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ENVIRONMENTALLY AND SOCIALLY SUSTAINABLE DEVELOPMENT
Rural Development

Integrating Biodiversity in Agricultural Intensification

Toward Sound Practices

Jitendra P. Srivastava
Nigel J. H. Smith
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Foreword

Agrobiodiversity has emerged from being an obscure, little-understood concept to assuming center stage in global efforts to intensify and sustain crop and livestock production. Much progress has been made in sensitizing the agricultural community to the value of protecting and better managing biological resources as well as underscoring the fact that agriculture is not always the "enemy" of the environment and biodiversity. Indeed, considerable biodiversity is found in many agricultural landscapes, and farmers on all continents have learned that they can improve their living standards by deploying a broader range of biological assets. Furthermore, it is increasingly apparent that habitats for wildlife will be saved from the ax or plow only if future demands for food and other agricultural products are met from areas currently cultivated or grazed by livestock. Intensification is an imperative across a broad range of land-use systems—from "traditional" to "modern," from well-watered to semi-arid, and from marginal areas to optimal farm lands. Agrobiodiversity is key to accomplishing this goal worldwide.

The many issues surrounding biodiversity conservation and use in agricultural development have been spotlighted at several conferences and in World Bank publications, all of which have contributed to this report. A wide-ranging discussion on agrobiodiversity took place at a one-day conference hosted by the World Wildlife Fund in Washington, D.C., in September 1996. This international conference, jointly organized by the Bank, the World Wildlife Fund, the World Resources Institute, and the Biodiversity Support Program, provided a fruitful forum for several nongovernmental organizations (NGOs), development banks, aid agencies, and government officials to discuss constraints and opportunities to enhance biodiversity in agriculture. The Food and Agriculture Organization conference on The State of the World's Plant Genetic Resources for Food and Agriculture, held in Leipzig, Germany, June 17–23, 1996, also helped to sharpen thinking on agrobiodiversity, because it brought the concerns and aspirations of dozens of nations to the surface. Much common ground was discovered during discussions at these conferences, and useful insights and perspectives provided by representatives from a variety of institutions worldwide have enriched this report.

This report pinpoints practical ways in which the environmental impacts of agriculture can be mitigated and demonstrates how biodiversity can be deployed to boost the productivity of crops and livestock. It builds on current work at the Bank to reconcile agricultural development with environmental concerns. Earlier Bank publications, particularly *Biodiversity and Agriculture: Implications for Conservation and Development* (Srivastava, Smith, and Forno 1996b) and *Biodiversity and Agricultural Intensification: Partners for Development and Conservation* (Srivastava, Smith, and Forno

1996a), lay out a conceptual framework for exploring the many issues surrounding the better integration (rather than destruction) of biodiversity in agricultural development.

In "Mainstreaming Biodiversity in Agricultural Development" (World Bank 1996), a joint effort of the Environment and the Agriculture and Natural Resources Departments, conflicts and complementarities between agriculture and biodiversity are explored, with a major emphasis on understanding the causes of conflicts and developing possible responses. This report takes its cue from the concluding section of "Mainstreaming Biodiversity" by addressing an agenda for the future.

The action agenda examined here proposes concrete steps for implementing "do no harm" strategies in the design of agricultural projects, including the identification of synergies between environmental conservation and agricultural intensification. Sound practices are also offered for ways to broaden the use of environmental assessments in agricultural development. It is recognized throughout that no technological quick fixes are available to harmonize environmental conservation with agricultural development. Policy distortions need to be removed, and institutions involved in technological development and dissemination need to be strengthened. More support for the further development of technologies, particularly those related to managing agrobiodiversity, is clearly warranted. At the same time deficiencies in the broader policy and institutional environment must also be addressed.

This report is geared primarily to the needs of task managers in agricultural projects, but it also offers some useful insights for other areas of the Bank's work, particularly in the preparation of country assistance strategies and policy dialogue with national governments. A concerted effort is needed to propel the mainstreaming of biodiversity in agriculture. This report contributes to this vital process.

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Abstract

Agrobiodiversity—biological resources that directly and indirectly contribute to crop and livestock production—is arguably the single most important natural resource in worldwide efforts to intensify agriculture while protecting the environment. Agrobiodiversity is key to transforming agricultural systems that are currently wreaking havoc on wildlife and human health and is also essential to boosting yields to satisfy the world's growing appetite for food, fiber, and other crop and livestock products.

This report highlights case studies in which modern and traditional agriculture have been successfully transformed to enhance biodiversity without sacrificing yield. Lessons learned from this review help to identify sound practices for designing and monitoring agricultural projects so that they improve rural incomes while safeguarding environmental assets, particularly biodiversity. The successful protection and deployment of biodiversity hinges on a favorable policy environment and on agricultural research and extension activities that stress farmer participation and greater sensitivity to the off-site impacts of agriculture. Suggestions for sound practices, therefore, include modifications of the policy environment and ways to strengthen research institutions and extension services so that agriculture can be intensified while better protecting and managing biological resources.

Acknowledgments

Many of the ideas explored in this report were honed during interactions with individuals at different forums in the World Bank and other organizations, such as the World Wildlife Fund. The encouragement of many individuals in the Bank, as well as nongovernmental organizations such as the World Wildlife Fund and World Resources Institute, has helped further thinking on this complex topic with many policy implications. In particular, we would like to acknowledge Marjory-Anne Bromhead, Nicole Glineur, and Steven Oliver within the World Bank, who took the time to comment on an earlier draft of this report.

Helpful comments on an earlier draft were also received from three international agricultural research centers within the Consultative Group for International Agricultural Research. We are grateful to Eric Roberts, acting associate director general for research at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); Grant Scobie, director-general of Centro Internacional de Agricultura Tropical (CIAT) in Cali, Colombia; and Michael Jones, Jan Valkoun, and Salvatore Ceccerali of the International Center for Agricultural Research in the Dry Areas (ICARDA). M. S. Swaminathan of the M. S. Swaminathan Research Foundation also kindly critiqued an earlier draft of the report.

The views and recommendations of this paper are those of the authors and are meant to stimulate discussion rather than imply endorsement of any institution.

Executive Summary

Agricultural intensification, a worldwide imperative, can be accomplished only if biodiversity is better protected and managed. Conversely, biodiversity will be safeguarded only if it contributes in a tangible way to human welfare and if essential needs are being met from areas already in production. This report highlights ways that *agrobiodiversity*—that portion of biodiversity used directly or indirectly in agricultural production—can be harnessed more effectively to boost productivity. The report also underlines agrobiodiversity's critical role in intensifying agriculture. Practical ways are identified to better manage and conserve the biological resources that underpin crop and livestock production.

A central theme of this report is that technological "solutions" alone will neither sustain greater agricultural productivity nor enhance biodiversity in the long run. Policy distortions that drive inappropriate land use practices must also be addressed, and institutions must be revamped and strengthened in order to raise and sustain yields while safeguarding biodiversity. Agricultural projects are usually inserted into a policy environment and an institutional framework that can hinder or promote their success. The purpose of this report, then, is to highlight policy, institutional, and technological issues to improve agricultural projects designed to boost crop and livestock yields while incorporating greater biodiversity and reducing pressure on wildlife habitats.

Biodiversity has already been mainstreamed with varying degrees of success in many traditional agricultural systems. Traditional systems have not solved all the environmental problems associated with agriculture, but such systems are generally richer in the array of crops and livestock deployed and also harbor greater genetic variation within crops than do modern production systems. The main challenges are to boost the productivity of traditional systems while maintaining their "environment-friendly" dimensions and to transform modern agriculture so that collateral environmental damage is reduced or eliminated as yields ratchet up. Agriculture will have to be intensified along the entire spectrum—from traditional to modern production systems—in order to have any chance of protecting forests, wetlands, and other habitats essential for wildlife and environmental services. This can be accomplished only by better management of biological resources.

In many cases the "educating" phase of highlighting the importance of biodiversity to agriculture has been accomplished. Two overriding constraints remain, however. The first obstacle is how to convince politicians that they must act. Many politicians are aware that biodiversity is important in the abstract, but they need to be shown how mainstreaming biodiversity contributes to increased agricultural production so that growing urban populations are fed, export earnings are increased, and urban and rural poverty is alleviated. The second is to offer guidelines or "best bets" as to how to encourage environmentally sound agriculture while still addressing the need to increase production.

The case studies in this report illustrate how managing biodiversity in agriculture can make a practical contribution to rural well being, but more analysis is needed. The main points to consider in reconciling biodiversity conservation with agricultural development are:

- Agricultural intensification will be successful in the long run only if biological resources are protected and managed wisely.
- Many agricultural research programs and development projects are ignoring potentially useful agrobiodiversity, an oversight that will likely further erode biodiversity. Not enough consideration is being given to ways to better harmonize biodiversity conservation and agricultural development.
- A great deal of biodiversity is found in managed landscapes. Biological resources in cultural settings therefore need to be better used and conserved, ranging from farmer-derived crop varieties to insect predators for integrated pest management strategies and microorganisms essential for recycling nutrients in cultivated soils.
- "Protected" areas embrace only a small fraction of the earth's surface. Most of the world's biodiversity is thus under varying degrees of pressure from human activities. Land use practices can be modified to enhance the broader spectrum of biodiversity, such as by creating wildlife corridors between fragmented habitats.

Biodiversity will be successfully mainstreamed in agricultural development only if the ultimate managers of biodiversity—farmers and livestock raisers—are involved in the design and implementation of research and development projects. Without local participation by farmers and their communities, major stakeholders in biodiversity management will be cut off from decisionmaking, thereby undercutting the chances for success. Farmers and livestock owners can provide important insights on suitable ways to use and manage biodiversity. A blend of indigenous knowledge and scientific research will be needed to further the transformation of agricultural systems so that they are more biodiversity-friendly and achieve higher productivity.

CHAPTER 1

Introduction

Agricultural intensification is under way across a broad array of land use systems on every continent. Increased demand for food and other agricultural products as a result of population growth and dynamic economies is driving this widespread process. Agricultural intensification is well advanced in some agricultural production systems, while in others it is only just beginning. In some cases productivity is faltering after many years of yield gains. In all systems sustainable management of natural resources needs to be taken into consideration.

Time-worn agricultural intensification strategies of adding more fertilizer or relying on increased use of machinery no longer work in many areas because of soil degradation. Moreover, these strategies are no longer acceptable because of off-site environmental impacts. Off-farm inputs are still an important component of intensification efforts, but they can now be combined with better management of biological resources. For many farmers fertilizer and machinery are not an option for intensification. They will have to follow different paths for raising productivity and protecting the environment. A new paradigm for agricultural research and development is emerging, one that emphasizes diverse approaches to intensification, but with two key ingredients in all cases: a blend of scientific and indigenous knowledge allowing for wiser management of biological resources.

Destroying Myths about Modern Agriculture

The debate surrounding agricultural development and environmental conservation often depicts "modern" agriculture as an almost sinister force that is destroying the planet's biological heritage. However, this "straw man" approach to the complex issue does not illuminate many of the promising paths to enhancing biodiversity in agricultural intensification. First, modern agriculture may not deploy a large assortment of crops and varieties in a relatively small area, but that does not mean that agrobiodiversity has been wiped out. In the case of hybrid maize, for example, the relatively small number of varieties grown over large areas rests on a massive pyramid of genes that are constantly being rearranged and tested by breeders. The image often conjured up of modern agriculture with expensive tractors and the heavy application of pesticides and fertilizers does not apply in all cases. Modern and highly productive farms may still rely on purchased inputs, but they are increasingly *biological* rather than chemical or mechanical. While the potential and reality of nonsustainable practices exist in modern agriculture, efforts and practices at reducing environmental impact and promoting biodiversity need to be encouraged. Agricultural practices emphasizing integrated pest, nutrient, and crop management techniques such as pesticide reduction, crop diversification, precision farming, and use of biological inputs need to be encouraged and promoted.

Another myth that needs to be put to rest is that the release of modern, high-yielding varieties inevitably bulldozes aside traditional varieties. Similarly, the deployment of popular super breeds of livestock is said to extinguish locally adapted breeds either by replacing them outright, or by genetic swamping as they interbreed. Modern varieties and livestock breeds merely provide additional options to farmers who have access to them; they do not necessarily lead to the abandonment of heirloom varieties or ancient breeds. The area devoted to the cultivation of traditional varieties may diminish, but they are not always lost. Many small-scale growers of maize, wheat, and potato, for example, continue to cultivate their traditional varieties after they adopt modern varieties (Bellon and Brush 1994; Brush 1995; Brush and others 1988, 1992; Smale 1997). Sometimes high-yielding varieties replace relatively recent lower-yielding material rather than indigenous varieties honed over hundreds or even thousands of years by local farmers. Continued investment in technology development is essential in order to develop varieties that suit specific agro-socioeconomic requirements.

Harnessing and Managing Biodiversity

In the past agricultural research and development has tended to promote monocultures and a commodity approach rather than a systems perspective. The resulting toll on biodiversity and the natural resource base has been well documented—salinization in irrigated areas, rampant soil erosion, the draining or despoiling of wetlands, and the disruption of food chains by pesticides. In the case of the Punjab, for example, indiscriminate applications of chemical inputs, improper management of water for irrigation, and continuous cropping with rice and wheat have damaged soil health and structure and depleted the water table. However, farmers in the Punjab and elsewhere are counteracting the adverse impacts of their activities on the environment, and we need to know more about what factors facilitate this regenerative process.

Biodiversity needs to be better harnessed and protected to foster the worldwide process of agricultural intensification and to avoid potentially serious setbacks in productivity gains. Further gains in the productivity of existing crops and livestock, as well as the domestication of new crops and animals, will be difficult and ephemeral if biodiversity losses continue. Encouragingly, governments in developing countries increasingly recognize that agricultural intensification must clearly address biodiversity conservation issues, as in the Brazilian Northeast (Magalhães and Lima 1995:108).

The management of biodiversity for agricultural intensification implies a more rational use of this resource and improved conservation efforts. Because it is difficult to predict what parts of the broader biodiversity pool might provide a yield breakthrough in the future or a new biocontrol agent for reducing pest damage, a wise course is to safeguard as much biodiversity as possible in natural and cultural habitats. With the adoption of appropriate farming practices, crop and range lands can be used in such a way that they minimize damage to wildlife, water supplies, and nearby habitats. Agricultural intensification could help alleviate destructive pressure on habitats by meeting agricultural production needs on existing farmland.

This report outlines measures that can be taken to alleviate some of the collateral damage associated with agricultural development and pinpoints ways that biodiversity can be enhanced on landscapes managed for crop and livestock production. A number of measures are being taken to mitigate at least some of the more obvious off-site impacts of agriculture. In addition to highlighting steps that can relieve the adverse impacts of agriculture on surrounding habitats (both wild and cultural), attention also focuses on ways to enhance biodiversity within agricultural systems.

Rationale

The conservation and sound management of biodiversity is essential for improving agriculture and a host of other economic activities, but agricultural expansion or inappropriate intensification is a major cause of natural habitat degradation. Yet farming and livestock raising can also enhance biodiversity in disturbed areas. And by deploying sound management practices, farming can relieve pressure on a mosaic of habitats so essential for a broad range of environmental services (Srivastava, Smith, and Forno 1996b).

Whereas biodiversity is reduced by the destruction of natural habitats, the apparent economic productivity of the resulting agroecosystems is usually higher than the current economic value of the intact habitat it has replaced. Natural habitats are being replaced mainly because the carrying capacity of modified landscapes is generally greater than the original environment. Yet the economic productivity of land transformation should be assessed in light of ecological and environmental costs. Biodiversity destruction as a result of habitat modification is a negative externality because it is not reflected in the marketplace. The implementation phase of an agricultural project usually has a short time horizon, usually five years or less, and although productivity gains may look impressive, they may not hold up over the long term. Also, damage inflicted on biodiversity and the environment may not show up on the books when economic and cash flow analyses continue to be performed after the project has been implemented.

The value of wild areas as a source of novel crops and domesticated animals is often unappreciated. Few crops or animals have been domesticated in the past two thousand years, although there has been considerable effort to improve the productivity of existing cultivated plants and livestock. As changing consumer tastes have created an interest in domesticating new plants and animals, some agricultural practices are destroying the very resources—undervalued plants and animals—that could provide income and sustenance for the next generation of farmers and consumers.

Farmers are constantly seeking new crops to replace those that are no longer profitable. Similarly, varieties often become obsolete because of pest pressure or other factors. Farmers can stay in business only if they can secure new and better-adapted crops and varieties. The pipeline of new crops and varieties, introduced from other regions or recently domesticated, must therefore remain open. The erosion of biodiversity is akin to turning down the spigot and can stall agricultural intensification efforts.

Conceptual Approach

Cultural landscapes—areas that have been modified to varying degrees by human activity—now dominate most of the earth's land surface, and surprisingly high levels of biodiversity are often found in areas devoted to crop production and livestock raising, particularly in "traditional" farming areas. Some of that biodiversity is directly useful to improving agricultural productivity, such as traditional varieties of crops with disease resistance genes and wild or weedy populations of crops that are tapped by breeders for other useful traits. In order to improve agricultural productivity and raise rural incomes, biodiversity must therefore be better managed in transformed habitats. This report not only outlines measures that can be adopted to reduce the off-site impacts of agriculture on biodiversity, but also pinpoints policy options to help conserve and better utilize agrobiodiversity-plants and animals, including beneficial insects, that are essential for agriculture.

We begin by presenting several case studies in which biodiversity has been enhanced as agricultural systems were intensified. The cases sampled here are drawn from a variety of production systems in different climates and continents to illustrate the widespread nature of intensification. The sample of case studies clearly illustrates that progress toward environmentally sound agricultural intensification is feasible and is being achieved in diverse settings. The case studies reveal that breakthroughs can usually be attributed to the coalescing of a variety of factors, including changes in the policy environment, institutional reform, and the agile diffusion of biodiversity-friendly technologies.

The case studies serve as the foundation for an analysis of specific measures that can be adopted to promote agricultural intensification in a biodiversity-friendly manner. Sound practices are grouped for convenience into four sections:

- Farm or community level
- Landscape scale
- Fiscal and regulatory environment
- Institutional aspects, including the generation and transfer of appropriate technologies.

The above-mentioned categories are not stand-alone components, but they have been teased apart to help focus the discussion. It is important for decisionmakers, especially task managers, to realize that these topics are all interconnected. For example, sound practices can be implemented at the farm or community level only if the right policy environment and incentive structures are in place. And gains in agricultural intensification will be sustained only if investments in appropriate research and technology dissemination are supported over the long term.

Constraints to adopting more biodiversity-friendly agriculture can be traced to failures of the policy and regulatory environment, institutions, and markets. Sound practices for mainstreaming biodiversity therefore focus on such recommendations as removing subsidies for inputs that destroy biodiversity when more benign technologies are available that can sustain or even raise yields, realigning priorities at agricultural research institutions, and taking advantage of emerging market opportunities to diversify agriculture. It is also recognized, however, that enhancing biodiversity does not mean that high-yielding varieties that tend to dominate large areas should be replaced by a hodgepodge of varieties long abandoned by farmers. Resuscitating vignettes of the past is not the way to mainstream biodiversity in agricultural development. In some cases modern farms with high-yielding varieties are more resilient and less vulnerable to diseases, pests, and other environmental insults than traditional farms. Modern farms may not match the spatial heterogeneity of traditional operations, but they often deploy appreciable agrobiodiversity over time because of high rates of varietal turnover and diversified agriculture and cropping systems.

An appreciation for land use dynamics is emphasized in the discussion of actions that can be taken to promote biodiversity-friendly agriculture at the ground level. Biodiversity is generally enhanced if a mix of land use systems prevails in a given area. That does not mean that all farms should intercrop in a given area. Monocropping makes economic and ecological sense in some cases. But it is generally wise to support diversification across farms in order to slow the spread of diseases and pests, among other challenges to agricultural production. Too often, agricultural intensification leads to a homogenization of landscapes as a single production system expands at the expense of others.

Remedial measures proposed here are not meant to tie the hands of development planners or task managers. Tradeoffs between conserving biodiversity and meeting the need to increase agricultural production are inevitable, and policymakers and other decisionmakers should at least be aware that tradeoffs are involved. As many items as possible in the suggested checklist of sound practices should be addressed to the extent feasible. It is no longer sufficient to ignore biodiversity because it has not been "valued." In many cases such valuation is difficult and fraught with shaky assumptions. In other cases valuation efforts are under way, but it is not always easy to place a monetary value on all aspects of biodiversity and ecosystem services of natural habitats. The cautionary principle should be applied here (Myers 1993). A wise course would be to save as much biodiversity as feasible in order to keep as many options as possible open for the future.

CHAPTER 2

Promising Signposts to Sustainable Intensification

A broad range of land use systems in a variety of climatic zones are sampled to highlight the diverse ways in which agricultural systems have been intensified while mitigating adverse impacts on the environment and biodiversity. The examples presented below are meant to be neither an exhaustive survey nor an in-depth analysis. Rather, they are meant to illustrate succinctly some of the creative ways in which farmers are boosting productivity and their incomes while enhancing biodiversity.

While it is recognized that many traditional agricultural systems, such as home gardens in Sri Lanka and Mexico, are highly productive, only systems that have undergone change as a result of deliberate efforts to transform them are scrutinized here. Case studies are drawn from Africa, tropical Asia, and Latin America, where traditional systems and modern farming practices have been altered to boost yield while conserving biodiversity. The case studies also sample a diverse range of ecological environments, from temperate grasslands to semiarid regions and tropical forests. In some situations, where population densities were high and traditional production systems were stressing the natural resource base, the agricultural production system was modified to suit the natural resource base. In other situations population densities were low but inappropriate subsidies had encouraged nonsustainable agricultural practices that degraded the soil.

Intensification of Dairy Farming in Uruguay

Uruguay is naturally endowed with extensive grasslands that have been exploited for centuries for cattle and sheep grazing. As urban areas expanded, demand for food products increased and some grasslands were plowed under to grow cereal crops, particularly in the 1920s and 1930s when tractors first became widely available. The continuous cultivation of wheat, maize, and sugarbeet in southern Uruguay triggered serious soil erosion, degrading fields and often resulting in their abandonment.

During the 1980s much of this degraded land was restored to pasture for intensive dairy operations by smallholders and mediumholders alike (Wallis 1993). The degraded areas were restored by sowing pastures with several species of legumes to help restore soil nitrogen and organic matter and by adding phosphate fertilizer to jump start the exhausted soil, a practice honed in New Zealand. Scientists working for the Uruguayan government produced an inoculum of nitrogen-fixing *Rhizobium* bacteria for farmers to mix with their legume seeds. More recently, dung-consuming beetles, earthworms, and other creatures involved in recycling nutrients have been added to restored pastures. After several years of grazing on restored pasture, a rotational cereal crop is planted. With soil structure and conditions for soil microorganisms thus improved, milk production has increased dramatically. In addition, many dairy farms have created ponds for watering livestock and irrigating rice, thereby creating pockets of suitable habitats for aquatic wildlife.

Sustainable agricultural practices have been uneven in the area's transformation to intensive agriculture. Some farms have employed techniques to reduce contamination to the watershed. Manure from stalls is redistributed to grazing areas through mechanical spreaders, or is conveyed as slurry through irrigation pipes back to the land. Previous excessive chlorine use had a detrimental impact on aquatic ecosystems, but many farms now use less damaging disinfectants. Some dairy plants have successfully established pig operations. Whey is fed to the pigs, thereby reducing water pollution from that cheese- making by-product. However, some farms continue to contaminate local watercourses by pumping their effluent into nearby streams and rivers.

Although the size of the national dairy herd has remained stable at 660,000 head, milk production more than doubled from the early 1950s to the early 1990s. Between 1980 and 1992 alone milk production jumped by 40 percent while the area devoted to dairy farms remained constant at 1 million hectares. Uruguay currently exports dairy products to nearly two dozen countries, including the United States.

The public sector initially played an important role in promoting the restoration of degraded lands, but the effectiveness of the government agency responsible for this task has waned as its autonomy and resources declined (Wallis 1993). The private sector has now assumed the lead in sustaining intensification efforts in the dairy industry. For example, the commercial sector and farmers associations have introduced modern machinery for intensifying dairy operations.

The salient lessons from the intensification of dairy operations in Uruguay are:

- It is possible to increase productivity by deploying modern breeds as long as the natural resource base is enhanced.
- Removal of subsidies can provide a stimulus to become more competitive by investing in more intensive production methods.
- Intensification is facilitated when mechanisms are in place for exchanging information about appropriate technologies developed in distant locations.
- A good infrastructure of roads and electrical power is essential for commercially oriented intensive agriculture.
- The restoration of soil agrobiodiversity boosts crop productivity.

Adjustments to Farming Practices in Response to Rapid Population Growth in Southeastern Nigeria

Southeastern Nigeria has some of the highest population densities in Sub-Saharan Africa and one of the most threatened ecosystems on the continent: the rainforests of West Africa. As population pressure has mounted, fallow periods have declined. In the past the rest period for the acid and leached soils of southeastern Nigeria was around seven years, but by the early 1990s the fallow period had been short-circuited to less than four years in many parts of Imo State. Four years is generally considered an insufficient period to restore soil fertility in the forest belt of southern Nigeria (Goldman 1992). When the population density reached around 500 persons per square kilometer in Imo State, sufficiently long fallow periods were no longer possible. Farmers complained that the soil was becoming exhausted and crop yields were dropping.

Instead of doggedly pursuing old strategies, farmers shifted their agricultural practices in the face of mounting population pressures. Farmers have intensified their traditional bush-fallow cultivation system by adopting several strategies: applying fertilizer (albeit in modest amounts), intensifying their management of fallow vegetation, and relying more on species-rich home gardens for subsistence and commerce.

Compound gardens around homes are an effective way of keeping land in continuous production without deteriorating the resource base. Multitiered home gardens are common to many parts of West Africa, as well as other parts of the humid tropics, and are islands of agrobiodiversity in transformed landscapes. Home gardens in Imo State contain a rich assortment of vegetables, fruits, tree crops, and some staples such as manioc and yams (Goldman 1992). Animal and human manure, ashes from domestic fires, kitchen waste, and leaves and crop residues maintain soil fertility in home gardens. In Imo State home gardens are serving as refuges for "lost crops," such as cocoyam and yam beans, which have disappeared from cultivated fields for a variety of reasons. The greater the density of the rural population, the larger the home gardens. Species-rich home gardens with their year-round production of crops are an important strategy in increasing the resilience of agriculture in densely settled areas (Goldman 1995). In southern Nigeria home gardens can occupy close to a third of the cultivated area and account for nearly two-thirds of crop output (Cooper and others 1996).

Farmers in much of Imo State and other parts of southeastern Nigeria have traditionally managed fallow by planting an assortment of shrub and tree species, particularly for soil improvement (Cooper and others 1996). Farmers enrich fallow by sowing such species as the fast-growing bush *Dactyladenia barteri* and by cutting down species that compete with useful shrubs and trees. The resistant wood of *Dactyladenia barteri* is used for a variety of purposes, including the staking of yams, and the leaves help maintain soil organic matter. This multipurpose, semidomesticated bush is most intensively managed in areas with the highest human population density, attesting to its role in helping raise crop yields and providing a variety of other commodities, such as firewood and construction material (Goldman 1993). The fire-resistant *Acioa* bush is specifically planted to produce a wood crop between seasonal crops.

Salient lessons from the Nigeria case study are as follows:

- Fertilizer use is not necessarily an undesirable part of the intensification package, particularly if applied judiciously. Indeed, it may be essential to sustain productivity and to build up organic matter in the soil. The use of organic mulches alone as a means of increasing soil organic matter in fields is rarely practical in the humid tropics because of the rapid rates of decomposition of plant material and the high cost of transporting and applying the huge quantities needed to make a difference.
- Some traditional land use systems—in this case home gardens—which are often ignored by mainstream agricultural research can play a critical role in agricultural intensification.
- Indigenous knowledge of plant resources, rather than reliance on top-down approaches to technology transfer, warrants close scrutiny in efforts to intensify agriculture. This Nigerian case study shows how local useful plant experts helped to manage fallow.

Home Gardens in Mexico and the Amazon: A Pantropical Cornucopia

Home gardens are arguably the most species-rich agricultural systems in the world. In some cases they represent miniature cultural forests, festooned with a wide variety of products for the kitchen and cottage industry. Shady, multitiered home gardens contribute significantly to subsistence and income generation in town and country, and women play a particularly important role in assembling and maintaining these rich islands of agrobiodiversity (Abromovitz 1994).

In addition to their social and economic benefits, home gardens are also havens for the largely unseen helpers in agriculture: soil microfauna and microflora and beneficial insects that pollinate crops and control pests. In spite of all the benefits of home gardens, they represent probably the least studied and appreciated agricultural production system in the tropics. In Europe and North America the functions of the home garden have changed over time from a primarily utilitarian place to a place for aesthetic pleasure, relaxation, and play (Taylor and Lawson 1994). Home gardens in much of the industrial world are now mostly showcases for flowers, manicured lawns, and painstakingly cultivated vegetable plots. Far more has been written about the ornamental plants of home gardens in Europe and North America than about the hundreds of food, medicinal, fiber, and other plants tended in tropical home gardens.

A few examples will serve to illustrate the rich diversity and untapped potential of home gardens for agricultural intensification. The home gardens of a single village in the Yucatán Peninsula of Mexico have recorded 387 plant species (Herrera 1994). A survey of 21 home gardens on the uplands near Manaus in the middle of the Amazon found 61 cultivated species; one garden alone had 41 intercropped species (Leuuwen and Gomes 1995). On the Amazon flood plain itself home gardens are equally diverse, a surprising finding considering the sweeping annual floods (Smith 1996). Dozens of fruit and nut-bearing trees are adapted to the varied terrain and to differing flood regimes of the Amazon River. Many of them are largely unknown outside the region, but could contribute to efforts to intensify agriculture and rehabilitate degraded wetlands.

Three main points are worth emphasizing with respect to home gardens in developing countries:

1. They can generate food and other agricultural products in towns, villages, and even in bustling cities (on rooftops or in tightly packed backyards).
2. They are important arenas for plant domestication and serve as launching pads for some of tomorrow's crops.
3. Conventional agricultural research institutions and development organizations have largely neglected home gardens. It is now time to bring their merits to the attention of a wider audience of policymakers.

Oil Palm in Malaysia and the Amazon

At first glance oil palm cultivation may seem like an odd example of how to intensify agriculture while enhancing biodiversity. Oil palm is generally grown as a monocrop and oil palm plantations have been a major driving force behind deforestation in Malaysia. Also, oil processing mills have been among the worst water polluters in the country. Nevertheless, oil palm productivity has increased dramatically in Malaysia, deforestation to establish perennial crops has slowed considerably, and mill wastes are now largely recycled on plantations. And because oil palm is grown by smallholders as well as large estates, successful intensification of this crop enhances the well-being of broad segments of society.

Although oil palm plantations certainly do not match the biodiversity levels of the habitats they have replaced, they are not ecological "deserts." Oil palm plantations in Malaysia have adopted a range of practices that mitigate environmental damage and enhance agrobiodiversity (Wallis 1993). For example, the Guthries Estate Company deploys locally adapted breeds of sheep to control weeds among young oil palms. Several species of legumes are planted on mature plantations to further check weeds and to enrich the soil with nitrogen. And in some plantations nest boxes have been set up to attract the common barn owl, an effective predator of rats, which often proliferate in oil palm estates. Not all oil palm estates or small farms have adopted the above-mentioned environment-friendly practices, but most deploy at least a ground cover of legumes.

In the Brazilian Amazon a 9,000-hectare oil palm plantation, owned by the Banco Real Group along the PA 150 highway between Belém and Marabá in Pará, deploys a number of sustainable practices that go even further with regard to coexisting with the surrounding ecosystems. A substantial portion of the property will remain in forest, in part because it harbors biocontrol agents that help suppress pests. No insecticides are used on the plantation because the palm depends on weevils for pollination. A 100-meter strip of forest is being left along water courses, and oil palm is planted only on relatively level terrain (Smith and others 1995). Buffer strips of forest help bring biocontrol agents closer to the crop. A thick mat of ground cover is provided by *Pueraria*, a nitrogen-fixing legume that smothers weeds, helps preserve soil moisture, and checks erosion. Finally, about 20 oil palm hybrids are planted and the mix of clones provides a genetic mosaic, possibly further reducing pest and disease pressure.

The implications of some recent developments in oil palm production are:

- Synergies can be found between maintaining natural habitats and boosting crop yields, particularly for integrated pest management.
- Deploying a mix of clones enhances agrobiodiversity even on large, monocultural plantations.
- Intercropping with a leguminous ground cover reduces the need for herbicides and fertilizers, thereby reducing or eliminating the downstream impacts of agricultural development.

Upholding Intensive Rice-Wheat Farming on the Indo-Gangetic Plain

The Indo-Gangetic Plain, spanning 11 million hectares in six states, is India's main bread basket. The green revolution in wheat and rice took off here in the mid-1960s and has contributed to dramatic increases in grain production. Most of this increased production was achieved by increasing yields rather than increasing the cultivated area. After spectacular yield gains in the 1960s and 1970s productivity gains slowed or in some areas even halted by the mid-1980s.

Degradation of the natural resource base is a major reason for the plateauing of rice and wheat yields. Loss of soil organic matter as a result of continuous cultivation with cereals has triggered a decline in organisms involved in recycling nutrients and has adversely affected soil structure. Although fertilizers are used extensively, nutrient imbalances have arisen in some fields, thereby impairing crop development. Prolonged irrigation, a major ingredient in the success of the green revolution, has provoked salinization of the topsoil in some areas, another factor in the braking of productivity gains. Water tables are falling in northern India, as in many other parts of the world, because of the growing thirst of farmers, industry, and urban areas, thus restricting supplies of water to flush away accumulated salts. Continuous cropping with cereals has also led to a build up of weeds, pests, and diseases.

The intensification of agriculture during the green revolution has helped to feed millions of people and has raised incomes for numerous farmers. But adjustments to agricultural practices were called for in order to prevent slippage in productivity gains. Fortunately, farmers on the Indo-Gangetic plains are responding to the challenge by deploying a number of tactics, including:

- Adoption of precision farming techniques, particularly in the management of soil nutrients (amounts, timing, and placement)
- Crop diversification, particularly with vegetables, pastures, and agroforestry
- Relay cropping
- Alley cropping
- Reduced tillage
- Improved management of water for irrigation.

The pace of regeneration appears to be quickening. In the case of precision farming, for example, some farmers are sending soil samples to laboratories for analysis of soil nutrient deficiencies. Trace element deficiencies are then corrected in customized fertilizer formulations. Fertilizer use has declined because application rates are calibrated according to soil analysis results; this not only saves the farmer money, it also produces less stress on the environment, particularly on aquatic ecosystems. The soil laboratories are privately run, another example of how the private sector is involved in sustainable intensification.

Salient lessons from farming experiences on the Indo-Gangetic Plain include:

- Intensification improved living standards for farmers so that they were able to invest in improved technologies and services, such as paying for soil analyses.
- A paradigm shift is well under way with agricultural research institutions, which has enabled them to tackle natural resource degradation issues more effectively.

The new paradigm shift incorporates a systems rather than a commodity approach, thereby facilitating farmers in their transition to more diversified cropping.

Soybean on India's Black Cotton Soils: Filling a Vacant Niche with a New Crop

Double cropping with soybean in central India illustrates the importance of policy decisions in the process of intensification. Public policy decisions to help make India self-sufficient in cooking oil spurred the establishment of more than one hundred soybean-processing plants in central India. As a result, soybean production in India increased tenfold in the 1980s, through improved farming techniques and intensification rather than through the extension of farmland into wildlife habitats or otherwise unsuitable areas for cultivation.

In the past farmers achieved only one harvest per year on the black cotton soils in central India. Technically known as vertisols, these black cotton soils are relatively fertile but pose a major challenge to farmers: they are exceptionally sticky and hard to work during the rainy season because of their heavy clay content. Traditionally, wheat or cotton have been planted during the tail end of the rainy season so that the crop can take advantage of residual soil moisture. However, when soybean emerged as a viable cash crop in the 1980s, farmers found that they could grow soybean during the monsoon, when fields were "empty."

Farmers were able to improve the workability of their soils by creating ridges and furrows to improve drainage. Furrows conduct the water to small ponds, which are used to raise fish. The ponds do not have to be lined with plastic or other impervious material because the fine-particle soil seals the bottom and sides of the ponds. Furthermore, the ponds provide water for irrigating crops during the dry season. The emergence of a viable cash crop that could survive the increased disease and pest pressure associated with the wet season provided the incentive to intensify agricultural practices in ways that have enhanced, rather than destroyed, biodiversity.

Double cropping with soybean also increased farmer income and produced a ripple effect through the regional and national economies. Soybean processing plants provided urban employment opportunities, and the transport of soybean by road and rail created more jobs. Soybean meal exports soared to $318 million in 1993, while exports of de-oiled soy cake reached $25 million by 1991 (Wallis 1993). Soy oil production, destined entirely for the domestic market, had an import substitution value of $191 million in 1993.

Further research will be needed to uphold the gains from the widespread adoption of soybean cropping on India's black cotton soils. In some areas excessive demand has drawn down groundwater supplies, thereby imperiling future agricultural intensification. More efficient use of industrial and irrigation water as well as water recycling and recovery will be needed. Pests and diseases specific to the soybean are likely to build up as the crop is cultivated over vast areas every year. "Maintenance" research is always needed whenever productivity breakthroughs are achieved (Plucknett and

Smith 1986). The impressive growth in soybean production in India nevertheless demonstrates that agricultural intensification, agrobiodiversity enhancement, improved incomes, and job creation can go hand-in-hand.

Agricultural Intensification through Fallow Reduction in Anatolia, Turkey

In the previous example land was left fallow until a suitable cash crop emerged, which not only provided additional income to farmers but helped to enrich the soil with nitrogen. In the case of the Anatolian Plateau in Turkey fields were being left fallow for about a year after cropping with wheat or barley in order to help restore soil fertility and structure. Because only one crop was possible per year due to the lack of irrigation, farmers were increasing production by encroaching on erosion-prone slopes.

Fallow elimination would reduce pressure on marginal areas. But two questions remained. First, under what conditions could the fallow period be eliminated without depressing wheat yields? Second, which crops could safely replace fallow without exhausting the soil or interfering with the succeeding wheat crop? Valuable insights to these questions were gained from a World Bank-supported rural project in northern Anatolia in the late 1970s, which promoted the cultivation of high-yielding pulse and forage crops to replace fallow. Wisely, the project was attempted on a pilot scale first, and eventually many farmers in the project area (Corum-Cankiri) adopted a legume-wheat rotational pattern (Wallis 1993).

Still, it took action in the public policy arena for this more intensive agricultural production system to take hold over a wider area. A symposium on prospects for improving agriculture in rain-fed areas, organized in 1981 by the Turkish Scientific and Technological Research Organization, provided the catalyst for launching the National Program for the Utilization of Fallow Areas. Within two years of the symposium the Ministry of Agriculture and Rural Affairs had completed plans for the training of extension staff, made credit available, and taken measures to ensure that the expected increase in pulse production would find ready markets. In the meantime the agricultural research community in Turkey was in touch with similar efforts at fallow reduction in Australia and in Texas in the United States.

A favorable public policy environment coupled with an agile agricultural research community helped farmers to achieve impressive productivity gains. During the 1980s the fallow area shrunk from one-third to one-fifth of the cultivated area, and pulse production has doubled in Turkey. Some 1.3 million hectares of formerly fallow land are now cropped with chickpeas, lentils, or forage legumes—particularly vetch (Wallis 1993). As the national output of pulses, mainly from Anatolia, more than doubled in the 1980s, Turkey has emerged as a world leader in the export of pulses. Wheat and barley production increased by 20 percent and 35 percent, respectively, during the same period without expanding the area devoted to those cereals. On the other hand some areas formerly cultivated with wheat or barley have reverted to a more natural vegetation cover. Soil erosion has thus been reduced, and areas taken out of crop production can be used for grazing livestock. Fallow has not been eliminated entirely, however. About every five years land is allowed to rest in order to check the buildup of plant diseases, weeds, and pests—particularly nematodes.

Implications of the Anatolia case study can be distilled as follows:

- Technology development alone is not enough to ensure sustainable intensification; it takes a concerted effort between the research organizations, government organizations involved in policy formation, and the private sector to market opportunities.
- New or improved farming practices are best honed in relatively small pilot projects before attempting to promote technologies over wide areas.

Redundancy in research can be reduced by networking with scientists working in similar environments on other continents.

INTERFISH and NOPEST Projects in Bangladesh

As rice systems have intensified, biodiversity has often been lost on several accounts. First, the number of varieties deployed has shrunk as farmers adopt semidwarf, fertilizer-responsive modern varieties. In Sri Lanka, for example, the number of cultivated rice varieties has shrunk from 2,000 in 1959 to 5 major varieties today (Swanson, Pearce, and Cervigni 1994:13). Second, many farmers no longer bother with *Azolla* water ferns and their associated nitrogen-fixing systems now that fertilizers are widely deployed. Third, the use of rice-fish systems has declined as rice production has intensified, in part because of the widespread use of pesticides (Zandstra 1992).

The INTERFISH and NOPEST projects in Bangladesh were designed to wean farmers off dependence on pesticides by deploying integrated pest management strategies. By restoring natural pest predators and diversifying crops, thousands of farmers have been able to relinquish the expensive and environmentally damaging use of pesticides without suffering any yield declines. On the contrary, rice productivity has increased since the inception of the projects (Thrupp 1996a). Because pesticides are no longer used, carp can be integrated with paddy rice production; growth rates of the fish in rice paddies compare favorably with those in ponds. Furthermore, vegetables and sesbania are grown on dikes to provide food and fuelwood, thereby reducing the diversion of using cow dung for cooking meals and, instead, applying it to fields. Sesbania also enriches the soil with nitrogen because it is a legume.

After a little more than a decade of collaboration by CARE, the Bangladesh Department of Agriculture and Extension, and the U.N. Food and Agriculture Organization to introduce integrated pest management (IPM) technologies to Bangladesh, the NOPEST pilot project was launched in 1992. NOPEST targeted two districts with eight IPM practices for rice cultivation and included a fish culture component with assistance from Britain's Overseas Development Administration. Although not all the IPM strategies were effective, farmers participating in NOPEST cut pesticide use by three-quarters, while increasing yields by a tenth (Ingram and Kamp 1996). Farmers who did not participate in NOPEST experienced no increase in rice yields.

Although the NOPEST pilot program was discontinued in 1993, it was instrumental in launching INTERFISH, a broader program designed to reach 22,500 farming households. In addition to IPM and fish farming, INTERFISH also promoted vegetable growing on dikes. As in the case of NOPEST, the INTERFISH program emphasized participatory learning with farmers (Ingram and Kamp 1996). In 1994 the program boosted rice yields by an average of 7 percent, while eliminating the cost of pesticides. Fish farming and vegetable growing have increased family income, a clear indication that enhancing agrobiodiversity can promote improved living conditions.

Salient lessons from the INTERFISH and NOPEST experiences are:

- Start with modest pilot projects. Scarce resources are used more efficiently that way, and the risk of promoting inappropriate advice and technologies is reduced.
- Involve farmers with project design from the start, rather than trying to encourage them to adopt technology packages devised elsewhere.
- Foster collaboration between nongovernmental organizations, government agencies, and international organizations, rather than attempting a go-it-alone approach.
- Adopt IPM practices in order to increase crop yields.

CHAPTER 3

Sound Practices at the Farm and Community Levels

Farmers generally start shifting their agricultural practices in response to alarm bells such as declining yields, a drop in income, or in response to new opportunities to become a more efficient producer and possibly take on new crops. Falling productivity, in turn, is a symptom of a degrading natural resource base. Degradation and impaired ecosystem functioning can generally be attributed to four main causes:

1. Increased pest or disease pressure due to destruction of natural predators, monocropping, or excessive reliance on uniform varieties that are not backed up by a pipeline of suitable replacements
2. Increased competition from weeds
3. Degradation of the soil through erosion, destruction of organic matter and associated microfauna and flora, and changes in soil structure
4. Increased salinity due to the mismanagement of irrigation water.

Given the variety of ecological environments and the cultures involved, only sound practices at the generic level are highlighted here (table 3.1). It bears remembering that there is little new about the sound practices; farmers have employed many of them for centuries or even millennia. The Romans, for example, discovered the benefits of crop rotation early and farmers in many parts of the humid tropics have practiced mixed farming in their diverse agroforestry systems. But as agriculture was mechanized along more modern lines, many of these ancient practices were dropped or marginalized. The time is ripe to reintroduce them as part of the intensification process rather than discard them as symbols of obsolete, even backward agriculture.

A menu of recommended practices should not be forced on farmers in order to bring their agricultural systems round to a single model of agricultural intensification. Rather, they should represent a smorgasbord of opportunities to intensify their crop and livestock systems while minimizing adverse impacts on biodiversity. In other words, recommended practices will always have to be tailored to the specific climatic, soil, vegetation, and socioeconomic conditions of areas targeted for intervention.

Each of the sound practices outlined above is essentially a tree with many branches, offering a diverse array of distinct variations on the theme. For example, conservation tillage has a drop-down menu of numerous practices, from sod-planting, where seeds or cuttings are inserted directly into unplowed ground, to plowing (Srivastava and others 1993). Varietal mixes can include a basket of different cultivators in the same field, the use of multilines, which are essentially identical except for a few genes con-

Table 3.1 Agricultural practices that reduce natural resource degradation while boosting yields and enhancing biodiversity

Practice	Control			Conserve water quality and supply	Maintain soil fertility
	Weeds	Pests	Disease		
Relay cropping	+	+	+		+ a
Crop rotation	+	+	+		+ a
Mixed cropping	+	+	+	+ b	+ b
Varietal mixes		+	+		
Maintenance of traditional as well as modern breeds		+	+		
Buffer zones of natural habitats		+ c	+	+	+ d
Release of biocontrol agents		+			
Fallow management	+	+	+	+	+
Conservation tillage	+		- e	+	+
Crop-livestock integration				- f	+
"Precision" irrigation				+	
"Precision" fertilization					+
Terracing				+	+
Contour bunding				+	+
Contour strips of grass or perennial crops				+	+

Note: Integrated pest management is not a separate line item because it embraces several practices, such as relay cropping, mixed cropping, and the release of biocontrol agents.

a. If one of the crops is a legume or provides sufficient mulch to maintain levels of organic soil matter.

b. Especially if trees are involved that create a moist microclimate and help protect the soil against erosive forces.

c. Natural or relatively undisturbed habitats as integral parts of a farm can provide environments to support predators of crop pests. On the other hand, they may harbor crop pests and pathogens. However, the safeguarding of natural habitats is likely to be positive from the pest control perspective, among other benefits.

d. By reducing soil erosion by wind and water.

e. In some cases conservation tillage can increase disease pressure since crop debris left on the soil can harbor crop pathogens.

f. Can fertilize ponds for aquaculture, particularly with ducks or pigs, but cattle can pollute streams with their dung, and farmers may clear vegetation along water courses to increase pasture.

Source: Author's compilation.

ferring pest or disease resistance, or the planting of varieties in separate blocks. Close interaction with farmers is essential in order to choose the right mix of sound practices and their numerous variants.

At first glance it may seem that the sound practices identified in table 3.1 have little to do with biodiversity per se. Indeed, weed control generally lowers biodiversity levels in a field as unwanted, volunteer plants are eliminated. But from the perspective of sustainable agricultural intensification practices that reduce weed populations through nonchemical means are less likely to trigger collateral damage to the environment, such as the buildup of herbicides in the soil or the leakage of such chemicals into the groundwater. Similarly, the deployment of several varieties of a crop in the same field rather than the planting of a single cultivator may not sound like an impressive example of biodiversity enhancement, except that by so doing the need for pesticides can be reduced or even eliminated.

Entry Points for Promoting Sound Practices at the Farm Level

The case studies highlight how best practices are being applied in many different situations. Before looking at how such practices can alter the agrobiodiversity picture at the landscape level, it would be useful to outline some of the entry points for catalyzing the adoption of sound practices in managing biodiversity for agricultural intensification. Integrated pest management and the promotion of a balanced mix of modern and traditional crop varieties and livestock breeds are examples of practices that can be promoted at the farm level.

Integrated Pest Management

Integrated pest management (IPM) provides an especially useful catalyst to promote the concept of increasing biodiversity in agriculture at the farm level. IPM has already served as the vanguard for much of the thinking on sustainable agriculture (Thrupp 1996b). Farmers are generally amenable to IPM approaches because they can reduce their pest control costs and increase yields. Furthermore, IPM is applicable to all crop production systems. IPM strategies include a basket of practices ranging from crop rotation to the release of biocontrol agents and the judicious use of pesticides.

Constraints to a more widespread adoption of IPM include:

- IPM is more knowledge-intensive than applying off-the-shelf chemicals.
- Investments in research are needed to tailor IPM strategies to different farming situations.
- Training is required for farmers and extension agents.
- Although more durable over the long run, IPM approaches may not provide the immediate impact on pest populations provided by heavy applications of insecticides.

Promoting a Balance of Modern and Traditional Varieties

Farmers in many developing regions often plant several varieties of their main crops as a risk-aversion strategy, particularly to provide a buffer against unseasonable weather or disease attack. Small-scale farmers in the great lakes region of eastern Africa, for example, typically cultivate a dozen or more bean varieties in the same field. Many modern production systems promote the use of a single variety over large areas, often requiring heavy doses of pesticides. Farmers then find themselves on the pesticide treadmill as pests develop resistance. Furthermore, farmers can be vulnerable if more resistant and productive modern varieties are not waiting in the wings to counteract sudden challenges to productivity.

Modern varieties are understandably promoted in agricultural development projects because they are generally higher yielding. While it is true that modern varieties have helped to increase food production severalfold and have improved the livelihoods of millions of farmers, they are not always the only choice. The widespread policy in both industrial and developing countries of promoting the use of modern varieties has incurred hidden costs in some cases, including the genetic narrowing of our crop production base if the obsolete varieties are not saved in genebanks. Typically, credit is only available for approved varieties that have been certified by national seed boards. Certified varieties are generally those that have been tested by government agricultural research programs and have been deemed sufficiently robust to deliver on their promise. Traditional varieties are rarely included in such trials, even though they may perform better than improved varieties, particularly under the suboptimal application of inputs.

The farmer should be given more options. In many cases it makes sense to deploy only modern varieties, but in some situations the farmer might want to plant a mix of modern and traditional cultivators. It is a question of leveling the playing field, rather than denigrating modern varieties.

As a matter of policy, then, it makes sense to analyze the relative advantages of modern and traditional varieties when promoting a crop. It would probably make sense to identify a basket of improved and older varieties for farmers to chose from, rather than pushing only an approved variety or a single traditional cultivator. If farmers prefer to plant modern varieties at the expense of older, "heirloom" varieties, they should be free to do so. Hitherto, however, many farmers have abandoned traditional varieties because credit was not available for planting them.

Promoting a Balance of " Super" and Local Livestock Breeds

Livestock raising, especially cattle, chicken, turkeys, pigs, and sheep, is increasingly dominated by a handful of breeds. In the case of cattle, a few breeds now dominate the beef and dairy industry worldwide. Agricultural development policies often promote the spread of major beef and dairy breeds in the tropics and subtropics, leading to the extinction of local, better-adapted breeds. The driving force behind selection in the major cattle breeds has been rapid weight gain or volume of milk production. Although local breeds may not be as productive, their cost-effectiveness is often higher because they require less intensive care and thrive on poorer quality feed.

The alarming erosion of traditional breeds of livestock can be counteracted by two means. First, credit systems can be structured so that farmers can choose breeds they prefer. In many cases they are likely to continue selecting widespread, popular breeds at the expense of locally adapted livestock. But at least some farmers might opt for traditional breeds if the credit system is balanced. Second, incentives can be introduced to maintain breeds that might otherwise disappear. Several European countries are at the forefront of this trend. For example, the Roquefort cheese industry in France is based only on the milk of the Lacaune breed (Alderson 1994:67). In Italy Parmesan cheese can only be made from the milk of the Reggiana breed, while Fontina cheese is made exclusively from the milk of Valdostana cows.

Ultimately, the survival of breeds hinges on decisionmaking by individual farmers. Unlike seed crops, it is not easy to store livestock germplasm ex situ. Frozen sperm is used mostly to store genetic traits of superior breeds, and then only the most desirable studs of those breeds. Frozen embryo technology is expensive and not feasible for safeguarding, in a practical sense, the diversity of traditional breeds. How many breeds see the next century will depend largely on whether farmers retain them as paying propositions.

CHAPTER 4

Sound Practices at the Landscape Level

Certain practices can be adjusted at the farm level, but broader-scale processes are under way that warrant attention. The aggregate action of individual farmers translates into patterns of land use at the scale of a plain, valley, or entire watershed. The landscape ecology of farming areas is an exciting new dimension to conservation work because at this level steps can be taken to ensure that wildlife has sufficient space and resources to survive. For example, wildlife corridors, an important way to promote gene flow and sustain larger predators at the top of food chains, can only be effective if habitat fragmentation is avoided.

A few concrete steps that can only be taken at the landscape level are explored here. Particular attention is paid to ensuring a balanced mix of land use systems, minimizing the off-site impacts of farming, and initiating rapid agrobiodiversity surveys at the project design stage. The need to expand the scope of "protected" areas to include biological resources of potential value for agriculture is also discussed.

Promote a Balanced Mix of Land Use Systems

Government policies often promote the expansion of a particular land use because of its perceived economic value, and agricultural projects often build in such land use biases. Commodity programs typically discourage farmers from adopting alternative crops (NRC 1989: 68). In some cases agricultural projects have promoted, directly or indirectly, the expansion of agricultural activities into habitats used formerly for extraction purposes only, as has occurred in the Brazilian Amazon, where pasture formation has been encouraged at the expense of forest (Mahar 1989).

Development projects should promote a mix of land use systems in a given area whenever appropriate, thereby increasing agrobiodiversity as well as biodiversity in general. The diverse agricultural production and extractive systems of densely populated southeastern Nigeria are a good example of a rich landscape mosaic of essentially cultural habitats. In that region farmers extract oil palm and other useful products from old second growth and cultivate food crops in fields and home gardens. Particular attention should be paid to natural or near-natural habitats that contain significant plant resources that are extracted for local use. Such wild plants may not appear significant in market terms, but they are important to the livelihoods of locals and efforts need to be made to account for them in land use planning. Specific measures to accomplish this goal include:

- The removal of fiscal incentives for certain cash crops or cattle raising that tend to promote the homogenization of landscapes

- Setting aside natural habitats, with varying degrees of human intervention ranging from near total protection to multiple use
- Recognizing the importance of wild collected foods where appropriate for local inhabitants and safeguarding such habitats from destruction
- Identifying habitats that contain wild populations of crops or their near relatives, and encouraging locals to manage such environments without destroying them
- Identifying habitats that contain wild populations of livestock species or their near relatives and encouraging communities to manage such environments without destroying them
- Establishing buffer zones or shelter belts to reduce soil erosion and providing habitats for wildlife, including biocontrol agents, especially in degraded landscapes
- Recognizing how farmers and livestock owners use different habitats in a landscape at different times of the year so that essential seasonal grazing lands, for example, are not cut off or eliminated by development activities.

Minimize Off-site Impacts

Many downstream and upstream impacts of agricultural activities on the environment can be mitigated (World Bank 1996). In the past many agricultural development projects focused exclusively on raising productivity on farm and grazing land. Historically, little attention has been paid to how the development project may affect surrounding areas. Headway is being made in systematically incorporating more biodiversity in agricultural intensification, but much remains to be done.

The following adverse impacts of agriculture need to be addressed:

- Pesticides that reach nontarget organisms in and around fields, such as predators of crops and pollinators
- Herbicides and pesticides that filter into ground water supplies
- Pesticides that are washed into water courses
- Fertilizers in run-off that alter the water quality of rivers, lakes, reservoirs, bays, and estuaries
- Effluent from agricultural processing plants that can contaminate water supplies
- Diversion of water for irrigation that alters the quality and quantity of water to the detriment of wildlife
- Construction of dams for irrigation that may destroy wildlife habitats
- Increased sedimentation in water courses because agricultural practices have accelerated soil erosion.

The impacts of agriculture on freshwater and coastal biodiversity are often far-reaching and profound (Kottelat and Whitten 1996: 22). An accounting is needed of such potential impacts before an agricultural project is approved. This does not imply that pesticides or irrigation should not be used, but their adverse impacts on the environment need to be considered.

Task managers of development projects need operational tools to help mitigate the off-site impacts of agriculture on biodiversity. Bio-indices can serve as barometers of ecosystem health, and some pioneering work in this area has been accomplished by farmers collaborating with the M. S. Swaminathan Foundation in Madras, India, who check on the status of lichens as a means of gauging the levels of pollutants in the environment. The challenge is to come up with a streamlined list of bio-indices to assess the vigor of a wide range of ecosystem functions.

Bio-indices might include:

- Lichens or other plants in the environment that are especially sensitive to environmental pollution
- Periodic censuses of insect populations in agricultural settings and contiguous areas to detect any large-scale changes that cannot be attributed to natural population cycles
- Checking certain mollusks or other aquatic fauna that are easy to capture to see whether

pollutants are entering water courses from crop and livestock production areas
- Checking water quality in streams, rivers, lakes, estuaries, and groundwater for excessive nutrients or other chemicals that can be traced to farms and agricultural processing plants.

Such monitoring is not particularly expensive, at least when the harmful impacts of agrochemicals on the environment are taken into consideration. Genetically engineered biosensors are now used routinely to detect pollutants. Immunoassays have been tailored to detect a wide range of toxic compounds, including pesticides. One immunoassay has been developed that can detect the presence of a herbicide even at highly diluted concentrations of one part per billion. Recombinant DNA technologies have provided an array of tools for monitoring the environmental safety of agricultural production systems.

Conduct Rapid Agrobiodiversity Surveys in Advance of Agricultural Projects

In an extensive polling of more than one hundred nations on the threats to their plant genetic resources and possible remedial measures, many countries specifically cited the need for surveys to determine the status of local plant genetic diversity (FAO 1996a: 34). One of the merits of such an undertaking is that it provides a baseline from which to quantify trends. While such an undertaking is certainly worthwhile and warrants high priority, national-scale inventories of crops and traditional varieties are expensive and time-consuming.

An intermediate step can nevertheless be taken: a rapid agrobiodiversity survey as part of the planning phase of an agricultural project. Such rapid surveys are not a Noah's ark approach to genetic resources, designed to rescue materials about to be swamped by new and improved technologies. Rather, the idea is to understand the existing patterns of agrobiodiversity and the role that diverse combinations of plants and animals play in sustaining the livelihoods of locals. In this way it should be possible to weigh the comparative advantages of traditional and improved crop varieties and livestock breeds and alert planners to the dangers of losing unique germplasm. If enough agrobiodiversity surveys are undertaken and the findings are entered into computer databases and geographic information system (GIS) software, it should be possible to cross-reference varieties and crops that might be transferable to areas with similar soils and climate. The systematic recording of cultural information about traditional crop varieties—how they are used and what roles they play in nutrition and sometimes the religious life of people—has barely begun (Nazarea and others 1997).

Local people should be asked to participate in the design of the project, as evidenced by experiences with forestry and agroforestry development projects (Tamale, Jones, and Pswarayi-Riddihough 1995). Survey teams would assess the agricultural project with respect to its potential impact on:

Localized breeds or varieties. If farmers are likely to retire breeds or abandon varieties as a result of the project, measures should be put in place to see that any unique material is transferred to *in situ* or *ex situ* germplasm collections or both.

- Habitats that provide vital environmental services, such as watershed protection
- Habitats that provide important supplemental income or nutrition to local people, such as the gathering of forest products
- Habitats that are important gene reservoirs because they contain wild populations or near relatives of crop plants.

Agrobiodiversity surveys would address the following questions:

- What are the dynamics of varietal and crop replacement on the farm? Are obsolete varieties discarded or saved in a genebank? Do modern varieties always replace heirloom varieties, or are the heirloom varieties simply grown on smaller plots?

- Which traditional practices that are biodiversity-friendly can be encouraged without compromising yield or income generation?
- What is the scope for introducing new technologies on the farm that boost yields while reducing negative impacts on the environment?
- What mechanisms are in place at the community level to resolve conflicts over the use of biodiversity resources?
- Is the tenure picture clarified and property or use rights well established so that resource users feel they have a stake in the long-term productivity of the land?

The notion of agrobiodiversity survey teams is similar in spirit to recent efforts to conduct rapid assessment of biodiversity priority areas (World Bank 1995b: 96). With agrobiodiversity assessment teams, though, the aim is to ascertain whether any key parts of the managed biota will be imperiled by inappropriate practices or development schemes before they are implemented and to assess whether governance at the local level is capable of protecting biodiversity resources.

Given the many dimensions to managing and conserving agrobiodiversity, survey teams should include individuals with various disciplinary backgrounds. A range of disciplines—

Table 4.1 Agrobiodiversity performance indicators

Objective	*Performance indicator*	*Monitoring and supervision*
Reduce natural habitat loss	Intensification of systems to increase productivity and income-generating options on areas already in production	Encroachment by agricultural production systems; over-harvesting of extractive products from reserves
Reduce habitat fragmentation	Minimize fragmentation (and interruption of gene flow and loss of certain species because remnant patches are too small to support them) by providing wildlife corridors along "bridges" of natural habitat	Encroachment of agriculture in an uncoordinated manner
Reduce species loss even when natural habitat still intact	Decrease dependence on agrochemicals by shifting to integrated pest management; incorporate crop rotation, more perennials, or both; promote "green" labels for environment-friendly production systems; devise management plans for harvesting wild plant and animal resources	Air and water pollution or both; excessive sedimentation of water courses; excessive hunting, fishing, collecting, or logging
Arrest the decline of biodiversity of crop species on farm	Eliminate fiscal and regulatory measures that promote homogeneity; explore aspects of traditional, polycultural systems that can be rehabilitated while still raising yields and income	Adoption of new farming practices, such as monocropping with a cereal crop, possibly propelled by fiscal incentives
Slow or prevent a decline in biodiversity within species	Support research on traditional varieties that can achieve high yield; support research on modern varieties that may be replaced frequently (biodiversity over time) but are less dependent on agrochemicals to achieve high yields; promote heterogeneous crop varieties rather then genetically pure varieties; provide incentives for both modern and traditional varieties; provide eco-labeling of products certifying that they come from traditional varieties	Release of modern varieties and application of agrochemicals to protect them, possibly propelled by fiscal incentives; adoption of intellectual property rights

Source: Author's compilation.

from genetics, botany, agronomy, ecology, and the social sciences—need to be tapped to understand the dynamics of genetic erosion and to devise appropriate strategies to manage agrobiodiversity (Brush 1994). The Philippines national agricultural research program is at the forefront in this regard: ethnobotanical projects have been launched recently to study how communities manage and conserve plant genetic resources (FAO 1996a: 41). And the M. S. Swaminathan Research Foundation in Madras, India, has developed training modules on biodiversity indexing in agriculture for use on farms. The foundation is also training rural youth for the Agrobiodiversity Conservation Corps, which helps to conserve and monitor agrobiodiversity at the landscape level.

Monitor Agricultural Projects for Impacts on Biodiversity

Few agricultural projects traditionally incorporate performance indicators with respect to impacts on biodiversity. Even when agricultural projects are designed to be "green," the monitoring of performance indicators should be incorporated in the periodic evaluation of them (table 4.1). The importance of putting in early warning systems to alert citizens and policymakers about rates of genetic erosion is now widely recognized (FAO 1995).

Expand the Scope of Parks and Reserves to Include Agrobiodiversity

Most efforts to conserve wild areas focus on places with spectacular scenery or showcase animals and plants. In most cases parks and reserves are never set up because they contain species or populations of agricultural interest. If they happen to contain near relatives or wild populations of crops, it is usually by default rather than by design.

A few countries, however, recognize the importance of setting aside reserves because they contain biodiversity of direct relevance to agriculture (FAO 1996:36; Smith and others 1992):

- Mexico has established a reserve to safeguard the population of a perennial maize.
- Germany uses its system of nature reserves to conserve relatives of apples and pears.
- Bulgaria and Turkey have recently undertaken projects to conserve the genetic resources of several cereal, forage, and medicinal plants *in situ*.
- Israel has conducted pioneering research on strategies for the *in situ* conservation of wild populations of emmer wheat, one of the earliest domesticated forms of the crop.
- Sri Lanka has set aside areas with potential agrobiodiversity value, including promising fruit species in the forest.

CHAPTER 5

Strengthening Institutions and Technology Delivery

The agricultural research and extension systems in many developing countries are often weak and in many cases employ top-down research and development approaches that typically ignore local agrobiodiversity and may promote the destruction of biodiversity. Thus the issue is not just increasing support for agricultural research and extension systems; it is also helping to reform those systems so that they are more effective and systematically incorporate biodiversity concerns in their work. Revamped approaches to extension could play a critical role in promoting more biologically and genetically diverse agricultural systems, provided that they are equipped with adequate information tailored to the areas in which they work.

Education is another broader issue related to institution building and outreach. People at all levels, from farmers to government officials and staff at nongovernmental organizations (NGOs), need to be reached with information about best practices in agrobiodiversity. Given the relative newness of agrobiodiversity as a vital concern, much work remains to be done in educating decisionmakers about what is involved in conserving and better utilizing biological resources for agricultural intensification.

Agricultural Research: Elements of the Emerging Paradigm

Ultimately, it is the farmers, ranchers, and pastoralists who will determine how much biodiversity survives in the coming years and how agrobiodiversity can be better managed. In some cases locals have already honed sensible practices, and development programs can draw on this indigenous knowledge (Pichn and Uquillas 1996). Indigenous knowledge can help identify local varieties with greater commercial potential and can point to valuable plant resources in forest and other habitats that are exploited by gatherers (Moock and Rhoades 1992; Rhoades 1997). Yet agricultural research and development programs often ignore the ethnobotanical knowledge of locals.

Tap Indigenous Knowledge Systems

Canada's International Development Research Centre (IDRC) is one development organization that is promoting ways to enrich the agrobiodiversity of cultivated areas by incorporating indigenous knowledge. One such initiative at IRDC is the Community Biodiversity and Conservation Program (CBDC) that targets farmer breeders in parts of Africa, Latin America, and Southeast Asia.

Several of the international agricultural research centers are also exploring ways to improve the management of agrobiodiversity through greater involvement of farmers in research design. Traditionally, the international centers work with national programs, rather than with the farmers themselves. That distinction does not always hold up, especially in the economic and social science departments of the international centers that often work in partnership with national programs to survey farmers' needs and to incorporate feedback from farmers into technology research and development. On one level the international centers have been heavily involved in the spread of high-yielding varieties in developing countries, which in turn has reduced local agrobiodiversity in some areas. But the international centers can also play a role, as exemplified by the International Center for Tropical Agriculture's (CIAT's) hillside program, in incorporating farmers' input in the design and implementation of agricultural technologies, a process that can lead to greater valuation of local agrobiodiversity. Several of the crop-oriented international centers now promote participatory plant breeding with farmers.

An impressive number of initiatives are under way worldwide to promote the conservation of traditional varieties and local breeds in their natural settings rather than in genebanks. Much work needs to be done, however, in understanding how local people can help preserve agrobiodiversity *in situ*. An assessment of lessons learned from such experiences would be timely since they involve a wide range of institutional actors, including NGOs, community organizations, national agricultural research programs, and some international centers—especially the International Plant Genetic Resources Institute (IPGRI). The benefits and drawbacks of the *ex situ* approach to conserving the genetic resources of crops and livestock are well documented, but much less is known about the long-term implications of *in situ* conservation programs for crop varieties and local breeds.

Enhance Crop Genetic Diversity

Agrobiodiversity can be enhanced along two dimensions: increasing genetic diversity within species and deploying a wider range of crops. Markets tend to streamline the number of crop varieties deployed in the field. This is to be expected and is sustainable as long as the supporting genetic pyramid is sufficiently large and well-evaluated. For example, it is often pointed out that maize production in the Unites States, a multibillion dollar crop, rests on only a handful of genetically similar hybrids. But that does not mean that the genetic base of the commercial crop is narrow. Maize breeding programs in the private and public sectors in the United States maintain impressive collections of well-evaluated material from which they can develop new varieties relatively quickly.

Such is not always the case in many developing countries. When modern varieties are imported, they may not hold up for long and no breeding program may be in place to develop modern varieties better adapted to local conditions. In such cases the more judicious mix of modern and local varieties is a safer course for raising agricultural productivity.

Another way to promote biodiversity on agricultural landscapes and to enhance the risk-aversion strategies of farmers is to encourage crop diversification. Of the roughly 7,000 plant species that are cultivated or gathered by people for food, only a handful dominates food production worldwide. A total of 30 crops account for 95 percent of the energy and vegetable protein consumption of humanity (FAO 1996a: 8). Commodity programs typically focus on a handful of crops, often totally neglecting "minor" crops. Yet some of the lesser-known crops may hold the key to turning food production around in some regions, especially in hunger-plagued Africa (Vietmeyer 1996). Only a small fraction of the world's half-million plant species have been screened for their economic potential.

The policy implications of the prevailing underutilization of biodiversity are clear: support for the major commodities needs to be maintained, but a relatively small investment in lesser-known plants could produce major payoffs and would help stem the loss of biodiversity. When priorities for crop research are being established, therefore, consideration should be given to underutilized species so that they are not further marginalized (FAO 1996a: 9).

Specific measures that can be adopted by crop-breeding programs to promote greater species and genetic diversity include the following:

- Focus more effort on location-specific research in crop breeding because it tends to increase agrobiodiversity between sites, a practice already under way at a number of agricultural research institutes, including the International Center for Agricultural Research in the Dry Areas (ICARDA), based in Aleppo, Syria.
- Incorporate farmers in the breeding process as active partners rather than as passive testers of improved varieties and prototypes.
- Breed heterogeneous varieties of cross-pollinated crops.
- Adopt gene rotation as a means of staying ahead of disease and pest pressure.
- Develop multilines that are agronomically similar but contain different genes conferring pest and disease resistance.
- Develop a number of varieties that can be grown together in different farming situations, rather than the current pattern of promoting super varieties over vast areas.
- Support research on potentially valuable traits in wild populations and near relatives of crops and livestock.

Approaches such as these increase the up-front cost of breeding, but may save money—and certainly biodiversity—in the long run. More research is warranted, however, in the hard tradeoffs that will be involved as farming systems in different areas intensify. Economists can employ models, particularly linear programming models, to predict the yield increase and expect a windfall in terms of income for given input levels. But it is much harder to calculate the value of biodiversity saved from alternative approaches. How much biodiversity loss is "acceptable" in the interest of boosting yields?

Redouble Support for Taxonomists: Unsung Heroes of Biodiversity Work

The painstaking work of sorting out species—systematics—is often perceived as one of the least glamorous areas of biological research, yet it is one of the most vital. For much of the general public, as well as policymakers, the work of taxonomists is little understood or appreciated. Images of scientists shuffling through sheets of dead plants in mothballed scented cabinets come to mind. But an understanding of relationships between species is essential to efforts to conserve and better utilize biodiversity (Campbell 1989; Harlan 1984). Taxonomy is not only fundamental to the continuous process of enriching the crop gene pool, but is also essential for the identification of suitable biocontrol agents in integrated pest management (Claridge 1991). And taxonomists are at the cutting edge of some biotechnology work. Powerful new taxonomic tools are now being used to sort out species and genetic variation within species, such as DNA fingerprinting with restriction fragment length polymorphism (RFLP) and polymerase chain reaction (PCR)—PCR being more familiar to the general public because of its extensive use in crime detection work. RFLP began to be used to sort out plant germplasm in the 1980s, while PCR technologically only became available in the 1990s. Both techniques are now used in the laboratory to obtain a better handle on genetic variation within species (Bisby and others 1995).

Another exciting area of work in systematics is the use of paratoxomists, the equivalent of barefoot doctors when it comes to sorting out species. Rural people often have intimate knowledge of plant resources and their natural history. They can therefore be quickly trained to do the preliminary collecting and sorting of materials, thereby saving time and money for formally trained taxonomists. This approach has been tried successfully in several tropical forest regions where the diverse plant life has been little studied.

Diversify Approaches to Conserving the Genetic Resources of Crops and Livestock

A balanced approach to conserving crop varieties and livestock breeds will best serve the needs of farmers as they intensify their production systems. In the past the debaters of how to best conserve the genetic diversity of crops and livestock have been largely divided into two camps: those that favor *ex situ* collections in genebanks, and those who argue for *in situ* collections. Both *ex situ* and *in situ* approaches have their merits and drawbacks, and the appropriate balance between them will vary according to local conditions.

Without delving into all the intricacies of genebank and *in situ* approaches to conservation, a few salient points warrant attention:

- Collections in many existing genebanks have not been properly evaluated, thereby impairing their usefulness.
- Many accessions at genebanks, even in developed countries, are losing their viability. Funds are lacking, however, to regenerate many of these materials.
- Infrastructure at many genebanks is inadequate because freezing equipment needs repair or replacement, no back-up generators are in place, and curators lack computers to enter "passport" and evaluation information in databases.

The existing global system of genebanks therefore warrants strengthening as part of an overall, diversified strategy to conserve crop genetic diversity.

With *in situ* conservation the issue is how to preserve habitats while still allowing some harvesting of products. In some cases multiple-use reserves can harmonize the goal of conserving wild populations or crop plants and their near relatives or the equivalent with domesticated animals, but in other instances the overharvesting of plant and animal resources may impair the ecosystems. The main point is that reliance on genebanks and reserves alone to safeguard the genetic diversity of crops and livestock is unwise.

While genebanks and *in situ* conservation in reserves and in farmers' fields have important roles to play in safeguarding the global heritage of crops and livestock, specialty markets can help keep traditional varieties and breeds in production. Furthermore, ecotourism with a new twist—agrobiodiversity—might also encourage some farmers to maintain interesting and unique crops and livestock on their properties.

Training and Extension

Many kinds of training programs and technology delivery approaches can be used to bring know-how and improved practices to farmers.

Empower People with Knowledge to Manage and Conserve Agrobiodiversity

A broad array of training courses is needed to promote more biodiversity-friendly agriculture. Short courses are needed for farmers, individuals, and organizations involved in disseminating information, research administrators, and development officers. The Bank could offer in-house courses for task managers, while the World Bank Institute (WBI) could promote training opportunities in client countries. Agrobiodiversity instruction modules could also be developed at international agricultural research centers, national agricultural research programs, universities, and botanic gardens in developing countries. The Global Plan of Action approved at a recent international technical conference on plant genetic resources (FAO 1996b) calls for stepped-up training in such areas as taxonomy, population biology, ethnobotany, and ecoregional and agroecological surveying.

In addition to training courses, information on agrobiodiversity issues could be posted on the Internet. While few farmers in developing countries have access to computers, many national programs and all international agricultural centers enjoy access to the Internet. Furthermore, most NGOs, government agencies, and development organizations are either already linked to the Internet or soon will be. Websites could be set up to open doors to information on agrobiodiversity issues, conferences, and workshops. Some "meetings" could be held on the Internet through chat groups, and videotaped conferences can now be posted live on the Internet.

Diversify Approaches to Technology Delivery

For the most part government-run extension services do not operate efficiently. In many cases they are either pushing the wrong technologies or they rarely visit the field. Even in industrial countries extension services are often behind the private sector. Given the mixed record of extension services, it would make sense to pursue other or parallel means to bring know-how and improved practices related to agrobiodiversity to farmers.

One such approach is using the farmers themselves as a springboard to launching more biodiversity-friendly agricultural practices. By training small groups of farmers and providing them with modest logistical support, it is often possible to reach a much larger target group than with conventional extension agents. The state extension service in Turkey used this farmer-to-farmer approach to disseminate chickpea and lentil seeds among growers who were reducing fallow on the Anatolian Plateau (Wallis 1993). In Indonesia the farmer field school has been instrumental in disseminating IPM approaches to controlling rice pests. Self-help farmer groups embody the advantage that they are self-motivated to provide extension services and they use existing interaction networks among growers, seed suppliers, and produce buyers.

Another approach that warrants closer scrutiny is harnessing the private sector in extension. Too often this approach is dismissed because it purportedly only works for the "richer" farmers. But even the poorest farmers are willing to pay for technology or services if they improve their lot. In Madhya Pradesh in central India, the Soybean Processors Association of India and farmers cooperatives provide seed and technical advice to farmers (Wallis 1993).

NGOs are playing a valuable role in disseminating sustainable agricultural practices in many parts of the developing world. Such organizations range from church to green and social-issue groups. Unfortunately, little analysis has been done on the record of NGOs in agricultural extension. It would be helpful if an impartial, lessons-learned exercise was carried out for the benefit of all those concerned with agricultural intensification. NGOs have many strengths, including their close contact with farmers and their ability to make and implement decisions quickly, but they also suffer from limitations, such as their limited coverage and generally weak links to research. For this reason parallel approaches to extension work need to be pursued, rather than attempting to rally the research and development community behind the latest fashion in technology dissemination.

Quarantine: Forgotten Link in Sharing Biodiversity Resources

Quarantine services worldwide are generally understaffed and underfunded. Why is further investment in such services justified given competing demands for other institutions involved in agricultural research and development? Because weak quarantine services can impair the vital exchange of crop and animal genetic resources or allow diseased material to slip through, thereby imperiling efforts to intensify agriculture. Quarantine officers with insufficient information or training sometimes condemn imports of seeds and other plant material to the chagrin of crop breeders (Plucknett and Smith 1989).

Ways to increase the efficiency of quarantine services worldwide include:

- Develop CD-ROM materials for quick access to information on plants and known diseases and pests associated with them
- Equip quarantine services with computers with CD-ROM drives
- Create one or more websites for use by quarantine officers to help them gain background information on plant or animal materials in question
- Create "quarantine support" groups to link taxonomists, plant and animal pathologists, and quarantine officers by e-mail
- Provide on-going training opportunities for quarantine officers so that they are more familiar with emerging issues in their work area
- Streamline the paperwork involved in obtaining phytosanitary certificates so that delays are reduced, but without impairing the integrity of the service.

CHAPTER 6

Fine-Tuning Fiscal and Regulatory Environments

Some of the major constraints to farmers adopting more environmentally friendly agricultural practices can be traced to distortions in the fiscal and regulatory environments in which they operate. Furthermore, inappropriate fiscal policies are driving habitat degradation in several agricultural settings on virtually every continent. A wide assortment of credit and tax regulations either prevent farmers from using greater biodiversity in their operations or accelerate wanton destruction of natural habitats (table 6.1).

Some points of intervention in the policy arena are explored here. Policy interventions that are appropriate for a given country or region will vary widely according to such factors as macroeconomic policies, trade relationships, and the degree to which land reform may have been pursued. Issues explored briefly here include incentives for tapping niche markets, security of land tenure, and trade and intellectual property rights.

Tap Market Opportunities and Employ Specially Targeted Credit Programs

Markets are just as important in driving technology change on the farm as are fiscal policies and the regulatory environment. Little hope exists for saving much agrobiodiversity unless it is valued by farmers. The importance of agroindustry as a means to help diversify farmlands is one approach, but the tapping of market opportunities involves a broader set of initiatives. Scope exists for capitalizing on market opportunities to promote diversification on the farm, thereby increasing agrobiodiversity and possibly reducing the need for heavy applications of agrochemicals associated with monocropping.

Business opportunities abound for exploiting niche markets for specialty produce. In many cases no government intervention is needed at all. For example, similar approaches are already working successfully for some ancient, heirloom cereal crops, such as spelt wheat, which have been recently introduced in some breakfast cereals. Several businesses have emerged in Europe that specialize in the products of rare or endangered breeds, and their examples could be followed elsewhere (box 6.1).

Although green markets may have been oversold in some cases, agrobiodiversity can be promoted by addressing the concern of consumers for products that do not require massive doses of agrochemicals to grow them. Green farming techniques promote soil biodiversity and often incorporate multiple cropping and the deployment of numerous varieties as a means to combat pests and diseases. In Costa Rica, for example, it is the small-scale coffee growers, rather than the larger plantation owners, who are pursuing the grow-

Table 6.1 Fiscal policies that constrain adoption of more biodiversity-friendly agricultural practices

Distortion	*Remedial measure*	*Relevant Bank instrument*
Credit that is geared only to exotic, high-performance livestock breeds	Make credit available for local as well as modern livestock breeds—at the discretion of the farmer; create incentives to maintain local breeds whenever appropriate	Country assistance strategies (CASs), agricultural sectoral reviews, agricultural projects, and policy dialogue
Credit that is available only for modern, high-yielding varieties	Make credit available to plant traditional as well as modern varieties, at discretion of farmer	CAS, agricultural sectoral reviews, agricultural projects, and policy dialogue
Credit that is available for the purchase of pesticides, but not for other, less toxic approaches to pest control	Make credit available for integrated pest management approaches	CAS, agricultural sectoral reviews, agricultural projects, and policy dialogue
Heavily subsidized fertilizers that encourage over-application and pollution of water supplies, thereby impairing aquatic habitats	Reduce or eliminate subsidies for fertilizers, encourage deployment of crops or varieties that are productive with little if any fertilizer, increase support for research on Biological Nitrogen Fixation systems and inoculation with mycorrhizae	CAS, agricultural sectoral reviews, agricultural projects, environmental assessments (EAs), environmental adjustment loans, and policy dialogue
Heavily subsidized irrigation water that encourages inefficient use, excessive runoff impregnated with agro-chemicals, and water diversion for irrigation	Reduce or eliminate subsidies for irrigation water; invest in more efficient irrigation technologies, such as drip irrigation; switch to crops or develop varieties that produce good yields with little if any irrigation	CAS, agricultural sectoral reviews, EA, environmental adjustment loans, and policy dialogue
Fiscal incentives for monocropping or a single land use system, such as cattle raising, that tend to promote the homogenization of landscapes	Encourage a more level playing field for a variety of land uses, promote crop diversification	CAS, agricultural sectoral reviews, agricultural projects, and policy dialogue
Higher tax rates for unproductive land that often encourages unnecessary habitat conversion	Remove tax penalties for landowners who wish to maintain land in forest or other natural vegetative cover	CAS, agricultural sectoral reviews, agricultural projects, EA, national environmental action plans (NEAPs), environmental adjustment loans, and policy dialogue
Insecure land tenure that promotes clearing in order to establish "ownership"	Promote the security of property and resource use rights by local inhabitants	CAS and policy dialogue

Source: Author's compilation.

ing market for organic coffee in North America and Europe. Several coffee brands in Europe, Canada, and the United States buy directly from cooperatives whose members eschew insecticides, herbicides, and even fertilizers on their farms. Instead, they opt for mulches, shade trees that fix nitrogen, and intercropped fruit trees that help suppress pest populations and maintain a congenial microclimate for soil microorganisms (*The Economist*, 1 February 1997: 42). Coffee produced "the old fashioned way" commands a 20 percent premium over the price of mass-produced coffee that employs no shade trees and a gamut of purchased chemicals to maintain productivity. Green labeling is increasingly common, especially in Europe and North America. And in many developing countries, such as Brazil, markets are developing for green products among more affluent consumers in urban centers.

Certification programs to encourage green farming and the use of threatened traditional varieties and livestock breeds is another way to promote more environment-friendly agriculture. The European Union is at the forefront of such efforts. The Council of the European Union has passed a number of regulations to help harmonize agricultural production with

Box 6.1 A renaissance of local breeds

In the United Kingdom Heal Farm markets quality traditional meats based on rare, indigenous breeds and traditional recipes. Farmers are again turning to one of Britain's oldest cattle breeds, the White Park, because it is more efficient at converting feed and is hardier and calves more easily than dominant beef breeds. In France, another important center of diversity of livestock breeds, a breeder of endangered Basque pigs from the Pyrenees has established a business selling meat from that unique breed. And in Spain much appreciated *jabugo* is produced exclusively from the meat of dark and hardy Iberic pigs. Special credit lines could be made available to small businesses to accelerate this process in many parts of the world, especially in centers of diversity for livestock breeds.

minimal damage to the environment in general and to agrobiodiversity in particular. For example, Council Regulation No. 2078, passed in 1992, provides financial assistance to farmers who adopt or continue a wide variety of agricultural practices that are compatible with the environment and the "maintenance of the countryside" (FAO 1996a: 39). Under Council regulations some farmers are eligible for yearly grants if they cultivate varieties that are adapted to local conditions but are threatened by genetic erosion. Another council regulation establishes a certification scheme for agricultural products derived from old cultivars.

Such programs should not just be targeted at growers who cater to the discriminating tastes of well-to-do consumers. In most consumer markets in industrial countries organically-grown produce is usually more expensive than mass-produced vegetables using modern, intensive methods. Ways need to be found to effectively grow vegetables with fewer if any pesticides, while maintaining high productivity and dealing effectively with pest and disease problems. This is a particularly challenging task in the humid tropics. However, the potential benefits include reduced costs to the farmer from the reduction in chemical inputs. Such savings translate into greater profitability.

Credit can be a powerful tool to promote the better use of agrobiodiversity, but it should be used judiciously. Excessive reliance on credit to achieve a larger mix of crops in a given area would be unwise. If farmers depend heavily on government subsidies in order to enrich their crop mixtures, such hot-spots of agrobiodiversity are likely to prove ephemeral. Rather, the selective use of credit to encourage the introduction of new crops or promote the greater utilization of local, so-called minor crops makes sense in some situations, provided that chronic dependency on subsidies does not ensue.

Some would argue, with good reason, that credit programs tend to trigger further distortions in the production and marketing of goods. If credit for biodiversity-friendly agricultural technologies is deemed unwarranted, then at least such technologies should operate on a level playing field. Targeted credit enhances agrobiodiversity in some crop and livestock systems by providing the wherewithal for crop diversification. For example, the establishment of credit lines to promote agroindustry can create markets for new crops. We have seen how this has helped with crop diversification in the case of soybean production on vertisols in central India. With greater opportunities to market produce, farmers have more options for growing crops. The opening of fruit-processing plants in several parts of the Brazilian Amazon has spurred the diversification of farms for example, toward commercial agroforestry.

When designing an agricultural project, then, the following checklist focusing on the private sector needs to be addressed:

- Have any market studies been conducted on the potential of heirloom varieties or local breeds?
- Does the project rely on fertilizers and the further development of irrigation? If so, has any analysis been conducted on whether local varieties and breeds are more efficient users of fertilizer or water?

- If modern varieties are to be deployed, to what extent can green farming practices reduce the need for purchased inputs, such as fertilizer and pesticides?
- Is an incentive structure in place to increase the options for farmers who may choose to continue cultivating traditional varieties and raise local livestock breeds?

Taxation and Land Ownership

In some regions, such as many parts of Latin America, landowners are taxed at a higher rate if they leave their land in forest. Precisely the opposite should occur: forested land should be exempt from taxes and, in some cases, landowners with particularly valuable habitat or endangered species should be given tax breaks for leaving that land out of production.

Insecure property rights can also trigger unwarranted deforestation. Small- and large-scale operators alike often clear substantial tracts of tropical forest in Latin America to establish or reassert a claim to land. Measures that can be taken to reduce tension over the land and any resulting habitat destruction include the following:

- Address socioeconomic problems in source areas that are driving migrants into areas where contests over land and resulting violence and forest clearing are increasing.
- Legitimize land ownership by sorting out those who have lived in the area for a long time or those who otherwise have credible claims to the land.

Trade and Intellectual Property Rights

In general, the fewer the trade barriers the greater the chances that cash crops will be grown in areas with a comparative advantage. The more trading opportunities, the greater are the options for farmers to diversify their operations. Tariff barriers tend to hinder the greater integration of biodiversity in agriculture and should be reduced or removed whenever feasible. The trend toward the lowering and eventual elimination of trade barriers is well under way, as witnessed by the emergence and growth of regional trade associations; such trends warrant continued support. The World Trade Organization is a useful forum for promoting this cause, and the agrobiodiversity dimension to trade issues deserves fuller recognition at trading summits.

The issue of intellectual property rights is complex, and it is not possible to come out with a "position" with respect to agrobiodiversity. Suffice it to say that the issues warrant careful tracking by policymakers: on the one hand, assigning IPR to germplasm will enhance its value and therefore create an incentive for its conservation. On the other, varietal protection and patents may slow or even halt the exchange of crop and animal genetic resources, thereby impairing efforts to intensify agriculture. If intellectual property rights are more widely respected and mechanisms are in place to recompense all parties that have contributed to the improvement of crops and livestock, it would facilitate the exchange of both improved and primitive plant materials.

Chapter 7

World Bank's Role and Leverage

A number of instruments are available within the Bank to help mainstream biodiversity in agricultural development. Before such specific levers are identified, however, the issue of mainstreaming biodiversity should be placed within the context of the Bank's changing relationship with its clients. First, although the Bank remains a significant supplier of financing to developing countries, policy dialogue and technical advice are increasing in importance. Private sector financing in developing countries is increasing, so the relative importance of the Bank as a supplier of loans is diminishing. The Bank is increasingly seen as a leader in providing ideas and fresh approaches to development rather than merely as a financing pipeline. Second, while legally the Bank's clients are national governments, since they are the guarantors of loans, the Bank increasingly seeks dialogue and contact with the ultimate beneficiaries—in this case farmers and livestock raisers. Third, the Bank is engaging in constructive partnerships with other players on the development stage, such as NGOs. In this manner the Bank is able to enrich its work with other perspectives and serve as a means to get closer to the beneficiaries of the Bank's work.

The role of governments and international development institutions is to identify and help remove constraints to the better use and safeguarding of biodiversity. Some of these constraints include, but are not limited to, the following:

- Inadequate pricing and marketing opportunities
- Insufficient agroindustry for value-added processing
- Distorted credit and land tax policies
- Lack of knowledge and technologies due to inadequacies of the agricultural research system
- Suitable technologies available but inefficient extension systems for disseminating improved practices
- Lack of inputs.

The various instruments at the disposal of the Bank to influence the pace and manner in which biodiversity is mainstreamed into agricultural development include:

- Country assistance strategies (CASs)
- Economic and sectoral reviews, especially in agriculture and forestry
- Agricultural projects, including extension projects
- Environmental assessments (EA)
- National environmental action plans (NEAPs)
- Environmental adjustment loans
- National biodiversity strategy and action plans (BSAPs)
- Policy dialogue.

Country Assistance Strategies

The country assistance strategy (CAS) is the single most important instrument for modifying policies at the national level so that they better promote the conservation and use of agrobiodiversity. In the CAS features of a country's fiscal incentive and regulatory environment that are responsible for destructive land use activities typically are identified and remedial measures outlined. By identifying such distortions and suggesting changes, the chances of alleviating pressure on the remaining wilderness are improved. The CAS also typically addresses ways to arrest or slow the degradation of the natural resource base.

Several models exist for how biodiversity conservation can be addressed in the CAS, particularly those of Brazil, Mexico, and Nepal (World Bank 1996). The relevance of managing biological resources for more productive and sustainable agriculture warrants special attention in the CAS, especially in regions of megadiversity for crops and livestock (box 7.1).

Economic and Sectoral Reviews

Most of the important policy decisions affecting biodiversity are taken at the level of individual sectors, such as agriculture, infrastructure, energy, and transport (World Bank 1995a: 20). The Bank's recently launched Global Overlays

Box 7.1 Crop and livestock megadiversity centers

One hundred and fifty years ago the French biogeographer Alphonse DeCandolle observed that the greatest concentration of genetic diversity for a crop is likely to be found in the region in which it was domesticated. Our understanding of the diversity of crops was furthered in the early part of this century by Nikolai Vavilov, the great Russian crop breeder and geneticist. Vavilov proposed a number of centers of origin for our major crops, spanning parts of tropical America, Africa, the Middle East, and South and Southeast Asia. Discussion of crop "megacenters" tends to focus on the global staffs of life—wheat and barley (domesticated in southwest Asia)—and rice, which was brought into cultivation in Southeast Asia. The most widely cultivated root crop—the potato—was domesticated in the Andes, and more than 2,000 varieties of the tuber crop are cultivated in Peru alone.

While the major food crops would certainly warrant particular attention with respect to conserving agrobiodiversity, many countries outside of Vavilov's centers of crop origins also contain a significant diversity of crops and varieties. A megadiversity approach to conserving the genetic diversity of crops and livestock, at least in their conventional forms, could be a misleading approach. The Amazon Basin, for example, is home to more than 20 perennial fruit and nut crops, some of which have reached global importance, such as rubber and cacao, yet it falls outside most maps of megacenters of crop domestication and diversity. The "lost" crops of Africa can be found in virtually every country on that continent, and the neglected crops may well hold the key to overcoming chronic food shortages there.

The Global Plan of Action promulgated at the Leipzig conference on plant genetic resources sponsored by the U.N. Food and Agriculture Organization recommends that countries prioritize areas with high levels of agrobiodiversity for conservation and management. The success of the conference, which was attended by delegates from 150 nations as well as NGOs, is a clear indication of the increasing awareness of and greater consensus on how to deal with the complex issues of safeguarding the equitable use of plant resources for agriculture. But we still need to know much more about patterns of agrobiodiversity and make them available in user-friendly formats using geographic information system (GIS) techniques. Until we know much more about the agrobiological resources of all countries, especially those in the tropics, the cautionary principle should apply. No country should be written off as unimportant in terms of crop or livestock genetic resources. Even arid regions contain pockets of surprisingly high levels of biodiversity, and are often rich in endemic species.

Program seeks to extend the analysis of sector policy options to include global environmental impacts. In conjunction with partners in the donor community and NGOs, the Global Overlays Program is designed to help identify policy and investment measures to address biodiversity concerns.

Agricultural and Rural Development Projects

A survey of the Bank's agricultural portfolio revealed that biodiversity was rarely a component of agricultural projects (Jana and Cooke 1996). Considerable scope thus exists for systematically incorporating biodiversity issues in more of the Bank's agricultural work. Similarly, agricultural sector reviews could pay more attention to promoting the conservation and fuller use of biodiversity. Cross-sectoral linkages are important in biodiversity use and conservation, so sectoral reviews in forestry, energy, and health could also be sensitized to implications for agrobiodiversity. The Bank can play a role in identifying ways that client countries can better coordinate policies and programs between different sectors to promote more biodiversity-friendly agriculture.

Environmental Assessments

The Bank has had a systematic process for screening projects for their potential impact on the environment since 1989. Traditionally, the environmental assessment process within the Bank and other development organizations has focused on such green issues as impacts on endangered habitats and species. While such concerns are certainly warranted, the environmental assessment procedure that is applied to all Bank loans should be expanded to include agrobiodiversity. A separate agrobiodiversity screening procedure is unwarranted, but the agrobiodiversity dimension needs to be explicitly addressed in the environmental assessment.

The Bank has established policies for the protection of cultural heritage sites, wildlands, and the rights of indigenous people. Now would be an opportune time to broaden the scope of the environmental assessment by including such aspects as:

- Concern for the status of domesticated or managed biodiversity during screening, especially in areas where polyculture is common and many unique varieties or localized breeds are found
- Attention to the dangers of agricultural practices that can harm soil microorganisms that are essential to the health of agroecosystems.

For example, an agricultural development project scheduled for an area where an important crop originated, or where many so-called minor crops were domesticated, is likely to contain primitive forms that contain valuable genes. Such areas rich in agrobiodiversity might therefore be classified as an A for project purposes; they warrant special scrutiny and monitoring. Similarly, an agricultural project that might provoke land use changes and the impingement of farming activities on habitats that contain wild populations or near relatives of crops and livestock might also receive an A rating. While an A rating can slow project preparation, the ultimate costs of not heeding precautions are likely to be greater.

National Environmental Action Plans

National Environmental Action Plans (NEAPs) generally ignore the importance of agrobiodiversity. Of 46 NEAPs reviewed for a Bank study (World Bank 1996), only about half mention biodiversity loss as a major environmental concern. NEAPs tend to focus on protected areas and natural resource degradation, whereas the explicit inclusion of agrobiodiversity concerns would strengthen the case for conservation. Less than half of the Bank's client countries have drawn up NEAPs, in part because they are only suggested rather than required by borrowers of International Bank for Reconstruction and Development funds. As of June 1996 only 17 of 49 International Development Association borrowers, which are required to draw up NEAPs, had actually done so. It appears likely, nonetheless, that more NEAPs will eventually be prepared, because so much scope exists for incorporating agrobiodiversity concerns in future strategy plans. Experience with the implementation of environmental plans has shown that the involvement of all stakeholders is critical for their success (World Bank 1995c: 35), a lesson that should not be lost in efforts to better conserve and utilize agrobiodiversity.

National Biodiversity Strategy and Action Plans

As in the case of NEAPs National Biodiversity Strategy and Action Plans (BSAPs) have tended to overlook the value of biodiversity in cultivated or grazed areas, which account for much of the landscape in developing countries. BSAPs have been spurred by the 1992 Convention on Biological Diversity, which specifically mentions the importance of biodiversity for agriculture. BSAPs are relatively recent exercises, so the Bank and its partners are well positioned to influence the scope of such plans, which are an important vehicle for implementing the Convention on Biological Diversity. At present however, neither NEAPs nor BSAPs appear to have made much impact on development planning, either at the macroeconomic or sectoral policy level. In this case identifying an instrument for policy intervention is one task, whether it will be an effective lever is another matter. It therefore remains to be seen how useful NEAPs and BSAPs will be as mechanisms for promoting agrobiodiversity.

Environmental Adjustment Loans

Environmental Adjustment Loans, a relatively new instrument, provide opportunities for supporting such activities as *in situ* conservation of crops and their near relatives and reducing the off-site impacts of agriculture and livestock raising.

Policy Dialogue

Policy dialogue is part of all of the above instruments available to the Bank in shaping the manner in which biodiversity concerns are systematically incorporated into agricultural development. Other opportunities arise for exchanging ideas about appropriate policies and agricultural practices during the course of Bank business, ranging from visiting delegations from client countries to workshops, seminars, and annual meetings.

Chapter 8

Toward Implementation

This report has explored some ideas about how agrobiodiversity can be mainstreamed in agricultural development. This report, however, is only part of the process of attempting to put recommendations into practice at various levels from the farm to government agencies, NGOs, and international development organizations. Some suggestions offered here are still preliminary and warrant in-depth analysis and testing.

Several steps are required for making progress toward implementing recommended practices. To further refine sound practices for integrating biodiversity in agricultural development, it will be necessary to obtain a better appreciation of borrower perspectives on the issues and to assess in more detail "on-the-ground" experiences with agricultural intensification where biodiversity has purportedly been enhanced. Follow-up work is needed to visit apparently successful cases where biodiversity has been mainstreamed in agricultural development so that more hard data can be obtained to back up policy recommendations. Findings from location-specific case studies would bolster efforts to derive robust and generalized principles. Such work would also provide opportunities to interact with stakeholders at all levels of society in borrower countries in order to arrive at realistic recommendations for sound practices.

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