strategies for specific locations. ■

For further information see J. Pender, F. Place, and S. Ehui, "Strategies for Sustainable Agricultural Development in the East African Highlands," EPTD Discussion Paper No. 41 (International Food Policy Research Institute, Washington, D.C., 1999); S. Wood, K. Sebastian, F. Nachtergaele, D. Nielsen, and A. Dai, "Spatial Aspects of the Design and Targeting of Agricultural Development Strategies," EPTD Discussion Paper No. 44 (International Food Policy Research Institute, Washington, D.C., 1999).

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A 2020 Vision for Food, Agriculture, and the Environment

PROMOTING SUSTAINABLE DEVELOPMENT IN LESS-FAVORED AREAS

DEVELOPMENT STRATEGIES FOR WEST AFRICA

SIMEON EHUI, SAMUEL BENIN, AND DUNSTAN SPENCER

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Existing models of agricultural intensification (that is, greater agricultural production on the same amount of land) assume that population growth, access to markets, and agricultural potential will lead farmers to adopt new technologies, intensify farming, and use resources sustainably. Yet despite policy reforms and structural and sectoral adjustment programs designed to improve production and marketing incentives for farmers, low agricultural productivity, resource degradation, and poverty are still severe and worsening problems in West Africa. In only a few cases have farming systems evolved into highly productive systems that have substantially increased farmer welfare (such as in the northern guinea savannah of Nigeria). It is well known that establishing intensive farming systems requires making investments (in, for example, animal traction and use of manure), but insufficient attention has been paid to the complex factors and diverse agroecological conditions under which farmers operate and the incentive systems that ensure that appropriate investments are made.

Since agriculture provides a third of gross domestic product, employs about two-thirds of the labor force, and is in many cases the primary provider of foreign exchange, it is unlikely that the West African economies can achieve a significant and sustained recovery unless they can reverse the economic decline of the agricultural sector. Identifying effective policies and investments for sustainable development should start by considering the comparative advantage of various livelihood strategies (pathways of development) in different situations and locations. The main determinants of comparative advantage are agricultural environment, access to markets, and population pressure. This brief considers the comparative advantage of strategies for West Africa based on the four agroecological zones—humid, subhumid, semiarid, and arid—found there. These zones are defined by the amount and distribution of rainfall, temperature, and length of the annual growing period.

THE HUMID ZONE

The humid agroecological zone consists of forests and forest-savannah transition and covers about 10 percent of the region, including Liberia and parts of Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Sierra Leone, and Togo. It receives more than 1,500 millimeters of rainfall annually and has a growing period of 7 to 12 months. The soils are very acidic and easily degraded without vegetative cover. Crop-livestock interactions are low because of trypanosomiasis, which is a major constraint to livestock production.

Agricultural potential is greatest for root crops like cassava and yam and tree crops like cocoa and rubber. Given that most of the tree crops are exported for foreign exchange, investments in roads, which are in poor condition, and market facilities are a high priority. These investments will also increase the profitability of root crops, which are perishable, bulky, and of low value compared with horticultural crops. Making credit available for local processing enterprises will increase the returns to marketing infrastructure.

Because world prices for key agricultural commodities are declining, West African farmers must diversify into high-value commodities and reduce production and marketing costs. To do this, they need modern varieties that are resistant to diseases and respond well to limited amounts of purchased inputs. Improved varieties are also needed for other crops such as yam, plantain, and cocoyam, which contribute to household food security. When households are food secure, they can channel resources into producing more tree and export crops.

There is little potential for animal traction in most parts of this zone. The light soils in this zone make cultivation by hoe easy, and the prevalence of tree stumps makes animal traction unprofitable because of the large investments required for destumping. Potential for meat production, however, is high, and investments should focus on making available disease-resistant cattle breeds such as the N'dama and on improving the animal health delivery system. To overcome the feed constraint, researchers should work to increase the digestibility of crop residue biomass (which is plentiful in this zone) that would not otherwise be used by livestock. Given the limited interaction between crop and livestock, and therefore the limited application of manure, other soil fertility maintenance activities such as mulching and alley cropping should be encouraged through extension and education.

THE SUBHUMID ZONE

The subhumid agroecological zone consists of savannah type vegetation and covers about 16 percent of the region, including Guinea-Bissau, parts of the countries that also lie in the humid zone except Liberia, and parts of Benin, Burkina Faso, Mali, and Senegal. The zone receives between 1,000 and 1,500 millimeters of rainfall annually and has a growing period of six to nine months. Leaching of nutrients is less common than in the humid zone, and soil degradation is largely physical, through erosion and loss of structure. Although trypanosomiasis is also a major problem here, mixed crop-livestock systems are more common because of heavier soils, which make operation of the plow profitable, and the absence of tree stumps.

A wide variety of food and forage crops, including maize, millet, sorghum, cassava, yam, groundnut, cowpeas, and leguminous forages, are grown in the zone. It is believed that this zone has the greatest potential in West Africa for producing grain, meat, and milk. The zone cannot realize this potential, however, until it is food secure and can export surplus production. Mechanization would appear promising here because of the lack of trees and flat terrain, but the use of tractors has proved unprofitable because cultivation usually needs to be done within a short period of time, causing conflicts among potential users and preventing the high fixed costs from being spread over a wide area. Strategies should therefore promote animal traction by introducing disease-resistant breeds and improving health infrastructure. In areas with good market access (such as around Kaduna in Nigeria or Bamako in Mali), animal fattening and milk production will be important. Extension, education, and credit for adopting livestock feed technologies such as planting of forage legumes, which help restore soil fertility, will be important in such areas.

Although high-yielding varieties exist for most of the crops cultivated in the zone (such as maize, sorghum, millet, soybean, and cowpeas), they are not widely adopted, especially in areas with poor market access and low precipitation. The high costs of fertilizers required for these high-yielding varieties erode their profitability, especially since the removal of fertilizer subsidies. In addition, demand for food by the nonagricultural sector is weak because of limited urban demand, insufficient exports, and cheap food imports. Therefore, to realize the potential of the zone, modern, stress-resistant varieties that respond well to small amounts of external inputs are needed. These varieties must also meet local tastes so that they can satisfy farmers as well as domestic urban markets or export needs. In addition, efforts to stimulate demand by investing in rural roads, improving marketing, and promoting rural nonfarm work are needed.

THE SEMIARID ZONE

The semiarid agroecological zone covers about 20 percent of the region. The zone receives between 500 and 1,000 millimeters of rainfall annually and has a growing period of three to six months. The soils are poor and deficient in nitrogen and phosphorus. The high temperatures accelerate the degradation of plant organic matter and reduce the water-holding capacity of the soil. The main crops cultivated are sorghum, millet, groundnut, cowpeas, and cotton. In the relatively higher rainfall areas, mixed crop-livestock farming systems dominate, as trypanosomiasis and other livestock diseases are less prevalent than in the humid and subhumid zones. In general livestock production will maintain its comparative advantage as diseases continue to constrain livestock production in the humid and subhumid zones.

Given the poor soils and limited precipitation in this zone, crop production (except cash crops such as groundnut, cowpea, and cotton) is undertaken for subsistence only, with few resources devoted to livestock production, except in areas with good access to markets. To realize the potential of this zone, especially in areas with good market access, investments should focus on extension, education, and credit in livestock fattening programs, milk production, and improved marketing and health facilities. The use of groundnut and cottonseed cakes—protein-rich byproducts of the processing of groundnut oil and cottonseed lint—for livestock feed should facilitate the intensification process. Credit and training should be made available for developing local processing of groundnut oil, cottonseed lint, and feed and for improving the marketing of these products. In remote areas small ruminants, which are easily transportable over long distances, will be more important than cattle. Generally, extension and animal health care services are needed. Furthermore, education and training in nonfarm activities are vital, especially for people seeking to migrate to more favorable areas.

THE ARID ZONE

The arid agroecological zone covers a large portion of the region (about 54 percent), including mostly Chad, Mali, Mauritania, and Niger. The zone receives less than 500 millimeters of rainfall annually, and the growing period is less than three months. Rain is highly variable and insufficient, and the soils are shallow, saline, calcerous, and low in organic matter, making cropping a risky enterprise. Nomadic and transhumant pastoral systems based on communal grazing are the dominant farming systems. Because of population pressure, range degradation, and increasing conflicts over property rights, intensive livestock production will increase, especially in the less moisture-stressed areas. Therefore, drought-resistant modern varieties and extension and education in soil and water conservation techniques are needed. For many people in this zone, however, migration to more fertile and less moisture-stressed areas to engage in farming or nonfarm activities is the only sustainable livelihood strategy. Therefore, training in intensive crop-livestock farming and in nonfarm activities will be needed.

Some people will remain pastoralists, and for them, improving property rights to a variety of pastures and water resources and the right to move between those resources will be important. This step can improve the use of the sparse water resources and pastures that are dominated by annual grass species. ■

For further information see Simeon Ehui, Timothy Williams, and Brent Swallow, "Economic Factors and Policies Encouraging Environmentally Detrimental Land Use Practices in Sub-Saharan Africa," Dunstan Spencer and Ousmane Badiane, "Agriculture and Economic Recovery in African Countries," and Keijiro Otsuka and Christopher Delgado, "New Technologies and the Competitiveness of High and Low Potential Rural Areas in Asia and Africa," all in G. H. Peters and D. Hedley, eds., *Agricultural Competitiveness: Market Forces and Policy Choice,* Proceedings of the 22nd International Conference of Agricultural Economists (Aldershot, U.K.: Dartmouth, 1995). See also Prabhu Pingali, Yves Bigot, and Hans Binswanger, *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa* (Baltimore, Md., U.S.A.: Johns Hopkins University Press, 1987).

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A 2020 Vision for Food, Agriculture, and the Environment
2020 VISION

Promoting Sustainable Development in Less-Favored Areas

The Role of Agricultural Science

Shawki Barghouti and Peter Hazell

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Many agricultural policymakers and researchers are skeptical about the efficacy of investing in agricultural research for less-favored areas. Growing conditions are very diverse and often marginal and risky, so that improved technologies may (1) lead to low productivity payoffs on average, (2) not be attractive to farmers because of the risk of input loss in bad years, and (3) may not have widespread application (in contrast to the Green Revolution technologies that spread over tens of millions of hectares of land). Technologies are also perceived to be more difficult and perhaps more costly to develop. There is undoubtedly some basis for these concerns, especially for commodity improvement research, but as shown for India, agricultural research can have significant productivity impacts and reduce poverty in some types of less-favored areas. Research and development (R&D) for less-favored areas needs to respond to these concerns in realistic ways.

BIOPHYSICAL POTENTIALS

It is important to know the biophysical potentials for increasing land productivity in different kinds of less-favored areas. If they are not much larger than the levels that farmers are currently achieving, then R&D is unlikely to be helpful. Many less-favored areas have enough sunshine and average annual rainfall to sustain good yields but lack adequate soil nutrients and the means to capture and store the available rain until it is most needed. Theoretical plant modeling studies show, for example, that yields of rainfed grain crops in semiarid tropical areas of West Africa could be doubled or tripled if plant nutrients, especially phosphate, were adequate and seasonal soil moisture constraints were overcome. Likewise, experimental trials based on increasing key plant nutrients (such as combining rock phosphate applications with improved fallows planted to leguminous trees or cover crops) and water catchment at the landscape levels suggest that land productivity can be increased by 100–200 percent in some less-favored environments. Plant-breeding work for greater tolerance to stresses like drought, salt, and acidity also suggests that significant yield increases are possible, even under existing plant nutrient and soil moisture regimes. In Brazil, liming and no-till farming has converted poor and acidic *cerado* soils into some of the most productive agricultural lands in the country. These results suggest that most less-favored areas have considerable biophysical potential for achieving much higher yields. The real challenge is to find profitable and environmentally sustainable ways to tap these yield potentials.

R&D alone cannot meet the challenges of less-favored areas. The task also requires enabling policies and local institutions, as well as public investments in rural infrastructure and the health and education of local people. These issues are discussed in accompanying briefs. We focus here on guidelines for appropriate R&D strategies for less-favored areas.

R&D STRATEGIES FOR LESS-FAVORED AREAS

- *Plant breeding.* Plant breeding to develop improved varieties for less-favored areas is vital to achieving higher yields (such as food and cash crop varieties that are more tolerant of drought and poor soil conditions and that have greater pest and disease resistance). Conventional plant-breeding methods can make an important contribution, but biotechnology may be able to open up new opportunities for breeding as well as shorten the time it takes to develop better varieties.
- *Improved natural resource management.* There is a growing consensus that any major productivity improvements will first require improved natural resource management practices and technologies, especially for water catchment and soil fertility. These have the potential to increase yields with existing crop varieties. They will also create more favorable environments to enhance the payoff from developing improved crop varieties. The types of improvements needed in natural resource management will vary widely according to the most limiting factor of production, across agroecological conditions, and according to other social and economic factors.
- *Solutions to large-scale problems.* Given the huge diversity in local conditions, R&D on natural resource management problems should focus on those problems that are common to a significant number of poor people, and *only* on those that can be scaled up from benchmark sites. The scaling up need not mean that all sites have to be homogeneous, just that improved natural resource management practices can be easily and cost-effectively adapted by local people and institutions to different site-specific circumstances.
- *Low-external-input technologies.* Because many less-favored areas have poor infrastructure and market access, it is uneconomic for farmers to use high levels of external inputs. But low-external-input technologies are typically labor intensive, both seasonally and in total, and this can be an important constraint on their uptake. Fallows and green manures also keep land out of crop production, and composting and manuring compete for household energy use and are difficult for many small farms. The challenge is to develop low-external-input technologies that boost labor and land productivity.
- *Diversification.* While improved technologies for food crops for subsistence and local needs are often much needed

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in the poorer less-favored areas, sustained increases in per capita incomes will depend on diversification into higher-value agricultural products such as livestock and horticultural products and nonfarm activities such as agricultural processing.

- *Property rights and collective action.* Past R&D attempts in less-favored areas point to the importance of social and institutional factors, particularly indigenous property rights systems and the local capacity for organizing and sustaining collective action for managing natural resources. Some of the most successful agricultural technologies have avoided these problems (such as the high-yielding cereal varieties of the Green Revolution) because they could be captured within a single agricultural season and hence did not require secure property rights. Nor did they require collective action; individual farmers could adopt regardless of what their neighbors decided to do. These features made adoption decisions relatively simple and help explain why high-yielding varieties are able to spread quickly and widely in diverse socioeconomic situations. But where research agendas must focus on the sustainable use of natural resources, local institutional issues become much more prominent. For example, planting of farm trees is a long-term investment that requires secure property rights, though not necessarily collective action. Many other technologies for improved natural resource management require both secure property rights and effective collective action. Watershed development, for example, requires secure property rights because it involves long-term investments that can be successfully made only if the entire community living within the relevant landscape is mobilized to support collective action. If these institutional conditions are not met, then the technology is not likely to be adopted and maintained, regardless of its profitability and scientific soundness.
- *Indigenous knowledge.* Much of the R&D needed for less-favored lands does not involve high science but rather the spread and adaptation of indigenous knowledge and practical innovations. Some nongovernmental organizations (NGOs) have been very successful in pursuing this agenda and in working with local communities to overcome social and institutional constraints. There are serious questions about whether many of these successes can be scaled up and sustained over time at reasonable cost. Nevertheless, formal R&D institutions need to better integrate their own products into the broader portfolio of technology options available to farmers.
- *Participatory approaches.* There is a need for more participatory approaches to developing research agendas and testing new technologies if they are to be relevant and adopted, especially by the poor. Given that researchers must work on scaled-up problems to achieve impact beyond specific sites, then a research focus on representative benchmark communities can be a useful approach.

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The challenges facing R&D for less-favored areas are great. These areas are much more diverse than many high-potential areas. Sustainable development in less-favored areas involves changes in complex natural resource management systems that have been developed over generations to cope with uncertain rainfall and weather conditions, poorer and often more fragile soils, and the high costs of external inputs given poor market access.

To meet these challenges, agricultural research and extension systems must adopt a more client-oriented, problem-solving approach for all types of technologies and agricultural conditions. This approach will often require more on-farm research under conditions that are difficult and diverse and are likely to be much different from research stations. Not all of the technological challenges facing poor people will be solved by more on-farm work; biotechnology conducted in a strict laboratory environment may be critical, for example, in raising yield ceilings or improving drought tolerance. However, even biotechnology will be more effective if it addresses priorities set on the basis of a client-oriented, problem-solving approach that draws many of its insights from interaction with farmers.

Institutional reforms are necessary to change incentive structures within public research and extension systems, so that scientists and extension officers are more responsive to the needs of their clients. But to be effective, these changes will need to extend to all levels of management. The kinds of changes needed in national agricultural research and extension systems will also require the forging of new partnerships between the public system and NGOs, private sector firms, and farmers. ■

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