

## Module 4: Investments in Sustainable Agricultural Intensification

A growing population and limited natural resource base means that if current and future food and fiber needs are to be met, natural resources will have to be used in a more sustainable way. Promoting sustainable agriculture requires that farm management techniques foster synergies, conserve nutrients, increase economic stability, and promote equitable outcomes for male and female small-scale farmers. This overview summarizes the basic underlying principles and approaches for planning investments in sustainable agricultural production systems, including technologies to intensify production. These issues and investments complement investments needed for the sustainable management of off-farm natural resources important to agricultural production systems.<sup>1</sup>

### Rationale for Investment

Future global food and fiber demand is expected to increase substantially as populations grow and average incomes rise, but limited land and water resources can be brought into production to satisfy this demand. If past production strategies are used to double food production, their expected ecological impacts could make production systems unsustainable. Agricultural systems must therefore intensify the use of land and water resources through more sustainable methods and through changing current production systems and diversifying into new, more productive enterprises.

Agricultural intensification is an increase in the productivity of existing land and water resources in the production of food and cash crops, livestock, forestry, and aquaculture.<sup>2</sup>

Generally associated with increased use of external inputs, intensification is now defined as the more efficient use of production inputs. Increased productivity comes from the use of improved varieties and breeds, more efficient use of labor, and better farm management (Dixon et al. 2001). Diversification, which represents a change in the farm enterprise pattern to

#### Box 4.1 Household strategies to improve livelihoods

- Intensification of existing farm production patterns through increased use of inputs or better quality inputs.
- Diversification of production, with emphasis on greater market orientation and value addition involving a shift to new, generally higher-value products.
- Increase farm size, an option limited to a few areas where additional land resources are still available.
- Increase off-farm income to supplement farm activities and provide financing for additional input use.
- Exit from agriculture, including migration from rural areas.

Source: Dixon et al. 2001

<sup>1</sup> See Module 5, "Investment in Sustainable Natural Resource Management for Agriculture," for more information on the sustainable management of *off-farm* natural resources important to agricultural production systems.

<sup>2</sup> See Module 6, "Investment in Fisheries and Aquaculture," for a discussion of these issues as they relate to aquaculture.

increase profitability or reduce risk, is one option for sustainable intensification.

Although intensification of production systems is an important goal, these systems need to be sustainable to provide for current needs without compromising the ability of future generations to meet their needs. Sustainable agriculture can be defined as *the management and conservation of the natural resource base, and the orientation of technological and institutional change to ensure the attainment and continued satisfaction of human needs for present and future generations*. Such sustainable development in the agriculture, forestry, and fisheries sectors conserves land, water, plant, and animal genetic resources and is environmentally nondegrading, technically appropriate, economically viable, equitable, and socially acceptable (FAO 1995).

A recent study investigating alternative household strategies for farming systems in developing countries reinforced the need for greater development attention to diversification and intensification (box 4.1) (Dixon et al. 2001). Table 4.1 presents the characteristics and relative importance of alternative poverty reduction strategies for five categories of farming systems that cover approximately 98 percent of cultivated lands. Intensification and diversification are important in all cases. In the relatively constrained circumstances of rainfed highlands and rainfed dry/cold climates, however, off-farm employment and exit from agriculture are more important (though not always easily achievable).

**Table 4.1 Comparison of farming systems and relative importance of different poverty reduction strategies**

Category	Wetland rice based	Rainfed humid	Rainfed highland	Rainfed dry/cold	Dualistic-mixed large/small farms
<b>Characteristics</b>					
Agricultural population (million)	860	400	520	490	190
Total land (m ha)	330	2013	842	3478	3116
Irrigated (%)	58	11	20	18	9
Agr. pop./cultivated ha	860	400	520	490	190
<b>Alternative strategies for poverty reduction<sup>a</sup></b>					
Intensification	*	*			***
Diversification	***	***		**	**
Increased farm size					*
Increased off-farm income	**	**	***	*	
Exit from agriculture			**	***	

Source: Dixon et al. 2001

<sup>a</sup>Assessments of relative importance based on expert judgment. \*\*\* indicates highest priority, \*\* second-highest priority, and \* third-highest priority.

Sustainable agriculture is not a clearly defined production model, but rather a set of complementary approaches that seeks to minimize negative environmental impacts from agriculture, by increasing efficiency of input use and by making greater use of biological and ecological factors in production processes (FAO 2003). A range of new technologies,

management strategies, and analytical tools relevant to sustainable agricultural intensification has emerged in recent years (box 4.2).

#### **Box 4.2 Production practices relating to sustainable intensification**

*Integrated pest management (IPM)* is an ecosystem-based strategy that seeks to control pests or their damage through a combination of techniques (biological control, pest monitoring against economic thresholds, habitat manipulation, modification of cultural practices, use of resistant varieties), using less toxic chemical pesticides only after pest monitoring indicates their need.

*Conservation farming (CF)* encompasses four broad, intertwined management practices: minimal soil disturbance (no plowing and harrowing), maintenance of a permanent vegetative soil cover, direct sowing, and sound crop rotation.

*Low external input and sustainable agriculture (LEISA)* uses farmers' knowledge and a range of management practices (agroforestry, IPM, intercropping, crop-livestock integration, microclimate management) to minimize the need for purchased inputs.

*Organic agriculture* employs agronomic, biological and mechanical methods to control pests and maintain soil fertility with virtual elimination of synthetic chemicals for crop and livestock production.

*Precision agriculture* maximizes productivity of inputs, often using a global positioning system (GPS) to match input application and agronomic practices with soil attributes, seasonal conditions, and crop requirements as they vary across a field or between small plots.

*Diversification* is an adjustment of the farm enterprise pattern in order to increase farm income or reduce income variability by reducing risk, by exploiting new market opportunities and existing market niches, and diversifying not only production but also on-farm processing and other farm-based, income-generating activities (Dixon et al. 2001).

Source: Authors

The heterogeneity in developing countries of productive resources, infrastructure, inputs, skilled labor and access to new technologies means that development initiatives have to be targeted to locally specific problems. For instance, in many African countries intensification will likely involve increasing the use of underutilized resources and external inputs (especially fertilizer), whereas in some Asian countries that have fully capitalized on green revolution technologies, substituting better knowledge to reduce external input use will be key to sustainable development (box 4.3).

#### **Box 4.3 Pakistan: effects of resource degradation on agricultural productivity**

The Pakistan Punjab illustrates the potential problems arising from agricultural intensification and resource degradation. Average growth in total factor productivity since the green revolution has been moderate at 1.26 percent but with wide regional variation. Negative growth observed in the wheat-rice system relates in large part to continuous and widespread resource degradation measured by specific indicators of soil and water quality. This resource degradation has offset much of the gain from investments in technology, infrastructure, and education. Policy distortions (especially water pricing) and lack of research and extension on more sustainable cropping systems have contributed to this resource degradation.

Source: Ali and Byerlee 2001

Environmental and social sustainability of productive resources depend in part on economic profitability that must provide for reinvestment in the maintenance of these resources (including the natural environment) and on a satisfactory standard of living for owners and employees involved in the production process. In turn, economic sustainability is dependent on a productive workforce and productive natural resources.

Sustainable agricultural intensification investments are particularly relevant to poor people in developing countries, where poverty, agricultural productivity, and resource degradation are closely interrelated and negatively affected by increasing population pressure on the natural resource base. Poverty often results in overcropping, which contributes to a loss of biodiversity, soil degradation, and reduced water availability and quality, and these problems further reduce future agricultural productivity.

### **Past Investment Activity**

Commodity-focused investments in the 1970s and 1980s sought to expand and intensify production systems for basic food crops and traditional cash crops, which had broad impacts on poor people and/or national economies. These investments generally supported monocropping and expansion of a single dominant technology or production system, and they often focused on more productive regions of a country. Since the 1980s, World Bank financing for the production of specific agricultural commodities has declined steadily, in line with the decrease in total Bank financing for agriculture and consistent with the growing recognition that the public sector is not well suited to picking commodities or production activities that are likely to be economically successful.

Few of the Project Appraisal Documents (PADs) for current projects specifically mention *sustainable agriculture practices*. This omission may reflect a significant and worrisome weakening of technical analysis and input into project preparation and appraisal. As sustainable agricultural intensification is a key strategy for reducing rural poverty and encouraging environmental conservation, there is an urgent need to increase support to this area. There is also a related need to increase technical expertise, to ensure sound planning for investments in the intensification and sustainability of production systems.

New investments for the intensification of agricultural production systems since the mid-1990s have generally been based on a better understanding of the underlying social, economic, and environmental elements of sustainability and a general commitment to the principles underlying sustainable agriculture and development. These investments have focused mainly on high-value commodities, minimum tillage, and IPM.

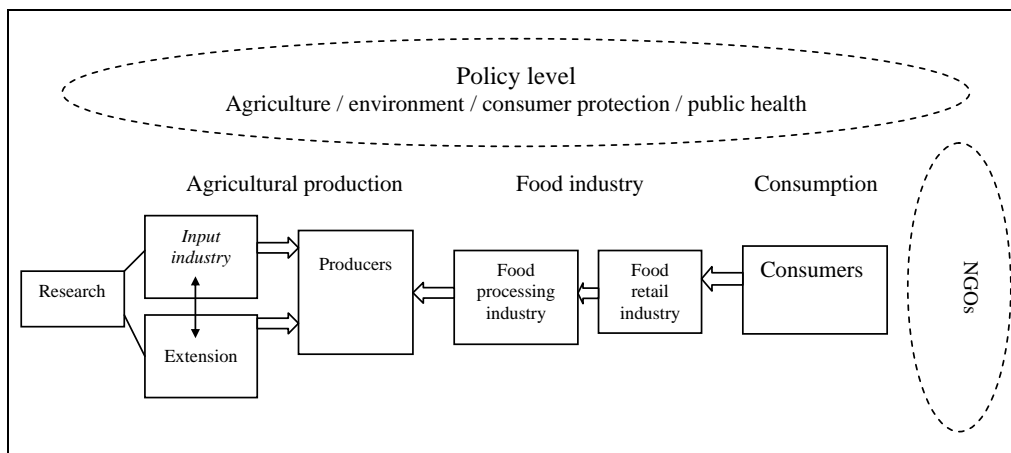
### **Key Issues for Investment**

Future investments are likely to support more diverse products and production systems and to include less favorable production regions. Investments will need to apply modern science and new marketing systems to help both women and men farmers move into more productive and sustainable production systems. Investments in sustainable agricultural intensification must be economically, environmentally, and socially sound,

efficient, and based on sustainable institutions. Common characteristics of these investments are described below.

*Based on holistic systems approaches.* Farming systems are defined by the economic, social, and environmental conditions within which they operate. Interventions must be based on an understanding of the interrelationships between these factors, and they will therefore frequently require a holistic, multidisciplinary approach. For example, introduction of a new production system or an innovation in an established system will often require attention to the policy environment, agroecology, market systems, social system (including how gender and social group influence the division of labor and access to resources), and the farm/household economy. In addition, marketing, supply chains, and a wide range of stakeholders are part of the holistic approach required for sustainable agricultural systems (figure 4.1).

**Figure 4.1 Stakeholders influencing agricultural production and supply chains**



Source: Sorby, Fleischer, and Pehu 2003

Note: Arrows represent the direction of major influences in the supply chain, though influence can flow both ways.

*Sensitive to social change.* The transition from one farming system to another is often as much an issue of behavioral change as of economic change. Production systems are rooted in cultures and traditions. Major changes may require two or more generations of farmers to make the transition from, for example, subsistence farming to commercial farming, nomadic pastoralism to settled agriculture, or traditional to nontraditional crops. Since social resistance to change may be strong, a sound social analysis should be part of the plan for new investments in agricultural intensification. Extension services must help farmers address and adapt to social change, but these services are frequently very weak in their ability to deal with social issues.

*Targeted to specific production environments.* There are 72 major categories of farming systems—each with numerous variations—found in the various agroecological regions of the developing world (Dixon et al. 2001). Investments in sustainable intensification must be designed within the context of established agricultural systems and the level of

technology, resource availability, and market opportunities in the area. In areas where high input use already threatens environmental resources, for example, the challenge will be to use fewer purchased inputs more efficiently. In other areas, as in most of Africa, the use of production inputs must increase to provide sustainable livelihood options to growing populations.

*Supported by a sound policy framework.* As the private sector is largely involved in agricultural production and marketing systems, governments have a key role in establishing a facilitating policy and regulatory environment for sustainable agriculture. To maximize agriculture's efficiency and sustainability, public policy should seek to internalize all costs and benefits in the prices of production inputs, such as improving pricing mechanisms for irrigation water, facilitating land market development, and eliminating distorting taxes and subsidies on chemical inputs, including fertilizers. Government investment programs must also provide for critical infrastructure (roads, electricity) and other public goods, such as regulatory frameworks, administration of property rights, research, and information services, especially for small-scale farmers.

*Built on knowledge-intensive innovations.* Sustainable intensification must build on a strong understanding of the system and its components. Research and extension will need to provide the technical and management recommendations suited to specific farms and fields rather than broad general areas. "Precision farming" systems will help apply the knowledge to field-level production. Investments in biotechnology, ICTs, processing, and marketing technologies are also needed.

*Focused on poor and marginal farmers.* If countries are to achieve social objectives and improve political stability, investment in sustainable agricultural production should be directed at poor people. Sustainable livelihoods within agriculture will not be possible for everyone, however, and some marginal farmers with little potential to improve incomes in agriculture must seek off-farm employment. Practitioners must consider the wider social impacts of investments and the need for alternative employment.

*Equitably shared by all gender and minority groups.* Agricultural production system innovations are socially sustainable only when all members of society share in the benefits. Because almost half of all farmers in the world are women, and because in most rural areas women carry out many specialized production activities (planting, weeding, vegetable gardening, managing small animals, postharvest handling), investments must ensure their participation in programs and avoid negative impacts. Men may displace women farmers, as has occurred in some parts of Africa, when export horticultural market opportunities have encouraged men to take over women's traditional plots of land. The same is true for many minority ethnic and cultural groups, who have more limited access to education, loans, property rights, and technical information. Social analysis is needed to guide project design and investment, draw on traditional knowledge, and identify and mitigate negative environmental impacts on different groups. Gender analysis is a particularly important tool for predicting gender-specific impacts of agricultural intensification investments and mitigating adverse impacts, such as increases in women's workload or reduced access to land.

*Participatory processes.* All relevant stakeholders should be included in the design and implementation of sustainable intensification activities, as this inclusiveness will empower farmers to plan and execute these activities and to obtain information and develop options needed in the decision-making process. With these skills, farmers have a better ability to link to markets and to negotiate their interests with agribusinesses and governments. Strengthening representative rural producer organizations (RPOs) and other advocacy groups for the agricultural sector can facilitate this empowerment.

*Environmentally sound.* Sustainable agricultural production systems must be environmentally sound—neither depleting the natural resource base on which they depend nor contributing significantly to the depletion of downstream resources. Agricultural intensification investments should seek to reduce soil erosion and land degradation, avoid loss of biodiversity, and improve the efficiency of land and water resource use. In general, more efficient use of existing resources avoids pressure on more marginal production areas, thus preventing more widespread environmental degradation.

*Nonpolluting.* As agricultural production systems use inputs more intensively, avoiding pollution of environmental resources (water, land, air) and food products through minimizing downstream pollution from agrochemicals, livestock manures, and soil erosion is critical to the sustainability of downstream production systems. Government regulation relating to pollution, both mitigation measures and charges, is relevant to environmental assessments of new production systems.

*Market and private sector based.* Small-scale farmers seeking to intensify and diversify their production systems are especially affected by poor access to knowledge and the lack of input and output markets. Investment is needed to develop these markets and infrastructure, which will expand producers' production options and facilitate production changes to satisfy consumers' demand for better quality production, safer products, and information on methods of production. In these circumstances, an effective response requires that agribusinesses and government and commodity organizations develop standards, grades, and certification of processes (certification of processes may relate to farm practices, including environmental and social conduct—that is, encouraging environmentally sustainable or “good” farming practices). Farmer organizations have a central role in scaling up production to develop new markets and meet market demands.

*Low risk.* Agricultural production nearly always involves substantial risk because of weather, pests and diseases, and market prices. Farmers, particularly resource-poor farmers, are risk adverse, and they may maintain traditional production systems and practices even when market, environmental, and technological changes make them unsustainable. Innovations for sustainable intensification are most acceptable to farmers when they involve minimal risk or reduce risks. Where this is not the case, investments may be needed to help deal with risk by providing financial, information, and risk management services, as well as improved infrastructure. In addition, financial incentives such as matching grants may be needed to encourage resource-poor farmers to try out more sustainable methods of production.

*Trade-offs.* Options for intensification will not necessarily involve win-win scenarios. In practice there are trade-offs between productivity (and income), environmental sustainability, and various social objectives. Common trade-offs include efficiency/equity, specialization/flexibility, profits/environmental benefits, and long-term/short-term paybacks. These trade-offs present difficult choices for policy makers, and sound cost/benefit analysis accounting for economic variables, and their social and environmental implications, must be employed. This will involve building the capacity of both public and private sector decision makers to make effective decisions within complex decision environments. It will also require compensatory mechanisms to mitigate adverse effects on groups that are negatively affected by initiatives that provide positive overall net benefits to the target population.

### **Future Directions for Lending**

Public investments to intensify sustainable production systems are generally best focused on (1) facilitating the capacity of farmers, government, and the private sector to make decisions about the appropriate technological and resource allocation and (2) providing the necessary social/organizational and physical infrastructure. It is critical that agricultural production systems be sufficiently flexible to adapt to changing environmental and economic conditions.

New technologies will be developed, and variations on established production systems are likely to continue. At present, options that may warrant public sector support include:

- *Variety improvement* will remain crucial as it becomes increasingly difficult to “adjust the environment to the plant.” Plant varieties adapted to specific production environments and sustainable agricultural practices, and to resisting specific pests and diseases, will become increasingly important. Livestock improvement will increase productivity and make more efficient use of scarce land and water. Biotechnology’s potential as a tool for sustainable production systems should be evaluated and supported on a case-by-case basis.
- *Conservation farming* practices can reduce unnecessary input use. Minimum tillage or no-till crop production reduces labor and equipment costs, enhances soil fertility, reduces erosion, and improves water infiltration, thereby reducing unit costs and conserving land resources. Improved crop residue management, including mulching, is often a necessary component of these systems. No-till systems of conservation farming have proven a major success in Latin America and are being used in South Asia and Africa.<sup>3</sup>
- *Organic farming* eliminates use of chemical inputs and can be sustainable as long as practices maintain productivity at a reasonable level, consistent with price incentives provided by growing market opportunities for organic produce. Organic farming depends mainly on the development of niche markets with reliable standards and certification systems for production.<sup>4</sup>

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<sup>3</sup> See the AIN, “Conservation Tillage.”

<sup>4</sup> See the AIN, “Organic Agricultural Production Systems.”

- *IPM systems* have been developed for many crops to control pests, weeds, and diseases while reducing potential environmental damage from excessive use of chemicals. Scaling up IPM technologies is a challenge, as these management systems rely on farmers' understanding of complex pest ecologies and crop-pest relationships. Thus, while IPM messages need to be simplified, IPM systems require continuous research and technical support and intensive farmer education and training along with policy-level support.<sup>5</sup>
- *Precision agriculture* improves productivity by better matching management practices to localized crop and soil conditions. Relatively sophisticated technologies are used to vary input applications and production practices, according to seasonal conditions, soil and land characteristics, and production potential. However, with help from extension and other services, resource-poor farmers can also apply principles of precision agriculture for differential input application and management on dispersed small plots. Appropriate technologies suitable for use by small-scale farmers include simple color charts to guide decisions on fertilizer application, and laser leveling of fields for irrigation.
- *Fertilizer use in Africa is low* and soil fertility is declining, which explains much of the lagging agricultural productivity growth in Africa relative to other regions. Fertilizer use is resurfacing on the African development agenda, and policy makers face a major challenge in deciding how to promote increased use of mineral fertilizers. There are several obstacles to overcome to avoid fertilizer-market failure, however. They include strong seasonality in demand for fertilizer, the riskiness of using fertilizer (stemming from weather-related production variability and uncertain crop prices), highly dispersed demand for fertilizer, a lack of purchasing power on the part of many potential users, the bulkiness and perishability of most fertilizer products, and the need to achieve large volumes of throughput in fertilizer procurement and distribution to capture economies of scale.

Public investment can also support the transition to more profitable and sustainable farming systems. Some of the *system adaptations* that are options for sustainable intensification of production include:

- *Integrated crop-livestock production* can enhance environmental sustainability by feeding crop residues to animals, thus improving nutrient cycling. This crop-livestock approach is likely to become increasingly profitable given the large, worldwide increase in demand for meat, milk, and other products derived from animals. The suitability of many livestock enterprises to small-farm production systems holds considerable potential for poverty reduction.
- *Agricultural diversification* must be pursued where existing farming systems are not environmentally sustainable or economically viable. Diversification into high-value, nontraditional crops and livestock systems (horticultural crops, for example) are attractive because of the growing market demand for these products, their high labor intensity, and the high returns to labor and management. In contrast to other

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<sup>5</sup> See the AIN, "Integrated Pest Management."

low-input strategies for sustainable intensification, diversification to high-value products frequently requires the use of relatively high levels of inputs, which must be monitored and managed carefully.<sup>6</sup>

- *Tree crops*, including fruit, beverage, timber, and specialty crops, offer opportunities for environmentally sound production systems, because they maintain vegetative cover and can reduce soil erosion. Tree crops, especially multiple-species plantations, help maintain a relatively high level of biodiversity. They are important to export earnings in many countries and, while often suited to large-scale plantations, are also important to smallholders with mixed cropping systems.

Sustainable intensification will frequently require activities that provide an enabling environment and support services for the market-led changes, or component technologies, including management practices. Much investment will come from market supply chains based in the private sector, including input supply and output marketing and processing enterprises and farmers. Public investment will need to focus on (1) new knowledge and information services, (2) public policy and regulatory systems, and (3) market and private sector development.

*New knowledge and information services.* A key investment area is in technology associated with management innovations to improve overall productivity and sustainability of agricultural systems. Much research will focus on developing improved management systems, with an emphasis on understanding agricultural ecology, farm management, and social systems. Biotechnology offers opportunities to diversify and intensify agricultural production systems—tissue culture for production of virus-free planting stock (for example, bananas) and transgenic crops with pest resistance or other beneficial characteristics (box 4.4).

**Box 4.4 South Africa: *Bt* cotton and sustainable development of the Makhathini Flat**

South Africa has been a leader in Africa in research, production, and commercialization of biotechnology products. In the Makhathini Flat, an arid region, smallholders grew cotton as a subsistence crop, but since growing *Bacillus thuringiensis* (*Bt*) cotton—genetically modified cotton producing a protein that acts as insect control—they have seen the following benefits:

- Environmental/agronomic benefits: more than 50 percent reduction in pesticide spraying; easier crop management; reduced risk of bollworm attacks.
- Economic benefits: 20-60 percent yield increases; higher gross margins (on average US\$50 per hectare); reduction in labor requirement.
- Social/health benefits: better school enrolment; fewer pesticide poisonings; general community livelihood improvement; less drudgery in weeding for women.

Source: James 2002

<sup>6</sup> See the AIN, “Market-Driven Diversification.”

Agricultural extension, education, and training investment is needed at all levels—farmers, technicians, and university graduates—to introduce principles of sustainable intensification and to develop human resources in this field. Many sustainable intensification investments have significant information requirements, such as weather forecasts, market information, natural resource conditions, and pest incidence, for which investments in rural information and communications systems are needed.

*Public policy and regulatory systems.* In many cases, government policies limit agricultural intensification and diversification by distorting production decisions and by encouraging monocropping through input and output subsidies (box 4.5). Pricing policies on water, land, and other natural resource inputs to agricultural production systems should encourage efficient allocation and use, an issue especially important to irrigation water management. Public policies should encourage investment in productive infrastructure, such as small-scale irrigation and erosion control. However, these policies must be complemented by regulatory systems and incentives that minimize pollution from agricultural production and processing. Government monitoring of changes in environmental conditions is an important input to guide policy formulation on sustainability.

**Box 4.5 Policy issues affecting adoption of sustainable agriculture practices**

*Price, trade, and tax policies*—input subsidies encourage excessive use; minimum support prices for cereals discourage diversification; electricity or fuel subsidies encourage groundwater depletion; subsidized milk/dairy imports discourage local production; and fuel or machinery subsidies discourage conservation tillage.

- Investments: analytical work, advocacy, stakeholder inclusion, policy formulation.

*Insecure property rights*—no incentive for long term investments.

- Investments: land titling, group ownership, conflict resolution, gender-based division of labor and access to resources, intellectual property rights (IPRs) required to promote private sector research and development.

*Externalities*—water and air pollution, siltation, salinization, climate change.

- Investments: advocacy, information campaigns, and regulations.

*Financial markets*—environmental conservation investments commonly have long gestation periods and high initial investment costs; traditional banking services are often inaccessible (a problem often compounded by insecure land tenure).

- Investments: new financial services mechanisms for agriculture.

Source: Authors

*Market and private sector development.* While investments in the policy and regulatory environment and in public goods knowledge and information services benefit the private sector, additional public investments may be needed to facilitate private investment. Governments must provide key infrastructure for rural transportation and communications, and they may need to share the risks that private companies undertake with new sustainable intensification investments. Targeted and time-limited grants promoting specific investment initiatives, such as pilot production trials, marketing trials, training, and extension activities, are useful to test and introduce new production systems

and innovations. Access to efficient financial services is key to enabling farmers to intensify production systems. RPOs provide a mechanism for collective action for input procurement, testing new technologies and innovations, and establishing sustainable output markets.

### Scaling Up Investments

Investments in intensification of sustainable agricultural production systems require monitoring systems that evaluate economic, social, and environmental changes throughout and following the program's implementation. Key impact indicators are investment profitability, poverty, and environmental conditions. Useful outcome indicators include area coverage, numbers of producers, value of production, equity in employment generation, and productivity changes of natural resources and other inputs.

A more clearly poverty-focused approach to lending, and a better understanding of the principles of sustainable agriculture, are likely to result in increased lending either as project components or as a project, integrating various elements of sustainable intensification. Increased technical input for project design and supervision to support additional lending is critical to complement those skilled in process and policy issues. Attention to two World Bank safeguard policies is especially relevant to investments in intensification and diversification of agricultural production systems:

- *Environmental assessment* (Operational Policy [OP]/Bank Procedure [BP] 4.01)—an Environmental Assessment is required if a new agricultural production system has potentially adverse environmental risks or impacts.
- *Pest management* (OP 4.09)—any agricultural production investment that involves the procurement and use of pesticides, or that could expand the use of pesticides and unsustainable pest management practices, requires an Environmental Assessment, a Pest Management Plan, and a list of the pesticides authorized for procurement.

### Selected Readings

Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

Bruinsma, J. (ed.). 2003. *World Agriculture: Towards 2015/2030: An FAO Perspective*. London: Earthscan Publications.\*

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## Market-Driven Diversification

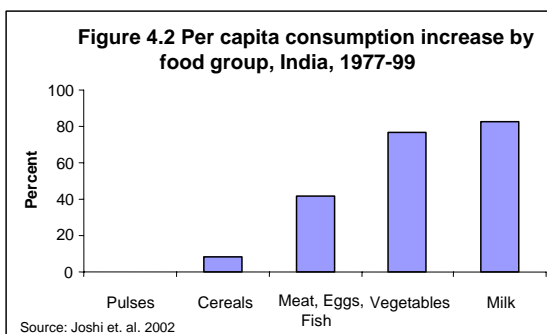
In many cases diversification can lead to improved agricultural productivity and income, through integrated resource management and by responding to changing markets and advances in technology. Important issues for diversifying into market-oriented production systems include: developing markets and market access, managing risks, targeting small-scale farmers, and promoting an enabling policy environment. Donors and governments will need to provide the training, infrastructure, and analytical support necessary to improve farmers' ability to make the transition to diversified production systems that are economically viable and environmentally sustainable.

Diversification at the farm level is the adoption of multiple production activities that are complementary in economic and/or ecological dimensions. This complementarity contributes to the overall sustainability of the farming system. The diversification process generally involves introducing new activities into the farm enterprise (for example, new crops, livestock, or processing methods) and reflects a reallocation of production resources and inputs as well as a change in production methods and the outputs produced. This note discusses the framework that will encourage market-driven diversification conducive to sustainable intensification, through improved crop rotations, complementarities among different farm enterprises (livestock and crop), and improved risk management.

### Need to Adjust to Changing Market Forces

Increasing international migration, global media and marketing systems, rising average incomes, and urbanization are rapidly changing the structure of consumer demand throughout the world. This is true for markets in both industrial and developing countries, and for food and nonfood products (figure 4.2). These changes give rise to new market opportunities (both domestic and export) at a time when prices for traditional commodities—such as rice, cotton, coffee, and tea—are declining.

On the supply side, technological advances have expanded the range of production possibilities at the farm level. Improved agricultural machinery, biotechnology, new herbicides, and IPM have facilitated better use of the sources of competitive advantage unique to developing countries (for example, unique microclimates and soil types, low labor costs, and counter-season production). New technologies have also increased the feasibility of integrating different systems within any one “mixed” farming system (multipurpose machinery for integrated crop rotations). Supply-side changes that expand the range of feasible options, and demand-side factors that alter the relative profitability



of those options, are requiring that farmers make a transition from traditional enterprises (often monoculture) to new and unfamiliar ones. The new enterprises can be more environmentally sustainable while also responding to market signals profitably.

## Benefits

Farm-level diversification involving mixed production systems can exploit potential synergies and complementarities among different operations for more productive and more sustainable use of the resources upon which farm systems depend. Replacing monoculture systems with mixed systems can improve biodiversity and reduce production risks associated with droughts and pest infestations. The increased variety of outputs produced reduces marketing risks associated with unexpected declines in the price of any one product. Diversification may also allow labor and machinery requirements to be distributed more evenly throughout the year, seasonal cash flows to be better managed, the range of products to be broadened, and marketing risks to be reduced (box 4.6).

### Box 4.6 Benefits of diversification to livestock production

- Provides a source of organic fertilizer.
- Buffers food supply, reducing the climatic and price risks of crop production.
- Provides meat, milk, and other animal products for household use or sale.
- Provides transport and traction, spreading labor demand and offering alternative sources of income.
- Uses crop residues as livestock feed.

Source: Authors

The transition to more profitable production systems increases demand for farm and nonfarm labor (largely due to the more labor-intensive nature of high-value crops) and is associated with increasing incomes for wage employees. Diversification can have large multiplier effects, creating off-farm employment opportunities in downstream and upstream economic sectors.

## Policy and Implementation Issues

Diversification must be a market-oriented process, driven by consumer demand and initiated by private sector agents. However, public sector participation will remain critical in certain areas such as the regulatory and policy environment and the provision of pure or partial public goods (for example, infrastructure and research).

*A stable and supportive policy environment.* Perhaps most important is an overall *agricultural policy* that does not skew production incentives and that promotes efficient decision making based on market demand and resource constraints. In many countries, agricultural policies distort production decisions toward food grains, undermining competitiveness and the long-term sustainable management of natural resources. Support policies aimed at encouraging adjustment to market-led production should be transitory and crop neutral.

*Liberalization of rules and regulations.* Rules and regulations governing market activity, curbing abuse of market power (particularly in network industries such as transport, energy, and communications), and enforcing contract law help to strengthen markets and ensure that the poor benefit equitably. Policies that protect resource use rights (land and

water in particular) and encourage investments on a long-term basis are essential for successful diversification initiatives (box 4.7). Insecure land title dampens the incentives for farmers to make the initial investments needed to transform their production systems. Secure land and water ownership rights improve farmers' ability to provide collateral to lenders, thereby facilitating access to the financial resources required for initial investments.

**Box 4.7 Turkey: policy reform to promote diversification**

Turkey recently reformed its agricultural policies to promote diversification. In phasing out input and output subsidies, a system of decoupled subsidies was used to partially cushion the blow to farmers. Because prior subsidies had led to a surplus of hazelnut and tobacco production, a project provided financial and advisory support to farmers to switch production to alternative crops. Support includes incentives for uprooting tree crops and technical and business advice on alternative production systems. Strengthening of national land administration systems and cooperatives are further elements of reform. Improved information systems will provide an additional foundation for comparing the cost, speed, and transparency of alternative production methods and will facilitate the monitoring of new production systems introduced in each region.

Source: World Bank internal documents

*Markets and infrastructure.* The transition to new production enterprises must be based on market demand and *sustained competitiveness* of producers (typically from either low-cost production or high-value and differentiated products). This depends on competitive nonfarm private enterprise at each stage of the supply chain, and it requires the strengthening of processing and logistical systems, input supply systems, and financial services.

*Risk environment.* Natural resource suitability, crop yields, market prices, and adequacy of infrastructure provide more *uncertainty* for new crops than for traditional products. Irrigation, integrated capital markets (to reduce price variability through risk pooling), stable government policy, and reliable information and communication systems all help to reduce risk. Technical services are needed to minimize risks of pests and diseases devastating new crop or livestock enterprises.

*Organized farmers.* RPOs are useful in facilitating innovation and diversification into new farm enterprises. Collective action enables small-scale farmers to source inputs in bulk and at competitive prices, explore market opportunities and linkages, obtain market and technical support, pool output to improve bargaining power, and form partnerships with commercial enterprises, governmental agencies, research and extension entities, and other community groups.

*Gender equity.* Diversification can offer new employment opportunities to women and men, but safeguards are needed to ensure equity of opportunity. Women are often disadvantaged by traditions that discriminate with regard to participating in market networks, accessing financing and inputs, and entering into contracts. Furthermore, diversification can displace women from traditional production and marketing activities. Processing plants frequently employ a high percentage of women in their workforce, but

labor standards are often low and the potential for exploitation of women is high. Activities involving diversification should allow for the empowerment and participation of women and minority groups.

## Lessons Learned

*Assessing alternatives.* The process of assessing alternative diversification opportunities requires intensive analysis and research, and farmers typically do not have the resources required for in-depth feasibility analyses (box 4.8). The public sector can facilitate this process but must maintain a supportive rather than a lead role, encouraging farmer and private sector initiative as opposed to “picking winners.”

*Information and communication.* Cost-effective, dependable communication systems are essential to convey market information to processors and producers, so that the products produced are competitive in markets and satisfy consumer demands. APROFA, a governmental agency in Mali, uses *agribusiness centers* and *reference centers* to disseminate new technologies and products to producers. It has become increasingly important to invest in *forward* information systems that maintain product identity and traceability throughout the entire supply chain.

*Targeting smallholders.* Diversification opportunities are not always equal, and small-scale farmers are often relatively less able to access information and financial resources that will allow them to enter new markets (box 4.9). Research and extension systems can be designed to respond to the needs of small-scale and marginal farmers, providing technologies suited to small farms. Improved transportation and communication systems reduce the isolation common to small-scale farmers in less productive areas and thereby reduce transaction costs for market participation.

### Box 4.8 Key considerations for diversification

- Government policy and stability of policies—exchange rate trends, volatility, and risks; trade tariffs, quotas, and taxes.
- Economic and environmental compatibility of alternative farming activities and potential conflicts among different enterprises.
- Infrastructure and distribution channels and participants in the supply chain.
- Market demand and sustainability.
- Asset ownership patterns and security of access to land, water, and loans.
- Food security (household and national).
- Storage requirements, critical product volumes, food safety requirements.
- Existing research and extension systems.
- Potential for value-added processing.

Source: Authors

### Box 4.9 India: self-targeting of project components

Many components of the Uttar Pradesh Diversified Agriculture Support Project were chosen because of their “self-targeting” character in reaching poor and disadvantaged groups. The seclusion of women required them to have access to home-based income-earning opportunities. The extent of landlessness required activities that were not biased against those with little or no land. Households with small or marginal landholdings benefit from horticultural activities, since fruit trees can be planted along plot boundaries or in home gardens. Livestock activities, including small ruminants (sheep and goats), and cow and buffalo milk production, provide significant benefits to the poor, including those with little or no land (provided they also have

access to commons, cut fodder, or crop residues).

Source: World Bank internal documents

*Public investments.* Diversification must be based on private investment, but co-investment by the public sector is likely to be required to facilitate adjustment and the introduction of new production and marketing systems. Investments must be appropriately timed and sequenced, with adequate market analysis before product-specific investments are made. Initial investments should be as generic and flexible in nature as possible to reduce the risk of market volatilities and production uncertainties for specific products. The public sector can finance or cofinance feasibility studies and investment strategies to promote private investment and can share start-up costs and risk by providing matching grants that are time limited and targeted. Public financing is also appropriate for public goods investments for removing infrastructure bottlenecks and ensuring adequacy of technical support systems.

*Sharing learning costs.* Diversification usually involves technology development and learning that can best be provided through research and extension systems that enable the costs of learning and experimentation to be pooled and shared equitably (box 4.10). In most cases, production and marketing technologies will not be readily available in country, but they can be “imported” from other countries, perhaps by sourcing the technology from either a private firm or a public research center. Local research capacity is useful—if not essential—to facilitate technology imports and address second-generation problems.

#### **Box 4.10 Vietnam: technical support for diversification**

In Vietnam, the Agricultural Diversification Project provided technical support for intensifying crop and livestock production, focusing on participatory research and extension (for example, in piloting fruit tree plantings and nurseries). The inclusion of farmers in the research process ensured that technologies responded to farmers’ needs. The project promotes a mix of farm activities, such as investment in rubber, livestock, and food crops, in a “smallholder technical package” that introduces sustainable management practices, such as terracing and contour farming on sloping and degraded lands.

Source: World Bank internal documents

## **Recommendations for Practitioners**

Diversification initiatives must be market led and based on sustainable comparative advantage. Public investments (box 4.11) should:

- Seek farmer collaboration through participatory evaluation of the suitability of alternative production systems and products.
- Sequence investments and activities such that they systematically build markets and capacity to supply them.
- Invest in *flexible* skills and technologies (rather than those that are highly product specific) and target products with multiple uses and markets.

- Establish appropriate means to manage risk through the development of infrastructure that reduces uncertainty in production and marketing processes.
- Facilitate the development of producer organizations to promote the interests of smallholders through collective action.
- Make production inputs and markets “user-friendly” (for example, available in small packages and convenient locations) so that farmers can test the new production system without committing to a complete transition.

#### **Box 4.11 Potential investments**

- Analytical support for market and technical feasibility.
- Development of output and input markets.
- Policy support and guidance for the sequencing of investment activities.
- Financial markets and risk management tools to encourage private investment.
- Infrastructure to improve market access—roads, ports, cold chains, telecommunications.
- Public good research and extension.
- Regulatory and certification systems to satisfy market and trade standards.
- Market and technical information systems.

Source: Authors

### **Selected Readings**

Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

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This investment note was prepared by Sam Kane, Kristina Sorby, and Shawki Barghouti, with input from the Sustainable Agriculture (SASKI) Thematic Team of the World Bank.

## Smallholder Dairy Production

Smallholder dairy production is common in many parts of the developing world, providing an important source of nutrition and income to millions of households. Income from such production often accrues to women, who use it to provide better nutrition and education for their children. Projections for future growth in demand for livestock products show good growth prospects for the dairy industry. Public support is often needed to put in place appropriate policies, establish marketing chains, and provide services for growth of smallholder dairying.

Globally, there are about 300 million rural and periurban poor whose livelihoods depend on the daily income and nutrition they receive from milk production. In India, about 40 million landless poor families get a major part of their income from milk. Since there are fewer economies of scale involved in dairy production than in some other livestock production systems, the strong concentration of production evident in the pig and poultry sector is not yet seen in the dairy sector. Markets in developing countries are secure, as demand for milk and milk products is expected to increase by more than 3 percent annually over the next 10 to 20 years (Delgado et al. 1999). Per capita milk consumption will then still be only one-fourth of the per capita consumption in the industrial countries.

### Smallholder Dairy Development

Smallholder dairy production takes many forms and is often combined with cottage industry (small household) processing activities. Smallholder dairy production is mostly carried out by the family, with some very limited hired labor. Examples of smallholder dairy production are the mixed farms in Central America with 25 cattle; small mixed farms in the highlands of Ethiopia with one or two cows; rice farms in the Punjab of India with 10 buffaloes; and Sahelian pastoralists with herds of up to 100 animals.

Although future regional market developments are difficult to predict, it seems that developing countries have a good chance of benefiting from new market opportunities. Milk production growth in developed countries is constrained by limited land and water availability and increasingly by strict environmental legislation and reforms in subsidies provided to the dairy industry. Because of the comparative advantage of temperate climates, production expansion is most likely to come from North America, the Southern Cone of South America, and areas such as the Ukraine, though there remain opportunities for growth in other areas, such as China, India, and East Africa (box 4.12).

#### **Box 4.12 India: Operation Flood—how a commodity project can reduce poverty**

Operation Flood was supported by the World Bank and other donors from the mid-1970s to the mid-1990s. It originally started as a marketing project but gradually developed into production and input services. It is based on a three-tiered cooperative system that includes:

- Village-level dairy cooperative societies, which are farmer controlled, with an elected management committee, including at least one woman.

- Regional milk producers unions that own the dairy plants and transport equipment for milk collection and processing.
- State federations for interstate sales and coordination.

The National Dairy Development Board, a government apex organization, provided technical support. Operation Flood now has 9 million members (60 percent are landless), with a daily milk throughput of about 30 million liters. It has made important contributions to poverty reduction, human health, and nutrition and is the most successful Bank operation in the livestock sector. Operational issues included interference by government, in particular in the federations, and its search for monopoly positions when support from outside sources was phased out.

Source: de Haan et al. 2001

## Benefits

Certain characteristics of smallholder dairy production systems—intensive, year-round labor needs, the provision of regular income, and easy substitution of the product between home and market—make dairy production a good example of pro-poor approach to agriculture and rural development. The production characteristics of smallholder dairying, such as use of crop residues, fodder-crop rotation, and production of organic fertilizer, provide a strong synergy with other parts of the farming system. Milk's perishable nature and the limited marketing leverage of an individual small producer make it highly suitable for cooperative marketing and hence an important tool for farmer empowerment. However, smallholder dairying carries risks. In many cases, a small herd constitutes a large part of the farmer's assets, and disease and death can wipe out these assets entirely, potentially leading to increased indebtedness and poverty.

## Policy and Implementation Issues

*Subsidies and dumping.* With milk production mainly being a smallholder activity, and milk seen by many as a being a staple product, the dairy sector is the subject of political attention and inappropriate policies. Thus the sector has suffered from excessive price controls, and greatly distorting subsidies both in OECD and developing countries. In developing countries, the dairy sector has been negatively affected by the dumping of surplus subsidized dairy products by the EU and USA. With global trade negotiations in the WTO on the issue of agricultural subsidies, producer groups, local industry, donors and finance ministries need to discuss issues of domestic liberalization and appropriate adjustment that may be needed as a transition mechanism. Other policy issues encountered in Bank projects include cooperative monopolies (India), excessive interference of government in the sector, the introduction of unsustainable subsidies—for example for artificial insemination (AI) (India, Kenya, Morocco) and health services--and excessive food safety regulations.

*Markets.* Milk, being highly perishable, requires daily collection and market delivery. Many past investments have focused on developing western-style collection, processing, and distribution systems, with pasteurized products. There is growing evidence, for example from Nairobi (Staal 2002), that this approach might be counterproductive.

Pasteurization and packing costs nearly double the price of milk to consumers, thus reducing farm gate prices and limiting access by the urban poor. Giving the formal sector the exclusive right to distribute milk and milk products also affects employment opportunities for many small intermediaries involved in the distribution system. In addition, marketing through a formal collection system introduces one of the few economies of scale in dairy production, as it is often accompanied by a requirement for on-farm cooling equipment, which normally is profitable only with a production level of 100 liters or more per day. Such requirements, in situations where milk is boiled before consumption, are unnecessary, as boiling obviates the need for pasteurization.

## Lessons Learned

Success in smallholder dairy production can be evaluated at three levels; farm, market, and institutional (box 4.13). Dairy production normally requires a high quality of support services as dairy breeds are generally more costly and more vulnerable than other cattle to disease and health problems.

*Veterinary.* Because smallholder dairy development is a rather risky endeavor, good, easily accessible veterinary services are essential. Experience in many countries, such as India and Kenya, shows that private veterinary services (also supplemented by public services for the “public goods” such as vaccination) are highly desirable and can provide the flexible, dynamic services the smallholder dairy producer requires.

*Breeding.* The choice of dairy breed has been subject to much debate. Past introductions of pure exotic breeds have almost universally failed (with the exception of restocking programs in areas such as the Balkans). Generally a combination of selection in local breeds and cross-breeding with exotic breeds is more appropriate, leaving it to the skill of individual smallholders to decide on the level of exotic germplasm they can manage. This approach has been quite successful in India, Northern Brazil, and Kenya.

Breeding systems are also subject to considerable debate. Although AI systems are often demanded by Bank clients, they have high costs and logistical and maintenance requirements, because of the need for liquid nitrogen to store semen. Such facilities can be organized in areas with good communications and infrastructure, but many AI systems have proven unsustainable without continued subsidies. Terminating subsidies, as in Kenya, can then cause the system to collapse, which in the absence of alternatives causes the genetic base of the dairy herd to deteriorate considerably. AI requires adequate producer skills, infrastructure, and communication

### Box 4.13 Indicators of success

A successful smallholder dairy sector is characterized:

- At the *farm level* by: calving rate of 80 percent or more, a production level (depending on conditions) of 600-3,000 liters per lactation (that is, about 300 days), mostly fodder based, and economically attractive.
- At the *marketing level* by: a viable formal collection system (private or cooperative), supplemented by small traders.
- At the *institutional level* by: an influential national organization.

Source: Authors

facilities. Where AI is to be introduced, it should be privatized, and where appropriate conditions do not exist, bull camps or the use of fresh semen have given good results, as in Indian Watershed projects.

*Extension.* Most general extension staff members have little experience with livestock and dairy farming. Key areas requiring additional extension training include fodder production and livestock feeding schemes, husbandry (in particular calf raising), and dairy hygiene. Health and breeding services can best be handled by specialized professional services. Extension staff must also help producers cope with social change, such as changing gender roles and issues of access and control over resources.

*Credit.* Capital requirements for smallholder dairy producers are high and may be especially constraining for women farmers. Credit schemes need to be long-term. If, for example, a pregnant three-year-old cow is the starting stock for the family dairy, credit terms should be for at least three years. Loans are ideally accompanied by an insurance system to mitigate animal loss risks. However, experience with livestock insurance has not been very good, because of the moral hazard problems involved.

The credit-in-kind system, whereby animals are provided on condition that some of the offspring are passed on to other members of the community, has been effective in many programs. If the program is adequately integrated in the local community, peer pressure ensures sustainability of the passing-on mechanism. A number of NGOs, such as Heifer Project International, Oxfam, and Farm Africa, are specialized in this area (box 4.14).

**Box 4.14 Indonesia: in-kind credit in Java**

The Provincial Development Program of Central Java Province introduced a new in-kind loan project in the 1980s to replace the small ruminant credit system. Target farmers were divided into groups of 10 with each farmer receiving two female goats or sheep. Each group leader received small ruminant management training and a good quality buck or ram. Each recipient had to repay four lambs or kids over a three-year period. Post-program evaluation in 1988 found the program to be successful in introducing new technology, increasing farmer income, improving production performance, and improving dynamics within farmer groups. The system can work equally well for dairy cattle.

Source: de Haan et al. 2001

*Farmer organizations.* The perishable nature of dairy products gives individual farmers little leverage in marketing. However, the involvement of many smallholders in milk marketing makes dairy products suitable to cooperative processing and marketing systems. Most cooperatives also provide services such as health and breeding, although cross subsidies of these services through the price of the milk become an issue. Government interference can however be a constraint to building organizational capacity.

*Feed supply.* Feed supply is a major issue for smallholder dairy systems, as most systems operate under conditions of extreme land pressure (Kenya, India) or labor availability (West Africa, with high labor needs at the end of a marked dry season). Feed

conservation for dry season supplementation has been a major issue, as most technologies, such as silage, haymaking, and urea treatment are not suitable for smallholder or humid tropical environments. Fodder trees and mixed tree-legume protein banks can be a solution.

## Recommendations for Practitioners

Key conditions for successful dairy development involve market access and availability of services to smallholders and require public policy and institutional development and targeted investment. Sound investments generally must (box 4.15):

- *Conduct a detailed assessment on the extent and nature of market demand.* Key questions to consider include: Do local consumers want pasteurized milk, and can they afford it? Are there opportunities to export? What safety and quality standards must be met? All initiatives to promote smallholder dairying must be led by market demand.
- *Promote private sector development of supply chain infrastructure required for efficient production and marketing.* This includes transportation and communication systems, food testing and certification facilities, and cold chain infrastructure.
- *Establish an appropriate balance between public and private involvement in the supply of services.* In many instances public sector involvement is best restricted to limited-term cofinancing arrangements that encourage private sector investment. A direct government role is appropriate in areas such as auditing of certification systems and management of quarantine procedures and epidemic risks.
- *Promote establishment of effective financial markets and risk management mechanisms.* This is largely the role of the private sector, and private investment may be best initiated through limited-term cofinancing schemes.
- *Provide technical assistance to both male and female farmers.* Assistance is needed in areas such as breeding policy (what breeds are most suitable to the production and market environment; where should breeding stock be sourced; is AI appropriate?), animal health (control of internal parasites, mastitis management), milk hygiene, and feeding policy (managing feed supply, conservation of surpluses, supplementary feeding).

### Box 4.15 Potential investments

- Animal health and breeding services, with a focus on developing private systems. Costs would be about US\$2,000-5,000 for breeding services and US\$10,000–20,000 for veterinary practices.
- Extension services to provide specialized skills for dairy production.
- Market development and infrastructure. Cooling systems vary between US\$1,000 and US\$20,000. Wood-fueled pasteurization plants at nominal costs can be effective up to about 500 liters per day; small pasteurization plants (2,000 liters per day) cost about US\$10,000; and larger processing plant costs vary according to individual design.
- Financial services (savings and credit) need to be included in the overall microfinance systems, eventually supported by special credit in-kind schemes.
- Producer organization support, mostly in the form of technical assistance.

Source: Authors

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Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

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This investment note was prepared by Cees de Haan, with input from the Sustainable Agriculture (SASKI) Thematic Team of the World Bank.

## Organic Agricultural Production Systems

Organic agriculture can improve farmers' incomes and the management of natural resources, but it entails additional production and certification costs and a significant time lag for the transition to organic certification and realization of profits. Organic production must be based on sustainable comparative advantage and is likely to be most successful in areas with effective research and extension systems, a supportive policy and regulatory framework, necessary infrastructure, adequate certification systems, and good access to foreign markets. Producer associations have been key to accessing markets, disseminating production technologies, and monitoring compliance with organic standards.<sup>7</sup>

Over the past 50 years, agricultural production has increased dramatically, in part through the use of chemical fertilizers, pesticides, and antibiotics. These technologies and the intensive production systems they support can pose increased human and environmental health risks. As a result, a market has developed for "organic" food products, which consumers perceive as safer and more environmentally friendly. Retail sales of organic products were estimated at US\$19.7 billion worldwide in 2000 and have grown more than 20 percent annually in major markets over the past 15 years. These growth rates are from a low base, however, and organic food sales generally account for less than 2 percent of total sales in most markets. Thus opportunities to profitably enter this market are somewhat limited by demand. Organic agricultural production, given its limited production levels and variability in yields, is unlikely to impact substantially on global food supplies.

### Organic Production Systems

Organic agricultural production systems employ agronomic, biological, and mechanical methods in place of chemical inputs. Cultural and biological practices control pests and crop rotations, and animal and green manures maintain soil fertility. There is a virtual prohibition on the use of synthetic chemicals for crop and livestock production. Most organic agricultural systems also apply improved land husbandry techniques, such as soil conservation measures, crop rotation, and reduced crop residue burning.

Organic production usually involves annual inspection of production sites by independent specialized certification agencies, interviews with producers, review of organic fertilizers and other inputs used, and laboratory tests of soils, water, and agricultural products. Requirements include: land must not have been used for conventional agriculture relying on chemical or synthetic inputs for a minimum time period (usually three years); conventionally grown crops must be a minimum distance from organic crops, and a forested area may be required as a barrier between organically and conventionally grown crops; inputs must be organic, with no chemical or synthetic inputs permitted; soil conservation measures must be applied; and farmer associations must be able to organize

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<sup>7</sup> This AIN was adapted from Damiani (2002).

supervision to ensure that organic standards are met by all members. Certification focuses on the process of production rather than the end product itself.

## Benefits

Small-scale farmers may have competitive advantages in organic farming and can benefit in several ways (box 4.16). First, production costs may be reduced by substituting labor and organic inputs for chemical inputs that are often more expensive and difficult to obtain. Second, prices may be higher for organic products. Third, organic production may reduce health risks from handling chemical inputs.

Finally, soil conservation measures and control of pests and diseases with manual and biological methods may reduce contamination of natural resources.

### **Box 4.16 El Salvador: benefits of fresh organic vegetable production**

Three farmer associations in the Las Pilas region are producing organic vegetables on 36 hectares. The 52 members of the associations previously cultivated cabbage and tomato with conventional technologies, selling them through intermediaries in the wholesale fruit and vegetable market in San Salvador. Their shift to organic production involved adopting a wide variety of new vegetable crops, planning cultivation to sell year-round, and direct marketing to supermarkets, restaurants, and hotels in San Salvador. Organic production in Las Pilas successfully competes against imports, mainly because of product quality and product differentiation.

Source: Damiani 2002

Benefits of organic production are by no means guaranteed as crop yields may fall, price premiums may diminish as production increases, distribution systems may prove inadequate, and unexpected negative environmental impacts (for example, weed migration from fields to natural habitats) may result. Investment in organic production should be made only after feasibility studies based on realistic production and market assumptions indicate that benefits are likely to be sustainable over the long term.

## Policy and Implementation Issues

*Yield of organic products.* Typically, yields fall (by as much as 10-30 percent) following the conversion to organic production, and significant pest and soil fertility problems are common throughout the transition period. The extent of declining yields depends on physical farm characteristics, farm management, and previous chemical input use. Small-scale producers who use little or no chemicals may see no change or even an increase in yields due to better management. Yields are also likely to be more volatile with organic production because of pest losses.

*Transition to organic production.* The transition from conventional to organic production usually takes three years. During this period, farmers cannot obtain organic certification and its resulting price margin. Access to affordable credit throughout the transition period is critical. While shifting to organic production does not require major on-farm investment, there are costs, such as certification costs, some additional investments in soil conservation and equipment, higher labor costs, and sometimes lower yields.

*Land tenure.* Most organic producers own their land. Small-scale farmers lacking secure land tenure are reluctant to move into organic production, as they need to invest in land-conservation measures.

*Technology issues.* Organic production requires a high level of managerial knowledge, the ability to protect crops from pests and diseases, and compliance with production process requirements. Access to adequate quantities of organic inputs, such as natural pest enemies, livestock manure, mineral rock phosphate, and organic matter can be a problem. The lack of technology can be an advantage for some organic producers: their success is related to not previously using chemical inputs; they can be certified as organic with little or no change in production practices; training and technical assistance costs are likely to be significantly lower; the transitional period can be shorter and less expensive; and yields are not likely to decrease as much.

*Environmental impacts.* Organic production systems can have some negative environmental impacts, such as overuse of animal manures that can lead to nitrite pollution of water supplies. Insufficient application of organic manures can lead to soil mining and long-term productivity declines.

*Certification requirements and costs.* Reliable independent accreditation and control systems are essential to enforce organic standards and regulations and to meet phytosanitary standards and general quality requirements. For organic farmers, certification is one of the most important cost items, with costs varying depending on the availability of a certification agency, farm size and volume of production, and the product. Total certification costs usually involve both a fixed and a variable cost that covers certification and inspection. For example, costs are: US\$18.50 per hectare for coffee farmers in Guatemala, US\$11 per farmer for cacao producers in Costa Rica, and 4.4 percent of gross revenue for sugarcane farmers in Argentina.

*Labor costs.* Labor use is often higher in organic production systems because of the need for additional soil conservation measures, such as the construction and upkeep of terraces and live barriers; new management practices, such as managing shade tree crops; the control of weeds, pests, and diseases through manual practices; the need to apply large volumes of organic fertilizers; and potentially increased harvest costs (table 4.2). The combined effect on production costs from increased labor requirements and lower chemical inputs will vary and must be assessed in relation to other factors, particularly yield and price changes. In places where chemical input use is low, total costs are likely to rise because labor cost increases are likely to exceed the savings from using chemicals.

*Processing and marketing facilities.* The marketing of most organic products requires certified sorting, processing, and packing facilities, handling only organic crops. This additional cost means the minimum volume of organic product needed for a viable enterprise is more than for conventional crops. Stable relationships with importers, traders, or wholesalers in the target market are important to coordinate distribution and access information.

*Gender issues.* Because of less business experience and gender-based discrimination, women organic farmers may find it more difficult to make required contacts, negotiate agreements, and obtain access to credit. Women find low-paying jobs in organic farming, providing labor for weeding and harvesting (for crops like coffee, cacao, bananas, and vegetables) and in packing facilities.

### Lessons Learned

**Table 4.2 Production costs of organic and conventional crops (US\$/ha)**

Crop	Organic	Conventional
<b>Sugarcane (Argentina)</b>		
Production cost (PC)	490	562
Labor cost (LC)	238	154
LC/PC (%)	49	27
<b>Coffee (Mexico)</b>		
Production cost (PC)	680	452
Labor cost (LC)	522	360
LC/PC (%)	77	80
<b>Bananas (Dominican Republic)</b>		
Production cost (PC)	2,560	2,370
Labor cost (LC)	1,826	1,218
LC/PC (%)	71	51

Source: Damiani 2002

*Research, extension, and training.* Extension services have, with the exception of coffee, faced problems in finding professionals trained in organic agriculture. Including organic production systems into research and education programs is essential to supplying technologies and well-trained professionals for the future. For small-scale organic producers, extension services are particularly important to improve product quality and ensure compliance with organic production methods.

*Strengthening farmer associations.* Producer organizations play a major role in enabling small-scale farmers to begin organic production, as they make possible economies of scale by marketing product in quantities that attract foreign buyers. These buyers find it easier and cheaper to contract with organizations rather than with a large number of individual farmers (box 4.17). Associations train large numbers of small-scale farmers, and organize monitoring systems to ensure compliance with production standards. Compliance is very important, because if only one member fails to comply with production standards, buyers' trust is lost and there are severe consequences for the entire group.

#### **Box 4.17 Costa Rica: farm associations and organic cacao and banana production**

The Talamanca Small Farmers Association (APPTA) created in 1987 had 1500 members by 2000. Most members abandoned cacao plantations in the 1970s because of disease and low prices and were making a living from subsistence crops and poultry. APPTA promoted a revival of cacao production and, with help of an NGO, established contacts with buyers of organic cacao in the United States. By the early 1990s, APPTA had a significant area of cacao certified by a U.S. certification agency (Organic Crop Improvement Association), allowing members to regain an important source of cash income. Following this initial success, APPTA obtained organic certification for banana production for baby food (puree of organic banana) for export to Europe and the United States.

Source: Damiani 2002

*Marketing organic products.* Supermarkets are the fastest growing sales outlets for organic produce, but small-scale farmers often do not sell to supermarkets because they lack marketing skills and connections. As a result, marketing through farmer associations has been key in helping small-scale farmers obtain better prices. Marketing contracts (that is, contract farming) may secure and stabilize prices and may provide access to extension services and credit. Outgrower schemes are common, but there may be high costs for monitoring and enforcing contract provisions. In developing countries, domestic markets for organic products are attractive because they can be less demanding than export markets in terms of quality.

## Recommendations for Practitioners

Organic production is one of several options for improving production and incomes of small-scale farmers. Investments in organic agriculture (box 4.18) should:

- Strengthen associations of small-scale producers that play a major role in marketing, production, dissemination of organic technologies, and monitoring members' compliance with organic methods of production.
- Provide financial support during the transition period by covering start-up costs of certification systems and organizing an effective and participatory monitoring system.
- Strengthen government policies and institutions dealing with organic agriculture, such that appropriate regulations protect producers, consumers, and exporters.
- Use NGOs with experience in organic production as preferential partners for projects. NGOs have frequently promoted production based on local resources rather than on purchased inputs and often have skills in supporting small farmer associations and marketing organic products.
- Consider using domestic markets as an entry point to gain experience with organic production processes, certification requirements, and quality standards.
- Target producers with the highest potential for success, concentrating on small-scale farmers with stable land tenure and access to financial resources and other inputs for organic farming.

## Selected Readings

Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

Coote, C., P. Greenhalgh, and J. Orchard. 2003. *High Value Horticulture and Organic Export Markets for Sub-Saharan Africa*. Kent: Natural Resources Institute (NRI).

### Box 4.18 Potential investments

- Training for producers on organic production and markets and problems of noncompliance.
- Extension services for organic production and maintenance of product quality.
- University training and research programs to develop resources and technologies for organic agriculture.
- Support for soil conservation measures and for certification costs during the transition period.
- Support for farmer associations, NGOs, and marketing firms developing organic agricultural markets.
- Financial resources to support investment in packing and processing facilities.

Source: Authors

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This investment note was prepared by the Sourcebook team, based on an IFAD publication "Small Farmers and Organic Agriculture: Lessons from Latin America and the Caribbean" by Octavio Damiani.

## Urban and Periurban Agriculture

Agricultural activities in and around cities and towns contribute significantly to meeting the needs of these urban areas, providing employment to urban dwellers, especially women, and absorbing city wastes. Institutional and technological innovations are needed to integrate urban and periurban agriculture (UPUA) with evolving urban marketing systems and to satisfy demands of urban consumers. Other investment needs include capacity for supply and demand analysis, awareness campaigns on food quality and environmentally sound practices, technological and institutional innovation for production and monitoring food safety and quality, and an enabling environment for the private sector to distribute inputs and services.

Migration of the poor from rural to urban areas (where basic services are more available and costs of living are less) will continue to be a major trend in developing countries. This results in shifting poverty from rural areas to urban slums and increasing urban and periurban agriculture. Sustainable production, processing, and distribution of food in and around cities and towns contribute to the goal of a safe, affordable, and reliable food supply for the urban poor and provide income and employment to a large number of urban poor, especially women. Critical issues concerning UPUA include the use of pesticides; use of urban waste in agricultural production; environmental pollution caused by agricultural activities in densely populated areas; conflicts over land and water between agricultural, industrial, and housing uses; unhygienic food marketing; and an inability of producers, wholesalers, retailers, and other agents engaged in food processing and marketing to integrate within coordinated food chains.

UPUA includes activities within or on the fringe of a town or city that use natural, physical, and human resources to grow, process, and distribute food and nonfood agricultural products for both local urban markets and for export. As the UPUA production system is close to urban consumers, it can be well connected in terms of input and output markets. UPUA products may reach urban consumers and processing points the day they are harvested. These systems are also characterized by the small scale of production, high proportion of perishable crops (especially leafy vegetables), disease and insect pressure, intensity of input use, crop diversity, and low use of mechanical power.

### Benefits

Poor men and women engage in UPUA to increase household food security and to generate income. The contribution of food produced in UPUA to meet the total food needs of different cities varies widely. For Hanoi, it supplies about one-half of the food demand and engages more than 10 percent of the urban labor force in processing, marketing, retailing, input supply, and seed and seedling production (Anh et al. 2004). These percentages are higher for many African and some Latin American cities. Even in cities like Manila, where little land is left for crop-based agriculture, the contribution of agricultural business activities to income and employment remain significant (Ali and

Porciancola 2001). UPUA systems can play an important role in environmental and public health by reusing and managing urban wastewaters and solid waste. Home gardening and maintaining a large number of trees in cities contribute to air quality as well as employment. Urban agriculture can also be seen as a survival strategy for the urban poor during crisis periods, and contributes to household food security, especially for women and the elderly.

## Policy and Implementation Issues

Key issues of UPUA in production, livelihood earnings, environmental protection, and input supply at the household, institutional, and policy levels are included in table 4.3.

*Input and service suppliers.* In the provision of agricultural services, especially those with some element of public good such as extension and irrigation, UPUA is often ignored. If these constraints to UPUA are not addressed, there may be major consequences in terms of the regularity and quality of food supply, poverty and gender equity, resource conservation, and human health in urban areas. Removing such public sector biases against UPUA would encourage private sector involvement in the supply of services and inputs critical to profitable and sustainable farming in urban areas.

*Information systems.* The diversity of UPUA is often high to maximize the efficiency of resource use, meet market demands, and to reduce risk. Off-farm employment options for family labor and the possibility of hiring labor add to the complexity of decision making. Changing market structure, increased demand for food quality, and fluctuations in output prices are additional dimensions of decision making. To cope with these changes, farmers (especially the poor ones) require efficient agricultural information systems and sophisticated managerial skills. Urban farmers are closer to markets than rural farmers and have an advantage in targeting specific consumer segments (high income, for example) and responding quickly to changes in the demands of these, provided they have good access to market information. There is always a danger that resource-poor farmers and disadvantaged groups in UPUA will be left behind.

**Table 4.3 Issues of sustainable urban and periurban agriculture (UPUA)**

	Household level	Institutional level	Policy level
<b>Production, processing, and marketing (both food and nonfood agricultural products)</b>	<ul style="list-style-type: none"> <li>• Farmers' understanding of urban markets; appropriate selection of farm and nonfarm enterprises.</li> <li>• Competent enterprise management.</li> </ul>	<ul style="list-style-type: none"> <li>• Institutes to develop and monitor standards for agricultural practices and food quality.</li> <li>• Public-private sector collaboration for input supply and market infrastructure.</li> <li>• Technologies to reduce seasonality of supply.</li> <li>• Enable small enterprises to integrate with emerging food chain structures.</li> </ul>	<ul style="list-style-type: none"> <li>• Recognition of the role of UPUA in urban planning, and appropriate price, trade, and land policies.</li> <li>• Policies for improving farmers' access to information.</li> </ul>
<b>Livelihoods</b>	<ul style="list-style-type: none"> <li>• Targeted technologies to</li> </ul>	<ul style="list-style-type: none"> <li>• Recognition of the role of UPUA in economic crises.</li> </ul>	<ul style="list-style-type: none"> <li>• Food and trade policies to reduce</li> </ul>

	improve the livelihood of urban poor.	<ul style="list-style-type: none"> <li>Strengthening the backward and forward linkages between rural and urban agriculture.</li> </ul>	the impact of high food prices.
<b>Environment, health, and equality</b>	<ul style="list-style-type: none"> <li>Adoption of sustainable practices.</li> <li>Monitoring pesticide residues.</li> </ul>	<ul style="list-style-type: none"> <li>Create awareness about fresh, hygienic, and quality food, and adopting food quality and safety standards.</li> <li>Institutional arrangements to manage environmental and social externalities of UPUA (e.g., heavy metal and microbial contaminations of the environment and food).</li> <li>Regulating use of city wastes.</li> </ul>	<ul style="list-style-type: none"> <li>Policies to encourage people to keep the city green.</li> <li>Awareness of environmental perspectives of consumers.</li> <li>Appropriate labor policies.</li> </ul>

Source: Authors

*New market structures.* The shares of high-value crops such as fruits and vegetables and livestock products are rapidly increasing in urban diets, and consumers are demanding better quality and safe foods. In response, the organizational structure of urban markets, including those in developing countries, is changing. Smallholder urban producers and small retailers and wholesalers in urban areas typically lack the resources, organization, and skill to provide quality food of the standard demanded by urban consumers or to integrate with new coordinated market structures.

*Health and environmental issues.* Input use, especially of fertilizer and pesticides, is relatively high in UPUA, leading to potentially high residues in food, especially vegetables. High input use may create health hazards for consumers and producers and degrade resources such as soil and underground water reserves. Farmers have little incentive to reduce pesticide use in view of low pesticide costs, inadequate knowledge of conservation farming options (IPM, for example), low availability of extension services, and inadequate market premiums for providing consumers with products that have been produced using environmentally sound and socially acceptable production practices. Farmers need technical advice to improve food quality and institutional innovations to monitor agricultural practices and food standards.

*Use of urban waste.* The use of solid waste and wastewater in UPUA has both advantages and disadvantages. It saves farmers money and reduces environmental pollution, but it may create microbial infections in food and heavy metal contamination of soil, water, and food.

*Land tenure issues.* The long-term continuity of agricultural production from a given piece of land in UPUA remains uncertain, because the opportunity cost of using it for agriculture is high owing to demand for industrial, housing, and development purposes. The right to use land for UPUA is sometimes not well defined, especially when it is practiced on vacant municipal or encroached lands. This uncertainty can create conflicts and lead to underinvestment as well as exploitative production practices and degradation of the land.

## Lesson Learned

*Technical and managerial capacity of farmers and food marketers.* Effective UPUA requires the provision of nondiscriminatory extension services for farmers that are linked with demand-driven research systems. The public sector can help to build and reform systems to supply farmers with required inputs and link them to downstream markets. It can also play an active role in building the capacity of farmers and food wholesalers and retailers to meet emerging market demands. It can also improve the capacity of the private sector to supply farm inputs and more effectively process and market outputs.

*Promote the adoption of environmentally sound farming practices.* The application of city wastes (both solid and liquid) and the large number of trees can help clean the city environment. However, to ensure that applications are not negatively affecting environmental indicators, and that they are not risking the safety of the food produced, effective regulatory systems are required. These include the quality of waste applied in agricultural production and levels of pesticide residue and microbial contamination on food. To be effective, these regulatory systems should be based on sound technical planning and credible monitoring systems. Extension is also important to bring to farmers new technologies that can ensure long-term environmental sustainability of the system. The public sector can play an important role in providing advice in planning and promoting effective supply of technical services to farmers, particularly involving the private sector and producer organizations.

*Producer organization.* Because of the very small operations, input purchase and output marketing are typically a problem in UPUA. Organization of producers can help them benefit from economies of scale in markets (box 4.19). These organizations can identify opportunities and constraints and organize funds to overcome bottlenecks. They can arrange inputs and organize training as new opportunity arises and can lobby to protect the UPUA from unnecessary regulations.

### **Box 4.19 South Asia: the AVRDC/CIRAD UPUA project**

In 2002, the World Vegetable Center (AVRDC) and the French Agricultural Research Centre for International Development (CIRAD) initiated a three-year coordinated project with national partners in Hanoi, Ho Chi Minh City, Phnom Penh, and Vientiane to diagnose problems and introduce technological and institutional innovations in urban and periurban agriculture (UPUA). The project has undertaken an analysis of supply and demand for food in urban and periurban areas, as well as an analysis of vegetable, fish, and livestock production and marketing systems. Other accomplishments include:

- Producer organizations were developed to improve the dissemination of technical innovations.
- Farmers' access to markets was strengthened by carrying out pilot operations for vegetable and fish production systems.
- Off-season tomato varieties and technologies and efficient marketing systems were introduced on a pilot basis.
- Pesticide residues and lead content of selected vegetables were analyzed, supported by the introduction of toolkits for spot-checking for residues of selected pesticides.
- Farmers were trained in off-season vegetable production and integrated pest management

technologies.

- Regional cooperation improved to share breeding material, information, and literature related to UPUA.

These activities and innovations are contributing to the enhanced safety and year-round supply of food, as well as providing income and employment in urban and periurban areas, both on- and off-farm.

Source: AVRDC/CIRAD internal documents

## Recommendations for Practitioners

UPUA must be given due importance in urban planning, encouraging its contributions in supplying food and engaging the labor force in food production, processing, and distribution. Other recommendations relating to investments in UPUA include (box 4.20):

- Create an enabling environment for the private sector to supply inputs and services by providing training and information.
- Promote the development of responsive agricultural extension and training programs to enhance farmers' ability to make efficient decisions under the complex environment of UPUA. This would include skill training, especially in good agricultural practices for crop and livestock production, business analysis, and developing information systems at the producer organization level.
- Encourage the organization of associations in the food chain to enable farmers and small enterprises to integrate with changing market structures in cities. Involvement of women and disadvantaged groups in these associations is necessary to improve social equity.
- Introduce pilot projects on innovative methods and tools to produce, process, and monitor the distribution of hygienic and safe food.
- Promote the reform of land tenure arrangements where this is a major constraint to market-oriented, environmentally sustainable UPUA. Well-documented land records can encourage sustainable, profitable, and equitable resource use.
- Develop cost-effective water treatment and manure decomposition plants to enable productive disposal of UPUA waste with minimal environmental risks. Equipment and procedures for lead and microbial contamination will also force producers to carefully use urban wastes to avoid environmental contamination or rejection of outputs for safety reasons.

### Box 4.20 Potential investments

- Market analysis of the supply and demand for food and evolving marketing structures.
- Training in business management for food retailers and wholesalers.
- Promotion of innovations to produce and market safe and hygienic food.
- Awareness campaigns for consumers and producers about food safety and environmentally safe production.
- Technical capacity and equipment for environmental monitoring, particularly with regards to high input use and applications of city wastes.

Source: Authors

## Selected Readings

Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

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This investment note was prepared by Mubarik Ali, with input from Gary Alex and Sam Kane, and updated by Riikka Rajalahti.

## Conservation Tillage

Conservation tillage (CT) can significantly improve rural agricultural productivity and incomes. At the same time it can conserve the natural resource base for agricultural production, as part of an overall approach to the management of natural resources. Widespread adoption in Latin America and expanding use in South Asia have shown that investment in research and extension systems, capacity building, and the development and distribution of CT equipment are effective means of promoting the CT use and benefits.

Conventional tillage practices of plowing and tilling the land evolved largely to control weeds. Although widespread, these systems have some serious disadvantages; they expose soil to wind and water erosion and incur high energy costs for tilling operations. Production systems using CT are becoming more common and offer a range of benefits, such as increased land productivity, reduced production costs, and prevention of soil erosion.

### Development of Conservation Tillage Systems

CT farming covers four broad, intertwined management practices: minimal soil disturbance with no plowing and harrowing; maintenance of a permanent vegetative soil cover; direct sowing; and sound crop rotation. Introduction of these practices requires a supportive social environment and institutional framework. Many CT practices have evolved from farmer innovations supported by farmer-led organizations, in partnership with private business. CT farming is a sustainable land resource management system that combines productivity gains and increased profitability with ecosystem management for environmental protection. However, CT farming should not be seen as a “quick fix” or a blueprint that solves all sustainability or profitability problems. It is highly location-specific, must be adapted to specific farmer circumstances, and requires time to change traditional attitudes and approaches and to demonstrate benefits (box 4.21). A successful transition to CT farming generally requires three to five years.

Key factors in the successful introduction of CT farming include the willingness of governments to empower rural communities and producer organizations; develop effective research and extension systems, support experienced producer groups or community organizations, and develop systems to secure land tenure and water rights. Other facilitating factors include effective input and output markets, access to seed of cover crops, and access to appropriate machinery.

**Box 4.21 Brazil: key elements of smallholder no-till systems for maize and bean production in Paraná**

- Use of animal traction, family labor, and limited use of purchased inputs.
- Biomass management with animal-drawn knife-roller and planting with animal-drawn no-tillage planter.
- Management of crop residues with knife-roller.
- Use of cover crop management.
- Runoff control with contour bunds built with animal-drawn moldboard plow.
- Planting of dwarf elephant grass on contour bunds for livestock feed.

Source: Pieri et al. 2002

## Benefits

*Economic.* CT increases farm profitability by improving land productivity through residue mulching practices that allow sowing at the optimal time, conserve moisture, and reduce vulnerability to drought or moisture stress. CT also reduces the costs of labor, inputs, and machinery (longer life and lower maintenance costs). In Brazil, net farm incomes increased by as much as 59 percent over five years and in animal traction systems CT farming has increased maize yields by up to 20 percent.

*Environmental.* CT adoption is likely to result in numerous environmental benefits: decreased soil erosion and water loss through runoff; decreased carbon dioxide emissions and higher carbon sequestration; reduced fuel consumption; increased water productivity; less flooding; and recharging of underground aquifers. Other benefits are increased fertilizer efficiency, improved drainage, reduced waterlogging, and greater diversity of desirable insects. In South Asia, CT farming is estimated to save 60 liters of diesel per hectare per year.

*Social.* CT initiatives are generally scale neutral, so smallholders benefit equally (box 4.22). Reduced labor requirements free more time for nonfarm employment, child education, and care of the elderly. Increased stability of production can increase food security.

### Box 4.22 India: impact of no-till in the Indo-Gangetic Plains

In rice-wheat systems of South Asia, conservation tillage (CT) has been estimated to save up to one million liters of irrigation water and about 60 liters of diesel per hectare. No-till has the potential to eliminate 6-10 plowing operations, which reduces costs by US\$50-60 per hectare compared to conventional tillage. Reducing turnaround time between rice harvest and wheat planting also increases wheat yields.

No-till has proven very effective in controlling weeds in wheat, because most weed germination is triggered by sunlight or by lower temperatures. Because soil is disturbed less with no-till, less weed seed is exposed, and less germinates. Data suggest that no-till reduces weed infestations over time, and eventually no herbicides are required in some seasons.

Custom machinery services allow small-scale farmers to use no-till and reduce operating capital requirements, since fewer tractor hours are needed. Farmers no longer need to maintain bullocks all year on the farm. In Haryana, India, in 2001, 70 percent of farmers who adopted no-till did not own a tractor and used custom tractor services, and 40 percent of the adopters were small landholders with farms of less than two hectares.

Source: Ekboir 2002

## Policy and Implementation Issues

*Technological base.* Effective CT implementation initiatives are based on a sound understanding of technical aspects of production, including CT plant cover and cover crops, crop rotation, equipment and IPM. Transition problems, such as increased weed growth in direct-seeded rice, occur in the early years of CT adoption. Development and supply of appropriate equipment and improved seed for crops as well as cover crops

facilitate farm-level adoption. Research systems must be able to provide solutions to varied location-specific production problems. Technologies, including biotechnology-assisted development of herbicide-resistant varieties and the development of safer pesticides and pesticide application strategies, will likely be important for increasing the use of CT.

*Disincentives to World Bank investments.* Factors that deter Bank investment in CT farming include the often lengthy time taken to develop and disseminate relevant technologies; high initial investments in equipment and farmer training and education; deferred benefits; and the Bank's pesticide safeguard policies on investments associated with increased use and their impact on CT herbicide use. There have also been misconceptions about CT farming (box 4.23).

**Box 4.23 Responses to common criticisms of conservation tillage farming**

*Limited to deep soils and high rainfall conditions:* Conservation tillage (CT) practices can be adapted to a wide range of soils under semiarid or humid tropical or temperate conditions.

*Suited only to large mechanized farms:* In Brazil and Paraguay, private entrepreneurs provide CT equipment for small farms in local markets and have enabled family farms to adopt CT farming practices using animal power. In South Asia, whole villages used rented farm machinery to adopt no-till in wheat after rice.

*Results in increased herbicide use.* Full adoption of CT practices (cover crops, crop rotations, and integrated weed management) over two to five years can reduce weed pressure, and practitioners claim that they use less herbicide (and other pesticides) than under conventional tillage systems.

Source: Pieri et al. 2002

*Capacity building.* Farmer organizations are key to changing traditional attitudes and practices, and they can do so because of their understanding of local conditions. CT investments must strengthen such farmer organizations and extension systems and link farmers to the scientific community.

*Other environmental concerns.* In some circumstances, CT farming can result in pest and weed buildup, requiring increased application of pesticides and herbicides, with negative implications for local biodiversity and water quality. Some farmers also burn mulch, which contributes to air pollution and loss of organic matter. No-till and low-till systems may also increase the growth of fungi in humid climates, risking contamination of agricultural produce by aflatoxins and mycotoxins, with a possible loss of markets and negative impacts on human health. Research investments are needed to develop systems for sustainable management of crop residues, such as using drills to plant into residues, baling and removal for livestock feed, and microbial sprays to speed decomposition.

## Lessons Learned

Changing farming practices that have evolved over many generations is difficult. CT is more than a switch from one technical package to another, and demands an *integrated approach*, including collaborative efforts on social mobilization, education and training, and marketing. Such action can be undertaken in discussion groups and seminars, and through field visits.

The two main *driving forces* behind the development and adoption of CT are farmers faced with acute and highly visible land degradation, and a few innovators who realize that radical changes to farming practices are required. A CT development strategy can create the conditions to capitalize on experiences of initial innovators and regional agents for change, such as farmers, technical specialists, the private input sector, and extension agents, to promote the spread of CT innovations through a network of local, state, and national POs.

Adaptive *research systems* guided by the concerns of farmers and other interest groups are essential to CT farming (box 4.24). *Extension programs* should foster linkages among those involved, synthesizing feedback from the field, prioritizing needs, and assisting with implementation of adaptive on-farm research. In Brazil, CT education and training in university courses has been an effective means of extension. In South Asia, traveling seminars were effective in bringing farmers to see CT systems in operation and to hear other farmers' experiences with the systems.

CT systems take considerable *time to implement*, with a lag between investment and realization of tangible results. In the initial stages of CT introduction, significant support (subsidized equipment, local meetings) may be required until benefits become apparent and sufficiently compelling for stakeholders to independently support the system. Planning should provide for phase-out of such incentives, particularly subsidies.

### Box 4.24 Priorities for conservation tillage adaptive research

- *Cover crops*: collection of locally available germplasm and introduction as appropriate.
- *Crop residues*: on-field management (both mechanical and chemical) and for productive uses.
- *Integrated production and pest management (IPPM)*: limited pesticide use.
- *Fertilizer*: mineral/organic requirements, (needs, timing, and methods of application).
- *Machinery/tool adaptation*: adaptation and fine-tuning of conservation tillage (CT) planters.
- *Integration of crops and livestock production*: best crop rotations, increase biomass.
- *Pathways of change*: on-farm test of pathways best suited to local/zonal typology.
- *Land/soil benchmark*: characterization of representative on-farm soils.
- *Soil as a rooting environment*: rooting depth, root distribution for crops and cover crops.
- *Socioeconomic studies*: reasons for adoption and nonadoption; gender considerations.

Source: Pieri et al. 2002

## Recommendations for Practitioners

Implicit in CT activities is that governments and other major stakeholders give priority to appropriate policies and coordinated interventions that help to achieve more rational land use, improve land management practices, and develop an updated knowledge and information base. CT investments should (box 4.25):

- Ensure that implementation plans account for context-specific attributes of the environment (slope, soil type, water resources). Establishing a geographical database may be helpful for this purpose.
- Identify and train innovative and entrepreneurial leadership, and stimulate a cooperative approach involving all interest groups.
- Ensure private sector participation in machinery supply, chemical and information supply, sponsorship of farmer organizations, financing, research, and extension.
- Develop effective coordination and communication mechanisms and networks to share ideas and knowledge between farmers and interest groups. Farmer-to-farmer contact is often the most cost-effective means of communication.
- Develop research systems with an on-farm research perspective that provides solutions to local problems identified by farmers and the wider community.
- Involve local manufacturers in the development and manufacture of required equipment that is within the budget of farmers. Farmers must be shown how equipment works and allowed to experiment with it.
- Pay special attention to the integration of crops and livestock in CT systems. A particular challenge is the development of rotational grazing patterns on cover crops that do not jeopardize the sustainability of CT systems.
- Use targeted, short-term subsidies to support small farmer testing and adoption of no-till practices.

### Box 4.25 Potential investments

- Farm and community group organization and orientation to conservation tillage (CT).
- Research systems for adapting CT technologies to local conditions.
- Extension systems that support the design, manufacture, and distribution of required equipment.
- Seminars, meetings, and demonstrations of CT equipment and practices.
- Support for institutions to improve rural financial services and land administration systems.
- Support workshops and study tours for private sector equipment manufacture, input supply, and services.
- Grant programs to encourage socially and environmentally beneficial practices where market forces fail to do so.

Source: Authors

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Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

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This investment note was prepared by Sam Kane, with input from the Sustainable Agriculture (SASKI) Thematic Team of the World Bank.

## Integrated Pest Management

Integrated pest management (IPM) practices, as part of crop management activities, have produced substantial economic and environmental benefits in various agricultural production systems. Implementing IPM requires a coordinated strategy of enhancing farmers' management skills, promoting awareness in food chain operators and consumers, developing an appropriate regulatory and policy environment, and providing economic incentives for incorporating the external benefits of improved practices into farm-level decision making. Training and capacity building at the level of the individual producer and service provider are essential.

The use of chemical pesticides in agriculture has produced impressive yield gains but has provoked concern over risks to human health, the environment, and food quality. In some cases, particularly where chemical inputs are subsidized, pesticides have been over-used, and the long-term sustainability of agricultural systems has been undermined. IPM as part of ICM (integrated crop management) is seen as a sound agricultural practice towards sustainable agricultural production to increase farmer income, foster growth, and improve food security by reducing pest losses while protecting the health of producers, consumers, and the environment.

### Investment in IPM

IPM is essentially a decision-making process that identifies pest problems and associated crop losses and devises science-based strategies to prevent economic losses. IPM offers a menu of options or management practices to keep pest incidence below economically damaging levels while maintaining a quality environment. These alternatives range from reducing pest status and reducing a crop's susceptibility to pest injury to combining reductions in pest numbers and crop susceptibility. Pest numbers can be reduced through targeted, judicious use of synthetic pesticides or by biological control and other nonchemical means (box 4.26). Reducing crop susceptibility, regarded as one of the most effective, economically sound and environmentally desirable tactics, involves developing host plant resistance and managing the crop environment. In addition to this mix of technical options, IPM focuses increasingly on enhancing farmers' skills to use agroecological knowledge to manage production systems. The application of IPM tools and tactics is therefore highly situation and site-specific.

Investment in public IPM research and farmer education and participatory approaches has yielded returns comparable to research on other agricultural technologies. Recently, the Bank's competitive research grants programs have channeled substantial funding into IPM-related research. Pest-resistant seed varieties developed through genetic modification techniques add new technological options to the IPM toolbox.

A number of reasons have been given as constraints to large-scale IPM adoption. The principal reasons are the gap between IPM theory (concept) and practice, weak research and extension systems, poor information and knowledge management, the influence of pesticides and the plant science industry, the lack of incentives for participatory

multidisciplinary research, and unfavorable national policies, especially pesticide subsidies. Regardless of the reason, good, practical IPM examples are still too few and often limited to pilots or to certain crops or sites. Chemical pesticides remain the most popular and convenient tools. In the future, priority should be given to action-oriented research aimed at reducing the gap between IPM concept and practice; to participatory approaches involving individual farmers and farmer groups in developing, evaluating, and using IPM technology; and to the need for policy and institutional frameworks conducive to IPM adoption.

#### **Box 4.26 Integrated pest management technical toolbox**

The practice of integrated pest management (IPM) requires a sound understanding of the biological information related to the interaction between pest and the host crop as well as the economics related to managing the pest. IPM offers a wide array of options or tactics used for pest control ranging from prevention to intervention.

*Prevention measures include:*

- Field tillage and sanitation.
- Seed and variety selection (host plant resistance).
- Crop rotation.
- Destruction of weeds and alternate hosts.
- Space and time disruption for planting and harvest.
- Intercropping.
- Habitat management.
- Irrigation and water management.

*Intervention measures include:*

- *Cultural practices:* field sanitation, seed selection, trap crops and refuge management, mulching, crop rotations.
- *Biological control practices:* Conservation and augmentation of natural enemies (predators, parasitoids, nematodes, viruses, bacteria, and fungi).
- *Biopesticides:* use of pest control products with pathogenic viruses (nuclear polyhedrosis Virus, granulosis virus), bacteria (*Bacillus thuringiensis*) and fungi (*Beauveria bassiana*).
- *Semiochemicals:* Use of pheromones or other pest communication chemicals (attractants, repellents, mating disruption, lure and kill).
- *Biotechnology-based practices:* tissue culture, sterile male technique, transgenic crops.
- *Chemical control practices:* use of chemical pesticides as a last resort where and when needed; judicious selection and application of chemical products advised to achieve proper control and minimize risks to non target species, humans, and the environment.

Biologically-based pest control strategies may often be feasible only in the long term. In such cases, rationalization of existing patterns of pesticide use may be the first step toward making more sustainable pest management.

Source: Authors

Research and extension investment alone is unlikely to result in broad-based adoption of IPM systems, which tend to be complex and management-intensive. Mass media campaigns and social marketing can shape the awareness and behavior of pesticide users. In Vietnam the simple message “do not spray early in the season” was successful in

changing commonly held perceptions and contributed to a significant reduction in pesticide use (see the IAP, “Vietnam: Entertainment-Education,” in Module 3).

## Benefits

Adoption of IPM practices can reduce pesticide costs, increase production, and reduce damage to the environment and human health. Concerns focused on groundwater pollution, pesticide poisonings, loss of biodiversity, and negative effects on soil health provide strong justification for public sector investment in IPM (box 4.27). The increasing application of food quality and safety standards has specific implications for pesticide residues in agricultural products. Developing the certification systems and the necessary monitoring capacity can be a major hurdle to market access, however, and investment in this area is critical. Evidence on the cost effectiveness on IPM is mixed. Most analysts suggest that IPM programs contribute to a decline in pesticide use but that labor costs may increase.

### Box 4.27 Turkmenistan: biological control

Since 1998, the Government of Turkmenistan has reestablished its biological control scheme for cotton production, a scheme that had been nearly abandoned. Biological control was introduced in the early 1980s after chemical pesticides became ineffective and residues, especially persistent organochlorine compounds, were found in water, soil, and food. The breakup of the centrally planned economy of the Soviet Union caused the deterioration of facilities to rear predators to control insect pests in cotton. Beginning in 1998, the government rehabilitated insect-rearing facilities (primarily for *Trichogramma* and *Bracon* spp.) and introduced cost recovery from farmers. With over 90 percent of cotton crop protection now under biological control, Turkmenistan has greatly reduced the environmental and health risks from pesticides.

Source: Schillhorn van Veen et al. 2000

## Policy and Implementation Issues

*Pernicious effects of subsidies.* Efforts to promote IPM often must struggle against the legacy of policies aimed at promoting pesticide use as a means of modernizing agriculture. Such policies, which include explicit subsidies, preferential tariffs and foreign exchange regimes, and chemical-oriented agricultural research and extension, reduce the cost of using chemical pesticides and can seriously undermine IPM adoption (box 4.28). Promoting input market pricing that reflects the true costs associated with production and consumption is critical to encouraging IPM adoption in areas where it can be beneficial.

### Box 4.28 Pakistan: incoherent policies constrain IPM adoption

Adoption of IPM in Pakistan is still in its infancy, despite significant investment in research and extension. The government sees IPM as a key element of agricultural policy, yet the deregulation of generic pesticide imports greatly widened farmers’ access to inexpensive chemicals and unleashed a series of problems. The misuse of pesticides in cotton production, for example, created resistance in insect pests and provoked a decade-long decline in cotton productivity. Poor rural women, who pick cotton as their only source of income, were most affected by the health and economic impacts of increasing insecticide use. The main motive behind changes in pesticide

policy has been to revive the cotton economy. After thorough analysis of the economics in the pesticide subsector, and consultation with all relevant stakeholders in 2001, a comprehensive national IPM program was designed. Features of the program include training farmers, tightening regulatory control, and removing pesticide subsidies.

Source: Ahmad 2001

*Time lag for adoption.* IPM skills and practices do not spread as easily as information embedded in technologies such as improved seed or chemicals. *Extension services* play a key role in providing IPM information, though the complexity of some IPM approaches requires a heavy emphasis on teaching agroecological concepts as a basis for farmers to adopt IPM practices.

*Cost/benefit issues.* Attention to the economic viability of IPM investments is particularly important in large-scale extension and training programs. When costs and potential benefits are extrapolated from pilot projects, training impacts may be overestimated and costs underestimated, as these investments in human capital development may produce benefits only in the long term. Program initiatives must assess expected and actual changes in production costs, yields, output prices, and pesticide use and evaluate the sustainability of these changes. In addition, yield variability is likely to increase, and farmers must have access to tools for managing production risks.

*Role of genetically modified organisms (GMOs).* Insect- and disease-resistant transgenic crops are becoming available to farmers in developed and developing countries. The benefits of these new genetically modified crops have been demonstrated in many cases. Their use, however, has generated a great deal of debate over the potential risks related to biosafety, over intellectual property rights, and over risks to human and environmental health.

*Long-term sustainability.* IPM initiatives will be most successful in situations where farmers overuse chemicals for to control pests, and where supportive research and extension systems and policy and regulatory frameworks are in place. Also, economic viability is enhanced where markets place a premium on IPM-produced products. The number of cases in which these criteria are met remains limited.

## Lessons Learned

*Need for comprehensive approach.* In many countries, IPM interventions have been planned without a clear understanding of pest management problems. IPM initiatives are often “add-ons” to regular research and extension projects, and they tend to be isolated activities. A comprehensive approach to pest management, integrating interventions within an IPM national strategic plan, is preferred. Coordinated interventions based on identifiable targets and benchmarks are likely to be more effective than isolated activities. The verification of IPM outcomes (for example, a reduction in pesticide use) is more important than simply measuring inputs, such as the number of farmers trained.

*IPM training.* Participatory training and extension are important to changing attitudes of farmers and their service providers. One such approach—the Farmer Field School—has received particular attention (box 4.29). An alternative strategy targets IPM for cropping systems with significant potential to reduce inefficient pesticide use and raise farm income; examples include cotton and horticultural crops. In cropping systems where low levels of external inputs are used, integrating IPM messages into a program to promote overall good agricultural practice is more effective than focusing on pest control alone. Training for input suppliers, extension agents, financial services providers, and produce buyers is important to develop the overall IPM knowledge system.

**Box 4.29 The Farmer Field School concept for IPM training**

The Farmer Field School (FFS) approach, stressing experiential learning of fundamental agroecological principles, evolved in the 1980s in Southeast Asia to address the overuse of insecticides in irrigated rice. Excessive use of broad-spectrum insecticides, stimulated by the lack of pest resistance in the first high-yielding rice varieties, disrupted the ecosystem and affected farmers' yields and profits. FFS farmers, trained in weekly sessions throughout the cropping season, conducted hands-on experimentation in the field to learn about the dynamics of insect-crop populations and pest control strategies. Capacity building for extension staff and farmer groups has been central to pilot projects for integrated pest management (IPM) training in FFSs in over 25 countries.

While the FFS model might be promising for promoting participatory IPM, mixed experience with large-scale projects in Indonesia and Vietnam raised serious reservations about the advisability of financing FFS programs on a large scale through public extension services. Large-scale programs have proven financially unsustainable and have had insignificant impacts on pesticide use and IPM diffusion (Feder, Murgai, and Quizon 2003).

Source: Authors

*New market opportunities.* In global markets, maintaining competitiveness requires producers to be sensitive to changing consumer preferences regarding product quality. Responding to changing preferences can provide new opportunities for cooperation between producers and the private sector. However, where IPM is to be used to increase product value, supporting labeling and certification systems must be established to assure downstream participants (including retailers and consumers) that IPM principles have been followed (box 4.30).

**Box 4.30 Options for cooperation with the private sector**

*High-value niche markets* for tropical products grown in an environmentally and socially responsible manner are a fast-growing market segment (for example, “sustainable” coffee). Integrated pest management (IPM) is an indispensable tool for delivering a good-quality product through a “sustainable” production process. Private firms developing specialty product lines are good partners for local authorities, farmer associations, and NGOs.

IPM programs may support the development of the *biopesticide industry*, which is still small but relevant to crops with limited markets that are not economically attractive to large pesticide producers. Cooperation with the *plant science industry* can be rewarding, as both the public and private sector share an interest in reducing pesticide overuse and in promoting resistance management strategies. Initiatives for “Safe Use” of toxic chemicals have been started by the

pesticide industry and sometimes supported as public-private partnerships.

Source: Authors

## Recommendations for Practitioners

Given the lessons emerging from past experience, investments related to IPM should (box 4.31):

- Promote policy changes required to allow the emergence of undistorted input markets that price pesticides at levels reflecting the true economic and environmental costs of producing and consuming chemically based pest control inputs.
- Develop a sound research base for developing and supporting IPM technologies and management systems.
- Address the larger institutional and policy environment issues governing pesticide use, before focusing on knowledge transfer to extension agents and farmers.
- Promoting and strengthening country pesticide regulatory framework as stipulated in the FAO Code of Conduct on the Distribution and Use of Pesticides.
- Develop a reliable information base on trends in pesticide use and productivity of pest management systems to support the design of a sound pest management strategy.
- Identify likely changes in markets and prices and production options, including the potential for adding value through certification of compliance with IPM standards.
- Include stakeholders from the agriculture, environment, and health sectors in activities to build consensus on approaches to use of IPM (Fleischer and Waibel 2003).
- Invest in IPM training of farmers and extension workers, adopting a demand-driven approach to target training inputs to address producers' pest management problems, and to respond to emerging market opportunities.

### Box 4.31 Potential investments

- Policy analysis and strategy development actively promoting IPM.
- Research on pests and diseases.
- Training of extension staff and other service providers.
- Decentralized participatory research and training.
- Awareness campaigns among farmers, consumers, and food chain operators.

Source: Authors

Box 4.32 provides an example of how to integrate IPM in project goals and activities.

### Box 4.32. The Tunisia Agricultural Support Services Project: integrating IPM in project goals

The Tunisia Agricultural Support Services Project aims at improving production quality, competitiveness, and market access, particularly for smaller- and medium-scale producers. More specifically, project seeks to:

- Develop organizational structures for producers that represent their needs and interests.
- Improve the institutional capacity and quality of agricultural services delivered by public and private institutions and producer organizations.
- Improve the flow of information for all stakeholders.

In the government's strategy to penetrate international markets, integrated pest management

(IPM) is used to achieve productivity gains while reducing reliance on chemical pesticides and meeting EU standards for pesticide residues.

The project uses institutional, technical, and policy tools to promote IPM among producers, researchers, and extension specialists. On the policy level, pesticide regulations have been updated to strengthen the regulatory framework to conform to recommendations of the FAO Code of Conduct on the Distribution and Use of Pesticides. New regulations were introduced to reflect the needs of organic production and minimum pesticide residue levels in food crops. Government ministries (agriculture, environment, science and technology, and international cooperation) are collaborating to expand the country's laboratory capacity to test for pesticide residues in food produce. Knowledge sharing and public awareness campaigns are designed not only to improve pesticide handling but to actively promote IPM adoption among export crop producers.

Source: Authors

## Selected Readings

Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

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This investment note was prepared by Gerd Fleischer (GTZ), with input from the Sustainable Agriculture (SASKI) Thematic Team of the World Bank, and updated by Aziz Lagnaoui, Senior IPM Policy Specialist.

## Integrated Nutrient Management for Sustaining Soil Productivity

Future food and fiber must be produced on existing agriculture land, with fewer negative impacts on natural resources and the environment than in the past. The timely supply, efficient use, and careful monitoring of nutrients in integrated crop, forage, and tree production systems offer the potential for significantly improving efficiency in plant nutrient use. Farmers, researchers, and other stakeholders need to be more actively involved in the generation and use of the knowledge required for integrated nutrient management.

Although science-based agriculture has made major contributions to both the quantity and quality of the global food supply, the rate of yield increase for major food crops has begun to slow in recent years. In many parts of the world, agricultural production increases have been accompanied by significant degradation of natural resources, including nutrient depletion on agricultural lands.

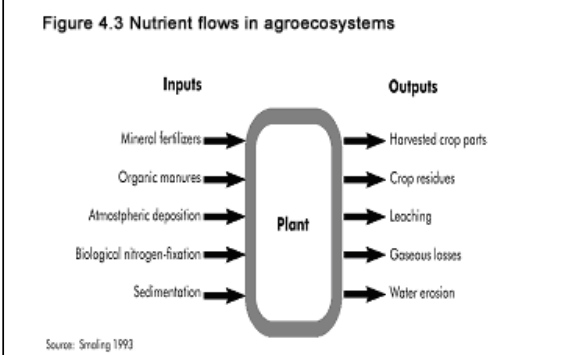
Integrated nutrient management (INM) is an approach that involves the management of both organic and inorganic plant nutrients for optimal production of cultivated crops, forage, and tree species, while conserving the natural resource base essential for long-term sustainability. Nutrient flows occur at different scales in any agroecosystem, and soil nutrient budgets for a given area and time can be calculated by the difference between the nutrient inputs and outputs (figure 4.3). Large soil nutrient surpluses can lead to environmental pollution, whereas persistent soil nutrient deficits usually indicate nutrient mining.

Effective INM involves four interrelated strategies:

*Conservation and efficient use of native soil nutrients.* Conservation practices help to reduce loss of nutrients from agroecosystems due to surface water flows and from erosion of soil by wind and water. Vegetative barriers minimize off-farm transport of dissolved nutrients, dust, and sediments, and deep-rooted plants act as nutrient safety nets, intercepting leached nutrients from the root zone and returning them to the soil surface via litter fall, mulch, or as green manure. In general, conserving existing nutrient resources is easier and cheaper than replenishing and rehabilitating degraded resources.

*Recycling of organic nutrient flows.* Returning crop residues and/or animal manure to cropland is important for system sustainability. Composting crop residues and animal manures enhances the utilization efficiency of easily lost nutrients such as nitrogen.

**Figure 4.3 Nutrient flows in agroecosystems**



Converting linear flows (lost from the system) of organic nutrients to cyclical flows (returned to the system) can reduce the need for external nutrient inputs. There are related potential price benefits in organic product markets. Livestock are important for processing crop residues, adding value to farm outputs, improving labor efficiency, and providing manure.

*Enhancing biological nitrogen fixation and soil biological activity.* Nitrogen-fixing crop, forage, and tree/shrub species scavenge nitrogen from the soil and/or fix nitrogen from the atmosphere when soil levels are below plant requirements. Most nitrogen-fixing plant species also form symbiotic relationships with mycorrhizal fungi that improve soil aggregation, nutrient and water use efficiencies, and protect the plant roots from a variety of pathogens. This is one example of an INM practice that also contributes to IPM. Integration of nitrogen-fixing species into cropping systems diversifies inputs/outputs and reduces risk on both economic and ecological fronts.

*Addition of plant nutrients.* The nutrient content of highly weathered soils is very low. In most cases, the export of nutrients in harvested products results in one or more plant nutrients becoming limiting. In the humid tropics, calcium and phosphorus are often limiting for crop growth and productivity. Appropriate amounts of lime and nutrients are essential to optimize plant root growth, enhance the efficiency of added nutrients, and avoid soil degradation (box 4.33). Although inorganic fertilizers such as limestone and rock phosphate are consistent with organic agriculture, inorganic fertilizers are often the most efficient means of adding soil nutrients. In many places (such as Africa) they are essential for improving productivity to levels that will then enable adoption of wider INM practices.

#### **Box 4.33 Soil nutrient recapitalization**

Researchers estimate that the croplands of many smallholder farmers, especially in Africa, have become depleted of the nutrients that are removed by crop harvests. Published estimates from 40 African countries indicate a net negative annual balance of 22 kilograms of nitrogen, 2.5 kilograms of phosphorus, and 15 kilograms of potassium per hectare of cultivated land. To meet increasing demand for food, soil scientists have recommended a major capital investment to replenish soil nutrients in Africa. Social scientists, however, caution against blanket nutrient recapitalization, as nutrient deficit statistics are based on limited data and fail to account for nutrient variability and transfers at the farm and watershed level. Furthermore, many socioeconomic and institutional factors influence farm management decisions. For example, smallholder farmers in western Kenya are gradually but significantly improving both crop yields and soil fertility because locally repackaged one- to five-kilogram bags of fertilizer are available, affordable, and can be transported and used on selected fields. As crop yields and input-output markets improve, farmers invest further resources for more fertilizer nutrients and improved seed.

Source: Anderson et al. 2002

In the past, the cost of soil and crop sampling and nutrient analyses made site-specific fertilizer recommendations prohibitively expensive for most agricultural programs. Blanket fertilizer recommendations were common, but blanket application of fertilizers is often uneconomic and can lead to pollution. Recent advances in plant nutrient decision

support models, improved access to high-resolution satellite images, and the improved interpretation of crop and soil spectral signatures make site-specific recommendations possible.

## Benefits

The reduced erosion and increased cycling of organic residues in INM can increase or at least maintain native soil organic matter levels and thus improve both nutrient and water retention capacity of the soil. Soils with around 3 percent soil organic matter content and dynamic soil fauna populations generally have better soil structure, water infiltration, soil aeration, and plant root growth than soils with lower organic matter. Improved soil water infiltration and retention significantly reduces surface flow of water, soil erosion, and nutrient removals, and it also minimizes the risk of downstream flooding.

INM can reduce plant requirements for inorganic nitrogen fertilizer, and reduced use of purchased fertilizer nutrients can result in a significant saving of scarce cash resources for small farmers. INM practices can also significantly reduce the emissions of greenhouse gases (nitrous and nitric oxides). Excessive applications of nitrogen fertilizer can result in increased leaching of nitrates into groundwater, increasing health risks to newborn infants and cancer risk in adults. Organic nutrient flows cycled through the return of organic residues as compost, manure, and/or mulch have significant implications for conserving soil fauna biodiversity.

## Policy and Implementation Issues

*Precision farming.* For large-scale farming, there has been significant private sector investment in fertilizer-based nutrient delivery and tracking systems. This investment has resulted in precision farming that uses satellite-based global positioning systems on tractors and harvesters to monitor and manage soil, plant, and grain nutrients by location in the field. Most smallholder farmers in the tropics, however, will need public support for participatory, multidisciplinary research and extension services to apply INM principles to the varied infrastructure, soil, and climatic conditions of their farms. This will require extensive local adaptive testing of technologies supported by comprehensive databases on soil characteristics, crop nutrient use and productivity, organic and inorganic fertilizer properties, and market prices.

*Results take time.* Benefits from INM are often seen only in the medium to long term, and in many cases the benefits are to populations living downstream of INM practitioners. Costs and benefits of INM practices should be monitored and quantified at farm and landscape levels so that appropriate premiums and taxes can be assessed to facilitate and promote the widespread adoption of INM practices. INM programs also need to consider the impacts on water and air pollution, siltation, salinization, biodiversity impacts, carbon sequestration, and greenhouse gas mitigation.

*Fertilizer, soil, and plant-testing laboratories.* Accurate information on the nutrient composition of available fertilizers and site-specific application recommendations are

important to INM, which relies on a good understanding of nutrient contents and flows. Consequently, there is a need for reliable soil, plant, and nutrient input testing facilities that can provide low-cost testing services to farmers in the initial stages of INM adoption. Opportunities exist for use of properly tested and treated urban waste and sludge, and these and local rock phosphates need to be tested to ensure that materials with high concentrations of heavy metals or toxins are not supplied to farmers. Public laboratories (especially for soil testing) are often inefficient, inaccurate, and poorly managed, whereas private laboratories are relatively rare and costly. Country-specific strategies are needed to establish and maintain accurate analytical laboratory capacity.

*Price, trade, and tax policies.* Fertilizer prices for many tropical smallholder farmers, especially in Africa, are more than double the prices paid by farmers in industrial countries. Crop prices are also too low or too unstable to allow farmers to profitably invest in replenishing nutrients on their depleted or degraded farmlands. Public policy needs to seek ways of reducing high fertilizer prices to farmers through more efficient marketing systems, but rarely should consider introducing subsidies.

*Labor supply.* Labor markets can be constraining, as INM often requires more labor inputs than do systems relying solely on inorganic fertilizers. Labor supply is affected by the dynamics of labor markets and the impact of disease (HIV/AIDS, for example). Appropriate tools and machinery for small-scale farmers, that can be locally produced, refined, and maintained, can significantly reduce the drudgery of field work and facilitate the adoption of labor-intensive INM practices. Excellent examples of such tools can be found in the cover crop and conservation tillage systems of southern Brazil.

## Lessons Learned

*Farmer learning.* Adding fertilizer nutrients will not be enough to improve and sustain crop productivity. It is essential to also engage farmers in the diagnosis and design of farm and watershed nutrient management and to facilitate farmer learning. As farmers become familiar with INM principles, they begin to innovate with different strategies in their own environments (box 4.34).

*Inorganic fertilizers.* In most tropical soils and integrated cropping systems, inorganic fertilizers must supplement organic nutrients. On degraded soils, inorganic nutrients are needed to prime the biological potential of native vegetation to produce the organic inputs prior to the adoption of INM strategies. The availability of appropriately formulated fertilizers at accessible prices is important for increasing the use of these nutrient sources by smallholder farmers.

### **Box 4.34 Nutrient budgeting tools: NUTMON**

A consortium of African and Dutch research institutes has worked with farmers in Sub-Saharan Africa to establish a program called NUTMON to monitor farm level nutrients. Participating farmers know that land productivity has been declining for years and that continuous cropping, loss of nutrients in harvested products, and manure shortages are to blame. NUTMON increases farmers' awareness of the role of soil nutrients and gives them a tool to assess nutrient balance on the farm. Researchers have documented changes in crop management as a result of NUTMON.

Source: Vlaming, Gitari, and van Wijk 1997

*Property rights.* Land and resource tenure rights influence the relative values of land, labor, and capital. Secure tenure is important in providing incentives for investment in land resources, soil nutrient buildup, erosion control, perennial crops, and other critical elements of INM. Land tenure security helps in accessing financial services to improve farmers' access to credit for these investments.

*Infrastructure and services.* INM strategies are adapted to many situations, but they are most likely to thrive in an environment in which supporting infrastructure and services exist and agriculture can be profitable. Roads are needed to bring in appropriate inputs and take out marketable products. Farmers must also have access to market information and INM knowledge obtained from productive research systems and extension information services. Good information services and other means to help manage risk provide a basis for farmer innovation and adoption of INM.

*Legumes and adapted species.* Legumes are central to the INM strategy, and leguminous species that combine moderate seed yield with high root and leaf biomass (and thus have a low harvest index) can help farmers meet household food needs while improving soil fertility.

*Soil microbes.* The selection and use of adapted soil microbes (rhizobia and mycorrhizal fungi), together with the active manipulation of soil macrofauna ("soil engineers"), organic residues, and modest levels of inorganic nutrients, can promote significant synergistic responses in plant growth and yield.

## Recommendations for Practitioners

Investments designed to facilitate widespread adoption of sustainable INM practices (box 4.35) will need to consider the:

- *General environment for agricultural profitability.* INM investment planning must assess the adequacy of infrastructure (roads, communications, markets), financial services, and technical support and structure INM programs accordingly.
- *Policy and price environment.* Fertilizer pricing policies as well as regulations governing environmental impacts of agricultural production (such as pollution from

### Box 4.35 Potential investments

- Policy analysis and formulation and regulatory system development relevant to fertilizers and soil fertility management.
- Training and extension to facilitate farmer access to knowledge on integrated nutrient management (INM) and advocacy and information campaigns.
- Soil, plant, and fertilizer testing facilities and incentives for private investment in such facilities.
- Participatory research on soil nutrient management, including site- and crop-specific fertilizer use recommendations.
- Regional fertilizer purchasing, mixing, and local repackaging.
- Processing of urban waste and sludge for use as soil amendments.
- Transportation infrastructure.
- Systems for environmental services payment (including quantifying on-farm and off-farm costs and benefits of INM).

Source: Authors

overuse of fertilizers) affect acceptability of INM innovations, and they need to be assessed in program planning.

- *Knowledge base.* Research and extension information systems are central to INM. NGOs and farmer organizations can be allies in promoting INM technologies, but sound research and soil/plant/fertilizer testing laboratories are essential backups.

## Selected Readings

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This investment note was prepared by Erick Fernandes, with input from the Sourcebook team.
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## Promoting Efficient and Sustainable Fertilizer Use in Africa

Increased use of mineral fertilizer has played a critical role in many developing countries that have experienced high and sustained levels of agricultural productivity growth. Policy makers in Sub-Saharan Africa face a major challenge in deciding how to promote increased fertilizer use. This investment note is grounded in the assumption that viable private sector-led markets for fertilizer will have to be developed if fertilizer use is to increase sustainably in Sub-Saharan Africa. The task will not be easy. On the demand side as well as on the supply side, fertilizer exhibits a number of characteristics that complicate the emergence of viable private sector-led markets. These include the strong seasonality in demand for fertilizer and the highly dispersed nature of that demand, the riskiness of using fertilizer, the lack of purchasing power among many potential fertilizer users, the bulkiness of many fertilizer products, and the need to achieve large throughput volumes in fertilizer procurement and distribution to capture economies of scale. Overcoming these challenges will require a concerted effort involving coordinated interventions in a number of areas.

### Why Invest in Promoting Increased Fertilizer Use in Africa?

It is widely recognized that achieving rapid agricultural productivity growth is essential to raising overall economic growth in Africa<sup>8</sup> and meeting the Millennium Development Goals, especially those related to reducing poverty and hunger (see, for example, NEPAD 2001, UN Millennium Project 2005, and World Bank 2005). There is also widespread agreement that improved soil fertility is needed to stimulate agricultural productivity growth in Africa (Crawford et al., forthcoming; FAO 2004; FAO, forthcoming). Low use of mineral fertilizer is one of the principal factors explaining lagging agricultural productivity growth in Africa relative to other regions. In 2002, the average intensity of fertilizer use in Africa (8 kilograms per hectare) was still much lower than in other developing regions (78 kilograms per hectare in Latin America, 96 in East and Southeast Asia, and 101 in South Asia). Even adjusting for differences in agroecological conditions and cropping patterns, fertilizer use is much lower in Africa than elsewhere, and yields are correspondingly lower.

**Comment [m1]:** I deleted the previous para because it recapitulates the discussion at the beginning of the Sourcebook.

For the foreseeable future, the welfare of rural populations throughout much of Africa will be tied to agriculture. Agriculture is the backbone of the rural economy in most African countries, generating a significant share of gross domestic product and providing by far the largest source of rural employment. All too often, however, agricultural growth has been disappointing. In many African countries, value added per capita in agriculture has risen very slowly for the past 20 years; in other countries, it has fallen. Across the region as a whole, food production gains have not kept pace with population growth, resulting in declining per capita production of food staples. Poor soil fertility is a leading cause of the continuing food insecurity in Africa, which suggests that programs that succeed in restoring soil fertility levels can deliver significant economic, social, and environmental benefits, especially to the poor.

<sup>8</sup> Unless otherwise stated, throughout this note “Africa” refers to Sub-Saharan Africa.

## Policy Issues Relating to Fertilizer Promotion

Fertilizer is now back on the policy agenda in Africa, because awareness is growing that there are powerful linkages between increased fertilizer use and agricultural productivity growth. The central role played by fertilizer in stimulating agricultural growth has been conclusively demonstrated in many countries, especially in Asia, where the widespread adoption of seed-fertilizer technology for cereals production led to the green revolution.

Efforts to promote increased use of fertilizer in Africa have often met with disappointing results. Despite several waves of fertilizer policy reforms designed to remove market distortions and attract investment from the private sector, viable private sector-led fertilizer marketing systems have yet to emerge in most African countries. Relatively little progress has been achieved toward developing the enabling environment that can ensure a smooth and rapid transition from rigid and inefficient state-run input distribution systems to dynamic and flexible privatized commercial systems. Measures needed to foster this transition include policy and institutional reforms to improve the enabling environment for the private sector, as well as investments to strengthen infrastructure, improve human capital, and generate and disseminate knowledge.

*Sustainability considerations.* Fertilizer use can be promoted through many different strategies, most of which fall into one of three basic categories: demand-pull approaches, supply-push approaches, or some combination of the two. Demand-pull approaches for promoting increased fertilizer use are designed to strengthen demand for fertilizer at the farm level. The three most important factors shaping farm-level demand for fertilizer include (1) the potential profitability to farmers of using fertilizer, (2) the willingness of farmers to purchase fertilizer, and (3) the ability of farmers to purchase fertilizer. Supply-push approaches for promoting increased fertilizer use are designed to improve the availability and affordability of fertilizer in the market. These approaches usually involve policy reforms, institutional changes, and supporting investments that make fertilizer production and supply services more profitable. Many supply-push approaches focus on opportunities to reduce the costs associated with fertilizer production, procurement, and distribution. The costs of supplying fertilizer are determined by four main factors: (1) sourcing costs, (2) distribution costs, (3) the availability and cost of business finance and risk management instruments, and (4) the adequacy of supply chain coordination mechanisms.

*Policy reforms.* Policy reforms are needed to stimulate private investment in the agricultural sector, as well as commercial financing of that investment. Examples of investment-stimulating policies include trade policies that promote the free flow of goods, macroeconomic policies that facilitate access to foreign exchange, taxes that do not place an undue tax burden on productive inputs, policies that promote competition by facilitating entry and exit of firms, and land ownership policies that encourage agricultural investment.

*Institutional reforms.* Institutional reforms are needed to ensure smoothly functioning commercial exchanges at all levels of the fertilizer value chain. Areas needing particular attention include (1) promulgation and enforcement of grades and standards, (2)

enforcement of business contracts, (3) prevention of undesirable consolidation of market power, and (4) streamlining of legislation concerning the creation and management farmers' cooperatives and professional organizations. The need for quality controls is particularly apparent, for fertilizer that is repackaged at the retail level to accommodate farmers' needs for small package sizes. Weaknesses in judicial systems make it difficult to enforce business contracts; this has a particularly negative impact on efforts to expand fertilizer credit.

*Environmental considerations.* The traditional role of fertilizer as a productivity enhancing input is being expanded as donors and governments seek to use fertilizer as an instrument for achieving a wide range of diverse goals (including economic growth, poverty alleviation, soil fertility replenishment, soil conservation, food security, and safety nets). Fertility replenishment and soil conservation are two of the environmental considerations included in the promotion of fertilizer use in Africa.

### **Lessons Learned: How Is Increased Fertilizer Use Best Achieved?**

One important lesson that has emerged from recent efforts to promote increased fertilizer use in Africa is that there is a need for much clearer thinking about how fertilizer policy fits into a country's overall development strategy. Increased use of fertilizer has the potential to make an important contribution to growth, but the size and the sustainability of this contribution will be limited as long as underlying structural problems in the economy remain unaddressed. Efforts that focus narrowly on promoting fertilizer as a panacea for broad-based and deep-seated problems such as lagging agricultural productivity are unlikely to be successful because they fail to address the underlying systemic causes of the problem.

Still, programs and projects designed to promote increased fertilizer use can make a significant difference at the margin (box 4.36). During the past decade, a number of innovative approaches have been piloted to stimulate increased fertilizer use. Several of these approaches provide particularly good examples of the use of market-smart subsidies:

- *Strengthening smallholders' links to the market* by building rural distribution networks and providing development grants that improve coordination along the marketing chain.
- *Providing vouchers* through public works programs to the poorest and most vulnerable farmers to purchase fertilizer.
- *Providing matching grants* for on-farm investments to promote the introduction of new technologies, for example improved soil fertility management and complementary practices.
- *Piloting innovative financial institutions*, such as weather insurance for crops or livestock and commodity risk management programs, to reduce risks for smallholders who adopt fertilizers.
- *Public sector procurement arrangements* to outsource the supply of public services, such as extension services for soil fertility management in order to stimulate private markets for services.

#### **Box 4.36 Starter Packs—A Tool to Promote Increased Fertilizer Use**

Starter Packs are packages containing small quantities of improved seed and fertilizer that are distributed to farmers at subsidized prices or free of charge, along with information on appropriate uses and management practices. As the name suggests, a Starter Pack is designed to get a farmer “started” on a new technology package.

When deciding whether or not to try a new and unfamiliar technology, farmers must weight the potential benefits against the likely costs. If offered an opportunity to learn about a new technology without having to make an initial risky investment, often they will be more amenable to trying the technology. Farmers who have been successful in using a Starter Pack on a small scale will be more willing to purchase the inputs in subsequent years and to adopt the technology on a larger scale. Starter Packs thus can contribute to a variety of desirable outcomes:

- Demonstration and validation of new seed-fertilizer technologies.
- Encouragement of farmer experimentation with new seed-fertilizer technologies, with the goal of bringing about successful adoption.,
- Promotion of crop diversification.
- Promotion of soil fertility improvement.

Source: Authors

Implementation of a successful fertilizer promotion program or project is likely to require attention to key strategic issues on both the demand side and the supply side. On the demand side, it is important to identify *appropriate entry points for overcoming weak or ineffective demand*. Policy analysts should ask a series of diagnostic questions when attempting to identify factors that may be depressing farm-level demand for fertilizer (Kelly et al., forthcoming). The questions can be used to help locate binding constraints that discourage fertilizer use, as well as potential entry points for resolving those constraints. Entry points at which there may be potential to stimulate stronger effective demand for fertilizer include: (1) strengthening agricultural research, (2) strengthening agricultural extension, (3) improving affordability of fertilizer, (4) managing risk, (5) improving agricultural infrastructure, (6) improving market information, (7) protecting farmers against volatile output prices, (8) promoting more effective farmer associations, and (9) improving the coverage and quality of rural education.

Similarly on the supply side, it is important to identify *appropriate entry points that offer the greatest potential to stimulate increased fertilizer supply*. Policy analysts should ask as well a series of diagnostic questions when attempting to identify factors that may be restricting the supply of fertilizer (Kelly et al., forthcoming). The questions can be used to help locate binding constraints that restrict fertilizer supply, as well as potential entry points for resolving those constraints. Entry points at which there may be potential to stimulate stronger effective supply of fertilizer include: (1) reducing fertilizer sourcing costs (foreign exchange, port facilities, economies of scale through bulk orders), (2) reducing fertilizer distribution costs (inland transport, storage, handling), (3) improving the environment for business financing and risk management, and (4) improving the environment for supply chain coordination.

## Recommendations for Practitioners

Today more than ever, policy makers and project designers are seeking guidance on what are the key elements of a successful fertilizer promotion strategy. While it would be convenient if this investment note could offer a general set of recommendations for designing interventions—in effect, a standardized “recipe” for success—unfortunately that is not possible. Constraints to using fertilizer tend to be context-specific, so successful strategies for promoting fertilizer are numerous and varied. At the same time, it is possible to identify some recurring lessons which, if adapted to local circumstances and properly contextualized, can assist in the design and implementation of policies, programs, and projects that respond to particular regional, national, or subnational fertilizer needs.

The following guiding principles will often be useful in informing the design and implementation of public interventions to support growth in fertilizer use, in Africa and elsewhere.

1. *Promote fertilizer as part of a wider strategy.* Fertilizer is not a silver bullet. Interventions designed to promote increased use of fertilizer should be developed within the context of a wider sector strategy that recognizes the importance of supplying complementary inputs, strengthening output markets, and appropriately sequencing interventions.
2. *Favor market-based solutions.* Long-term solutions to the fertilizer problem will have to be market-based. Interventions designed to promote increased use of fertilizer should be designed to support market development and not undermine incentives for private sector investment.
3. *Promote competition.* Competition in fertilizer markets is needed to ensure good performance. Barriers to entry into fertilizer distribution should be reduced (except possibly in the very short run), and markets should be kept competitive to ensure the lowest cost and best quality service.
4. *Pay attention to demand.* Farmers’ effective demand, shaped by the financial profitability of fertilizer use, should be the ultimate driving force of input supply systems and the foundation of a sustainable fertilizer promotion strategy.
5. *Insist on economic efficiency.* Efforts to promote the use of fertilizer should be driven by economics. Interventions should be carried out only where it is economically efficient to use fertilizer.
6. *Empower farmers.* Farmers should be in the driver’s seat. Interventions designed to promote increased use of fertilizer should empower farmers to make their own decisions on the most appropriate way to improve soil fertility in their particular context.
7. *Devise an exit strategy.* Governments should not be in the fertilizer distribution business for the long haul. Public sector interventions designed to promote increased use of fertilizer should be designed with a clear exit strategy, except for a few long-run, public good functions such as market regulation, infrastructural development, and natural resource management research.
8. *Pursue regional integration.* Market size matters, so trade matters. Countries should seek regional integration and harmonization of fertilizer policies to reap economies of

scale and size, which are especially important in a region such as Africa with many small countries.

9. *Ensure sustainability.* Solutions must be designed for the long term. Interventions designed to promote increased use of fertilizer should be economically, institutionally, and environmentally sustainable.
10. *Promote pro-poor growth.* Equity considerations matter. Assuming the previous nine guiding principles have been followed, a final consideration is that public interventions designed to promote increased use of fertilizer should also aim to promote pro-poor growth. In exceptional circumstances, poverty reduction and/or food security objectives may even be given precedence over efficiency and sustainability goals, if it can be determined that fertilizer interventions are the most cost-effective way of addressing these problems.

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Asterisk (\*) at the end of a reference indicates that it is available on the Web. See Appendix 1 for a full list of Websites.

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This investment note was prepared by Jonathan Agwe, with input and review from Michael Morris.

## China: Fruit Promotion in the Mid-Yangtze

Only about 137 million hectares of China's 960 million hectares of land are arable. Farming systems are intensive, with heavy use of inputs. Food grains occupy about 70 percent of total crop land, and although intensive farming has allowed China to meet its basic food needs, the government's central concern in recent years has been stagnating grain production. One element of the agricultural strategy involves exploring ways to increase the use of uplands and other underused areas to expand productivity of nonstaple food and commercial crops to meet demand, increase farmers' incomes, and reduce the pressure on land suited to grain production.

**What's innovative?** Focusing on bringing hillside lands, traditionally considered uncultivable, into sustainable production systems to increase farmer incomes – by using improved technologies and commercial solutions along the entire value chain.

### Project Objectives and Description

The main objectives of the Mid-Yangtze Agricultural Development Project were to increase the production, productivity, and marketability of fruit production in low-income areas of Sichuan, Hubei, and Chongqing as a means of increasing incomes and alleviating poverty. The project was designed to provide a demonstration model for the development of hilly wastelands—unused or underused lands—into orchards. Other specific objectives were to:

- Develop 12,000 hectares of new orchards and rehabilitate 2,500 hectares of existing orchards.
- Increase the provincial agriculture bureau's ability to: identify, propagate, and distribute healthy, disease-free planting materials; institutionalize virus indexing and budwood registration programs; and provide technical assistance for research and extension programs, and training for managerial and technical staff.
- Establish commercially independent Fruit Development Corporations to market fruit in local, distant domestic, and export markets.

The project focused on bringing hilly areas into productive, high-value citrus production. It emphasized the extension of existing research results to farmers, community participation in investment and operation, and an integrated approach along the value chain, from the selection of better varieties to the use of market-enhancing postharvest treatments. Villagers participated in terracing and planting the land, and (aside from terracing) soil conservation measures, such as contour planting and green cover crops, were introduced to improve environmental conditions. The new and better varieties included some with longer harvesting seasons, allowing greater production in off-peak months and consequently higher prices. New irrigation, planting, and postharvest technologies were adopted. Grading, packaging, and storage facilities were installed, and independent commercial corporations set up to market the output.

Farmers were responsible for contributing to the investment in orchard development through uncompensated labor during terracing, planting, growing, and harvesting. The county governments of the project area, which received International Development Association (IDA) funds, passed on orchard development costs, such as costs of terracing and technical services, to project farmers as 10-year loans at commercial rates of interest.

Commercial Fruit Development Corporations (CFDCs) invested in and managed modern treatment, packing, and storage facilities and purchased fruit from farmers. They sell the fruit purchased from farmers in local, distant, and export markets, although farmers are free to use other distribution channels. Provincial Fruit Development Corporations provide marketing services (such as market information) and interprovincial and export trading services to the CFDCs on commission, but the CFDCs are also free to use other channels, such as Foreign Trade Corporations and direct export sales.

### **Benefits and Impacts**

- Household income increased dramatically; for example, orange growers' income rose by Y13,000-26,000, depending on the variety grown.
- Income-generating activities and employment opportunities for participating farm families have increased, with 13,000 additional jobs generated during construction and implementation.
- Large numbers of nonproject farmers now use technologies developed under the project. It appears that the area of new orchards developed by farmers outside the project area amounts to four to five times that in project orchards.
- Soil erosion has been reduced by terracing and by planting vetiver grass for stability. In one example, eroded area was reduced from 48 percent in 1990 to only 13 percent in 1995.

### **Lessons Learned and Issues for Wider Applicability**

The project, providing a demonstration model for the developing waste hilly lands into orchards, has proven highly satisfactory. Key lessons include:

- Farmers' participation and sense of ownership from the beginning made a big difference in how the project was implemented.
- A strong research and scientific base, drawn from domestic and international experience, and the involvement of a science and technical committee, were essential to success.
- Cooperation among the Ministry of Agriculture, provincial and local governments, and research institutes was essential for effective implementation.
- Implementing agency staff must have strong technical skills relevant to program operations.

The project has applicability to other regions of the world that need to expand production to fragile hillside lands or to reduce soil erosion while improving production on these lands. If the baseline characteristics of the Chinese example (labor surplus, government

support, market demand) are used as a guide, such a project could be applied to similar regions.

<b>Country</b>	China
<b>Project Name</b>	Mid-Yangtze Agricultural Development Project
<b>Project ID</b>	P003541
<b>Project Cost</b>	US\$130.8 million
<b>Dates</b>	FY1991 – FY 1997
<b>Contact Point</b>	Rapeepun Jaisaard The World Bank, 1818 H Street NW, Washington, D.C. 20433 Telephone : (202) 458-4057; email Rjaisaard@worldbank.org

## India: Community Organization to Reclaim Sodic Lands

Uttar Pradesh State in India has about 17 million hectares under cultivation. It accounts for 10 percent of India's net sown area and 25 percent of the total irrigated area. It produces nearly 20 percent of India's food grains. A major concern in the state is the declining productivity of food grains, especially rice and wheat. This decline results mainly from water-induced land degradation (salinization, sodification, groundwater depletion) and loss of soil fertility (the sustained removal of nutrients is associated with more intensive cropping and the inappropriate use of heavily subsidized nitrogen fertilizers).

**What's innovative?** Making participation a necessary condition for sustainable land reclamation and development by investing heavily in participatory processes and community mobilization and organization, before and during implementation.

### Project Objectives and Description

The main objectives of the Uttar Pradesh Sodic Lands Reclamation Projects (Sodic I and Sodic II) were to:

- Develop models for environmental protection and improved agricultural production through large-scale reclamation of sodic lands.
- Strengthen local institutions to manage such schemes.
- Contribute to poverty reduction of the families concerned.

The Sodic I pilot took the approach that any physical investments in the land to reduce sodicity would have to be partnered and owned by a community that recognized their value. It thus designed a project based on participation, decentralization, and linking research and technology institutions to farmers. Under Sodic I, approximately 64,000 hectares of barren lands were brought under green cover for the first time. Sodic II seeks to use the approaches tested in Sodic I to increase agricultural productivity in 10 districts of Uttar Pradesh. Essential elements for sustained land quality improvements were defined to include community participation and ownership, rehabilitation of drains, improved irrigation management, and increased research on appropriate technologies. The research-extension link was also found to be weak and was to be strengthened through community-based mechanisms. Important components of participation and their characteristics include:

- The on-farm development and land reclamation component focuses on beneficiary-led, on-farm reclamation efforts.
- The technology dissemination component establishes a community-based, demand-driven system, building on the successes of the pilot project in developing grassroot organizations and their participation in supporting technology dissemination.

- Human resources development and institutional capacity building of support services focuses on staff training and institutional strengthening in the Panchayats (village governance institutions), NGOs, and executing government agencies.
- Adaptive research verifies and refines available technologies to suit the specific needs of local farmers and to bring about sustainable increases in the productivity of sodic lands through reclamation. Support for additional research on improving the cost-effectiveness and efficiency of land reclamation is made available through a Competitive Agricultural Research Fund accessible to both the private sector and national institutes.

Beneficiary participation occurs through targeted project interventions, including:

- Formation of water user groups (WUGs) consisting of 10-15 farmers responsible for a pump set and shared wells. WUG formation is supported by local NGOs that are also supported through project activities (capacity building).
- Establishment of Site Implementation Committees comprising two members (one male and one female) from every sodic landholder household, in combination with WUG representatives and indirect beneficiaries such as schoolteachers and local leaders. These committees have a mandate for resolving conflicts, monitoring progress, selecting resource people and trainers, and maintaining infrastructure.

### **Benefits and Impacts**

Yields of rice and wheat doubled as compared to original project estimates, wage rates doubled, and land values increased by a factor of four. By the end of the first project, cropping intensity had increased from 62 to 222 percent, wheat and rice yields had reached 2.7 and 3.0 tons per hectare, respectively, and more than one million people had directly benefited from project activities.

### **Lessons Learned and Issues for Wider Applicability**

Success has been attributable to flexibility in project design; strong commitment of project management and staff; strong beneficiary participation, facilitated by effective use of NGOs as supporting and motivating agencies; and a systematic approach to a full reclamation package including beneficiary involvement, construction of drains, on-farm development, application of chemical amendments, and crop production. Some of the key lessons include:

- Mobilization and involvement of communities in project implementation is essential. An important ingredient for motivating beneficiaries was that they were able to see returns in a short period by participating in the project.
- Joint partnership with all organizations that have key roles in project implementation helps to ensure that they are fully supportive and complete their functions on time.
- Public corporations/societies have more flexibility than line departments.
- Capable NGOs are important for forming, training, and supporting farmer groups.

<b>Country</b>	India
<b>Project Name</b>	Sodic Lands I and II
<b>Project ID</b>	Sodic Lands I: P009961 and Sodic Lands II: P050646
<b>Project Cost</b>	Sodic Lands I: US\$ 80.2 million and Sodic Lands II (org.): US\$286.6 million
<b>Dates</b>	Sodic Lands I FY 1994 – FY 2001 and Sodic Lands II FY 1999 – FY 2006
<b>Contact Point</b>	J. A. Perumalpillai-Essex and Paul Sidhu The World Bank, 1818 H Street NW, Washington, D.C. 20433 Telephone: (202) 458-9057; email : Jperumalpillai@worldbank.org and Paul Sidhu: psidhu@worldbank.org

## Malawi, Kenya, and Uganda: Developing Rural Agricultural Input Supply Systems for Farmers

Following the introduction of market liberalization measures in Malawi, Kenya, and Uganda, the private sector moved in and took up many functions previously performed by the public sector relating to the import, procurement, and distribution of agricultural inputs. Unfortunately, farm input supply companies concentrated mainly on urban areas and targeted primarily commercial farmers, so rural areas continue to be underserved. As a result, millions of poor farmers located in rural areas do not have access to affordable agricultural inputs, including improved seed, mineral fertilizers, and other agrochemicals needed to raise farm productivity.

**What's innovative?** Training, certifying, organizing, and providing credit to rural input suppliers as a means of improving African smallholders' knowledge about and access to quality agricultural inputs.

With the goal of improving food security and achieving the Millennium Development Goals, efforts are underway in these three countries to establish public-private partnerships that will strengthen demand for improved inputs by raising farmers' awareness of improved technologies and improving farmers' ability to use inputs efficiently. Three challenges will have to be overcome if these public-private partnerships are to succeed. First, measures will have to be found to increase the volume, range, and quality of agricultural inputs supplied via commercial channels to the doorsteps of poor farmers (accessibility). Second, input costs paid by farmers will have to be reduced so they can profitably use new agricultural technologies (affordability). Third, agricultural output markets will have to perform better so farmers can achieve higher prices and incomes from the sale of their produce (incentives).

The Rockefeller Foundation is supporting a project that works with three organizations in Kenya, Malawi, and Uganda to develop an agricultural input supply pipelines into rural areas. These organizations (AGMARK in Kenya, AT-Uganda in Uganda, and CNFA/RAISE in Malawi) are addressing the three key challenges of affordability, accessibility, and incentives by training networks of rural stockists to supply fertilizers and other inputs to farmers.

### Project Objectives and Description

1. To overcome a lack of technical knowledge and business administration skills on the part of input distributors, the project is training a network of rural stockists who can supply fertilizers and other inputs to farmers. Many of these stockists previously knew very little about improved seed and fertilizer or about safe handling of agrochemicals. Consequently, they were unable to provide farmers with credible information about using inputs efficiently and safely. To solve this problem, the stockists are trained using commercially-delivered training modules to develop their technical knowledge and business management skills. Once the training is completed, the stockists become certified as "agrodealers."

2. To improve the affordability of inputs for farmers, agrodealers pack and sell seed and fertilizer in small packages, ranging from 1 kilogram for seed to between 2 and 10 kilograms for fertilizer.
3. To help achieve economies of scale in sourcing and transporting fertilizer and other inputs, the agrodealers form themselves at the district level into “purchasing groups,” with group members providing joint collaterals to guarantee the supply of inputs from the companies. The agrodealers have organized themselves into national agrodealer associations as well, which allows them to better negotiate lower prices and improved credit financing arrangements with the agricultural input supply companies. Joining together into associations also helps them to influence government policies relating to imports, pricing, distribution, and marketing of agricultural inputs.

### **Benefits and Impacts**

In Malawi, where the CNFA/RUMARK project started in 2001, 322 agrodealers have been trained and certified across the country. A recent survey of rural markets showed that the majority of farmers now buy their inputs from agrodealers, compared to buying directly from the government-owned Agricultural Development and Marketing Agency (ADMARK) or large private companies. Within two seasons, these agrodealers moved seed and fertilizer worth close to US\$900,000 into rural areas based on the credit guarantees. Sales of fertilizer by certified rural stockists rose from US\$125,000 at the end of April 2003 to US\$676,000 at the end of April 2004—an increase of 441 percent.

The agrodealers have also become the most important extension nodes for the rural poor. In western Kenya, GIS-based “rural input access maps” have been developed, which now make it possible to determine the distances that farmers in various locations have to travel to purchase inputs. These maps, recently launched by the Government of Kenya, will be of great value to the government and donors in their attempts to better target fertilizer subsidy programs.

### **Lessons Learned and Issues for Wider Applicability**

- *Investing in the skills of rural stockists (agrodealers) to strengthen input distribution systems can be an effective means of accelerating the access of the rural poor to quality agricultural inputs in Africa.* Strengthening rural input supply systems significantly reduces search costs faced by farmers, making much needed production inputs available in rural areas at the right time and in appropriate volumes, sizes, and affordable prices.
- *To improve affordability of agricultural inputs, it is important that suppliers of agricultural inputs be encouraged to package their products in smaller sizes that are affordable to the rural poor.* Making fertilizer and other inputs available in small packages helps to improve effective demand, especially among the rural poor who tend to be lacking in cash. Although the possibility for adulteration arises when noncertified stockists try to sell unpackaged and rebagged fertilizers, such cases are becoming increasingly less common as the government regulatory agencies become closely involved in quality control, training, and certification of stockists.

- *There is a strong positive correlation between the availability of credit and the volume of trade in fertilizers and other agricultural inputs in rural areas.* The use of credit guarantees in Kenya, Malawi, and Uganda to help input suppliers finance their inventory is showing impressive results. It is helping to relax the high capital constraints faced by rural stockists, allowing them to significantly expand the range and volume of fertilizers and other inputs supplied to rural areas. The experience with credit guarantees in Malawi shows that every dollar of credit guarantee provided to the agricultural input supply companies generated sixteen dollars worth of supply of fertilizers and hybrid maize seed from the companies into rural areas—a leveraging ratio of 1:16. Efforts are needed now to scale up the training and establishment of rural stockists across Africa. Countries also need to now establish National Agricultural Input Credit Guarantee Facilities to link input supply companies to the trained agrodealers. This safeguard will help to reduce the risks they face in supplying inputs to the poor in rural markets.

<b>Countries</b>	Malawi, Kenya, Uganda
<b>Project Name</b>	Developing rural agricultural input supply systems for farmers in Africa (Malawi, Kenya, Uganda)
<b>Funding Agency</b>	Rockefeller Foundation
<b>Dates</b>	2001-present
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