Evolving opportunities to integrate management of agricultural landscapes and ecosystem health: Sustainability by opportunity *

J. Dumanski1, S. Joffe2, E. Terry3, and C. Pieri4

1 Introduction

The intimate connections between economic growth and ecosystem health are becoming increasingly clear. Pursuing these concomitantly makes good business sense and provides for considerable growth opportunities. The only choices are short-term, economic gains versus long term prosperity. The debate between “jobs or the environment” is becoming a debate of the past.

Agriculture and related biology based land uses, including forestry and agroforestry, occupy major areas of the earth’s land areas. Vitousek (1994) estimates that currently about one-third to one-half of the earth’s non-glaciated land areas are regularly managed, and up to 70% receive some degree of human intervention. How these lands are managed and the nature of management systems impact directly on the health of local and even global ecosystems and the services derived therefrom. These sectors have both major opportunities and responsibilities to ensure healthy ecosystems, but their current performance leaves much to be desired. Also, even though there are major trends towards global urbanization, the proper husbandry of rural landscapes has huge consequences to the provision of quality environmental services, such as clean water, to urban dwellers.

In the years since the 1992 Rio accords, economic growth of $US 2.4 trillion and population growth of about 400 million have placed continuing pressures on the earth’s natural resources and ecosystems (Brown et al., 1998). Tropical forest cover, wetlands and other natural habitats have declined by 3.5%, carbon emissions have increased by 4%, while natural carbon sinks in soils and forests have been degraded or lost. As much as 10 million hectares of land are being lost annually to severe degradation; we currently consume about half of the available fresh water, and more nitrogen is fixed by humanity than by all natural sources combined. Each year about one thousand new chemicals are released for use without any knowledge of their biological or synergistic effects, but only a few are regularly monitored. About one-quarter of the bird species has been driven to extinction, and two-thirds of the global fishery is fully exploited or over exploited.

We are transforming the earth through land clearing, forestry, over grazing, urbanization, mining, trawling, dredging, and so on. We remove species through over exploitation, while adding new variations through biotechnology and other means. In these activities, we alter the major biogeochemical cycles, with impacts on the global climate, and increasingly on global life support systems. A statement from the Ecological Society of America (cited in Lubchenco, 1998) states that “environmental problems resulting from human activities have begun to threaten the sustainability of earth’s life support system. Among the most critical challenges facing humanity are the conservation, restoration, and wise management of the earth’s resources”.

For the first time in history, global populations are of such magnitude that how we manage the land impacts directly on the ecological services that support life on this planet. These services include purification of air and water, mitigation of floods and droughts, detoxification and decomposition of wastes, generation and renewal of soil and soil fertility, pollination of crops and natural vegetation, control of potential agricultural and forestry

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pests, dispersal of seeds, translocation of nutrients, and maintenance of biodiversity (from which humanity derives major agricultural, medicinal and industrial benefits), protection from harmful ultra violet rays, stabilization of climate and moderation of climatic extremes, provision of aesthetic beauty, and support of human cultures. The importance of the global environment and ecosystem health is not just an issue for the resource industries. Increasingly, it is viewed also in the context of human health, world trade, social justice and even national security (Lubchenco, 1998). As a society, we have never been at this point and we are unsure how to proceed.

Many of the problems arise from our penchant to control rather than live within the bounds of nature. In the process we create wastes and other excesses beyond the capacity of global and local ecosystems to absorb. Examples are soil erosion beyond the capacity to form new soil, CO\textsubscript{2} emissions beyond the capacity for carbon sequestration, pollution beyond the capacity of local ecosystems to filter the wastes, crop yields beyond levels of ecological baseline productivity, groundwater withdrawals beyond recharge capacity, and deforestation beyond sustainable yields. In most cases the problems arise with natural resources that are simultaneously viewed as depletable and renewable.

2 Opportunities through the international conventions

Agriculture has historically been a major contributor to environmental degradation, but under improved systems of land management, it could be a major partner in the environmental solution. Land management decisions by individual farmers have implications for many environmental goods and services\textsuperscript{1}, such as effects on habitats for fauna and flora, on a variety of ecological services, and on amenity or aesthetic values (Joffe et al., 2002). The impacts may arise directly on land managed for agriculture and livestock, or indirectly as a consequence of fragmentation and degradation of natural (less managed) habitats such as forests and wetlands. Many of the environmental benefits associated with sustainable land management will accrue locally and nationally. These include productivity effects such as pollination, biological control, nutrient cycling, soil conservation, etc, as well as off-site effects such as water regulation and supply, disturbance regulation, waste treatment, and flood control. Others are more clearly global, or at least ‘supranational’ in scope, such as climate regulation, conservation of genetic resources with potential value in plant breeding or pharmaceuticals, international tourism, and trans-boundary water-mediated effects. Sometimes it is essential to promote intensified uses in more favored areas to reduce pressures on marginal fragile environments.

Although the ecological functions are discrete, in practice the boundaries are far from clear cut. The global environmental benefits and costs are those for which the global community, through international agreements and nascent trading frameworks, has expressed a willingness to pay. The rationale is on the grounds that:

\begin{itemize}
  \item They would normally receive sub-optimal attention within a national accounting and planning framework,
  \item They are considered highly valuable or irreplaceable,
  \item There is considered to be an unacceptable economic or humanitarian risk associated with further depletion.
\end{itemize}

The three categories relate to (a) Biodiversity (which embraces all goods and services associated with terrestrial ecosystems); (b) Climate Change (to do with concerns about emissions of greenhouse gases); (c) International Waters (where the negative impacts of depleted water flow or quality have serious transboundary implications). In all cases, there are direct linkages between global environmental change and land management, as well as opportunities under the international agreements to generate funding to achieve these objectives. The main relevant United Nations agreements and financing mechanisms are:

\begin{itemize}
  \item Convention on Biological Diversity (CBD),
  \item Framework Convention for Climate Change (UNFCC),
  \item Convention to Combat Desertification (CCD),
  \item Global Environment Facility (GEF).
\end{itemize}

**Biodiversity and agriculture**: Biodiverse\textsuperscript{2} ecosystems have a fundamental role and importance in sustainable development and provide many important benefits. They often contain a variety of economically useful products that can be harvested or serve as inputs for production processes. In addition, they provide habitats for flora and fauna, and many key ecological services including those associated with nutrient cycling,
disturbance regulation, availability and quality of water for agriculture, industry, or human consumption, etc. Agriculture remains dependent on many biological services, such as provision of genes for improved varieties and livestock breeds, but also for crop pollination, soil fertility services provided by microorganisms, and pest control services provided by insects and wildlife. Conversely, sustainably managed agricultural landscapes are important to the conservation and enhancement of biodiversity. The term agrobiodiversity has been coined to describe the important subset of biodiversity that contributes to agriculture.

![Diagram showing examples of environmental benefits of sustainable land management: local, national, and global layers (from Joffe et al., 2002)](image)

**Climate change and agriculture**: The linkages between agricultural land use and greenhouse gases relate to land-use dynamics and management of rural landscapes. During the 19th century, rapid agricultural expansion, primarily in temperate regions, led to widespread clearing of land and losses of organic carbon in vegetation and soils. In recent years, deforestation in temperate regions has been reversed, but land conversions in the tropics has greatly expanded. This has become a major source of CO₂ emissions to the atmosphere, in the order of 1.6 Gt C or about 20% of total anthropogenic CO₂ emissions; the continuing net global loss of C from cultivated soils contributes approximately an additional 5% of anthropogenic CO₂ (Paustian et al., 1998). Also, agriculture contributes around 50% of anthropogenic CH₄ emissions globally, primarily from the rumen of livestock and from flooded rice fields, and about 70% of anthropogenic N₂O, largely as a result of nitrogen inputs (synthetic fertilizers and animal wastes, and biological nitrogen fixation) (IPCC, 1996).

**International waters and agriculture**: More than 200 river basins are shared by two or more countries, accounting for about 60 percent of the earth’s land area. For example, there are at least 54 rivers that cross or form international boundaries in Sub-Saharan Africa, and 10 river basins have drainage areas greater than 350,000 km², affecting 33 SSA countries and Egypt.

Many of these shared watercourses are subject to alarming rates of environmental degradation that have strong linkages with land and water management. For example:

- Water withdrawals from lakes and reservoirs, water diversions, upstream dams and lake reclamation for
agriculture and aquaculture, significantly depleting the size of the water bodies, destroying habitats for plants and animals and sometimes causing very high levels of salinization.

- Deforestation and land degradation in international watersheds such as the Nile, Niger, or Indus affect rainfall patterns, increase the range of local temperatures, and cause major variations in water flow and quality. Soil erosion leads to siltation and sedimentation of lakes and reservoirs, shortens their lifetimes, destroys aquatic environments, reduces the productivity of their ecosystems, and diminishes their flood control capacity.

3 Linkages between sustainable land management and the international conventions

Any measure of physical and biological sustainability must combine measures of productivity enhancement, measures of natural resource protection, and measures of social acceptability. Thus, it is essential to integrate concepts of those who focus on resource quality with those who emphasize economic productivity measures. Such an integrated approach is being developed as a Framework for Evaluation of Sustainable Land Management (FESLM) (Smyth and Dumanski, 1993).

The FESLM was developed through collaboration among international and national institutions as a practical approach to assessing whether farming systems are trending towards or away from sustainability. In this context sustainable land management (SLM) is defined as:

Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:

- maintain or enhance productivity/services;
- reduce the level of production risk;
- protect the potential of natural resources and prevent degradation of soil and water quality;
- be economically viable;
- be socially acceptable.

These factors are referred to as the five pillars of sustainable land management and they can be applied for sustainable agriculture. Performance indicators for each pillar are used for assessing the contribution of that pillar to the general objectives of sustainable land management. Thus, for any given agricultural development activity, sustainability can be predicted if the objectives of all five pillars are achieved simultaneously. However, as is the likely case in the majority of situations, only degrees of sustainability can be predicted if only some of the pillars are satisfied, and this results in partial or conditional sustainability. The recognition of partial sustainability, however, provides valuable direction for the interventions necessary to enhance sustainability.

The linkages between the pillars of sustainable land management, the agricultural challenges to achieve food security, and the international conventions are shown in Table 1. This shows that agricultural objectives, under food security, still emphasize productivity and economic returns, whereas the international conventions encompass environmental goods and services. This dichotomy, developed under the historic paradigm of economically driven national development and nonlimiting natural resources, is being challenged in many parts of the world. The evolving debate creates opportunities to better harmonize the common ground and to capture the synergy between sustainable land management and food production. However, this requires that agricultural systems recognize that sustainable systems must also ensure ecosystem health. Conversely, it requires that conservationists recognize that improved local, national, and global environmental management will not be realized without first securing economically viable rural economies.

<table>
<thead>
<tr>
<th>The Pillars of Sustainable Land Management</th>
<th>Productivity</th>
<th>Risk Management</th>
<th>Soil/water Conserv.</th>
<th>Economic viability</th>
<th>Social acceptability</th>
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<td>International waters</td>
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Capturing the mutually reinforcing interactions (synergy) between these two aspects, the biophysical and the social, is the major opportunity for achieving the concomitant objectives of improved food security and ecosystem health. An important premise is that farmers normally are keen to manage their land better if they know how, but their management choices are often constrained by outside influences, including financial, marketing, and other constraints.

3.1 Selected examples of concomitant benefits between agriculture and ecosystem health

Examples of natural resource improvements are becoming increasingly available, and much can be learned from the factors and processes that led to their success. In some cases, e.g., Brazil, millions of hectares have become more stable, productive, and sustainable under improved land management systems, whereas in others, e.g., Kenya, profound improvements in land quality have been made in local areas, but the technologies have not yet spread to large areas. In either case, success is triggered by two key components of true sustainability (El-Swaify et al., 1999):

- Resilience reflected in the inherent capacity of living systems, including soils, to regenerate themselves when suitably managed,
- Deployment of the latent skills and enthusiasm of rural people when adequately informed, supported and empowered.

**Parana, Southern Brazil:** A micro-watershed, integrated soil and water management program was adopted in 1987 as the basis for comprehensive state wide rural development. The basis of the program was to help local communities address their land management problems, while improving the economic viability of their operations. Local decision-making, planning, implementation and monitoring (participatory approach) was assured from the beginning. Integrated technology adoption (no magic bullet) was employed, based on conservation tillage and crop residue management, cover crops and crop rotations, fertilizer and lime applications. Agricultural cooperatives provided efficient marketing and reliable supply of required inputs. There was strong political support over the life of the program and funding was provided by the State and complemented by additions from the World Bank and others. Within five years, the program was working with local communities in 2100 small catchments, covering over five million ha, and 165,000 farm properties. After 10 years of close monitoring, it was shown that the program was successful in controlling soil erosion, while agricultural incomes and rural economies improved. Also, it was shown that reduced sedimentation of waterways and improved water quality alone more than paid for the cost of the program.

**Kakamega, Kenya:** This is a program to assist self-help groups of small resource-poor farmers to improve their livelihoods through soil conservation coupled with a strong marketing component in local and export markets to improve cash flow. The basic philosophy is that small-holder farmers can, with enhanced skills and their own enthusiasm, bring themselves out of poverty by making better use of the natural resources to which they have access, notably rain water, organic materials, and soils. Products are marketed under predetermined “Conservation Supreme” standards, and under the “Farmers’ Own” label, which enables the group to gain and retain market share. Since the start in 1993, 300 farm families in over 150 groups have joined the process and participation is expanding rapidly. It is promoted by a small non governmental organization, “Association for Better Land Husbandry”.

**“Gestion de terroirs”, Sahelian West Africa:** This approach evolved from the need to mitigate the serious impacts of land degradation and desertification on local livelihoods. The process introduced involves management of common lands by the community, under sets of locally adapted rules. The necessary steps are:

- Participatory diagnosis by local people to identify resource problems;
- Election of a village or community committee responsible for resource management decisions;
- Establishment of the committee’s jurisdiction;
- Preparation of a management plan, zonation, and allowable land uses;
- Implementation, monitoring, and evaluation.

The approach requires commitment to local decision-making, local diagnosis of problems, and creation of clear lines of responsibility. Although not universally successful, the approach deals up front with issues of equity, power-sharing, self-reliance, and community environmental management. The approach has become widely endorsed by national governments and many donors.

**Changar, northwest India:** The issues centered on severe land degradation, runoff, and erosion, especially
on common land and state forest lands, due to inappropriate management of pastures and forests. The consequences were decreases in productivity, and severe water scarcity in summer months. The project worked with local communities (570 villages with 140,000 people) on catchment-based development in the highly fragile, sediment hills in the western Himalayan foothills. The project used a combination of interdisciplinary measures focused on better land management, effective soil and water conservation, and community-based forestry and animal husbandry. Through strengthening community organizations in land management, the project contributed to the simultaneous economic development and ecological stabilization of the region.

The Catskill Watershed, New York: New York City’s water supply comes from a watershed in the Catskill mountains. In recent times, poor land management in the upper watershed and contamination from sewage, fertilizers and pesticides deteriorated the water quality to below EPA standards. The options were to build a super filtration plant at a cost of $6 to 8 billion, plus annual maintenance costs of about $300 million, or restore the ecosystem integrity of the Catskill watershed. The city chose to purchase the land in and around the watershed so that its use could be restricted (agricultural land uses that contributed to pollution were eliminated), and upgrade existing treatment plants for a total cost of between $1 to 1.5 billion. Thus an investment of $1 to 1.5 billion to restore ecosystem functions resulted in a saving of $6 to 8 billion in physical capital. The project is expected to give a rate of return of 90 to 170% in a payback period of four to seven years (Chichilnisky and Heal, 1998).

These few examples illustrate the opportunities that can be gained when the objectives of economic development and ecosystem maintenance are combined. In all cases, successes were achieved by building on the knowledge and capacity of rural communities to manage their resources better. New technologies were introduced in most cases, but only under conditions of local decision-making. The international conventions provided an enabling policy framework and often incremental funding to cover initiation and transaction costs. These are classical “win – win” illustrations of sustainable rural development.

4 The way forward: SUSTAINABILITY as OPPORTUNITY

The challenges for the future are considerable, but so are the opportunities. However, we need to change our perceptions and develop some new ways of thinking if we are to take advantage of the opportunities available. Sustainability will never be achieved by “overcoming constraints”, which has been the driving paradigm of the past. Overcoming constraints promotes the concepts of human dominance over nature and recognizes neither the limits nor capacity of natural systems.

A more promising emerging paradigm, which is being promoted by the World Bank, is “Sustainability as Opportunity”. This approach is based on the practical reality that sustainable agricultural systems require economic growth while simultaneously protecting natural resources.

A broadly acceptable definition of sustainable agriculture has been proposed by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR):

Sustainable agriculture involves the successful management of resources for agriculture to satisfy changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources.

This is a practical approach to sustainability since it recognizes the legitimate use of natural and man made resources for satisfaction of human needs, but it cautions against the exploitation of these resources in a manner that would degrade the quality and potential of the resources on which production depends. More important, the definition recognizes that human needs change and therefore, the systems of production must also change. This definition embodies the concepts of system flexibility and natural resource resilience as primary criteria for achieving sustainability.

A logical out growth of this approach to sustainability leads to the concept of sustainability as opportunity. This can be defined as:

Ensuring that the choices for future production systems are not reduced by decisions made in the present. This view of sustainability is based on the following:

- Sustainability will not be achieved by overcoming constraints, but rather as a process to concomitantly capture economic and environmental opportunities. For example, investment in new knowledge has allowed many traditional farming systems to become more sustainable in the face of rapid population growth, by shifting from extensification based on expanding land area, to intensified use of existing
land area.

- Considerable substitution is possible in agricultural systems (the physical, biological, economic and social dimensions of sustainability), but the substitution is not perfect. For example, most agricultural production systems allow for a certain amount of input substitution, such as among different sources of crop nutrients, substitution of labor for land, and so forth. Such substitutions may contribute positively to sustainability as long as the impacts of the substitution are reversible, and they contribute to more resilient and flexible systems. Substitutions which lock a system into a restricted range of options, e.g., reduced agrobiodiversity, monocropping, etc., will not lead to sustainability.

- Agricultural systems with the capacity to change, that is, the capacity to remain flexible and resilient in response to major influences such as shifts towards a global market, important recent advances in science and technology, changes in labor availability, etc., will ensure more sustainable systems. Static agricultural systems are not sustainable systems. These continual shifts and adjustments often lead to new opportunities to intensify production, increase productivity and exploit emerging commodity markets. In other cases, negative market forces and adverse natural conditions beyond the control of producers will lead to transition out of agriculture and a search for off-farm employment.

- It is recognized that whereas the principles and criteria in sustainable land management systems are universal and transferable, technologies and application must be local. In sustainable agriculture there are no single solutions, short cuts or magic bullets. In fact, the magic bullet approach must be consciously avoided. Blanket recommendations are rarely successful and innovations found to be successful in one area will likely have to be modified somewhat to be successful in another. For example, zero-till is a successful technology contributing to sustainable land management, but some local modifications of the technology are almost always required for it to be successful. However, the basic principles of zero-till, that is, minimal disturbance of the soil surface and maintenance of continual soil cover are universal and therefore transferable.

- The primary agents of change toward sustainable agricultural systems are the rural communities (farmers, pastoralists) who depend on the land for their livelihoods, and the primary emphasis is on community-based or “farmer-centered” interventions. Rural families make decisions about production practices and land use in line with their objectives, production possibilities, and constraints, but these decisions are part of a wider process to secure and improve the family’s food security and livelihood; they are in turn influenced by government policies and market forces.

- Many of the environmental benefits associated with sustainable land management, such as pollination, biological control, nutrient cycling, soil conservation, water quality, waste treatment etc., accrue locally and nationally. Others are more clearly global, or at least “supra-national” in scope, such as climate regulation, conservation of genetic resources of potential value in plant breeding or pharmaceuticals, international tourism, and transboundary water-mediated effects. Policies and programs designed to capture economic growth as well as environmental benefits are more likely to ensure sustainability.

- A strong local and national commitment towards sustainable land management is required to bring down transaction costs and to capture national and global environmental benefits. In this respect, functioning rural markets for “traditional” goods and services, an appropriate system of land tenure and property rights, and a broadly enabling policy framework for natural resources conservation are prerequisites to the capture of global flows.

5 Conclusions

The need for agricultural growth strategies that can achieve the required growth and food security, while reversing the historical conflict with natural resources conservation, is now a front line issue for global sustainable development. It is widely recognized that agriculture and environmental management are inseparably linked and that tackling problems of natural resource degradation must be seen as part of a wider set of actions to revitalize the rural sector as a whole. Promoting rural development strategies that have “win-win” outcomes for agricultural livelihoods and the environment is mainstream policy for the World Bank and other major development agencies, and is considered vital to provide a sustainable basis for future productivity growth and poverty alleviation.
The Bank’s Rural Vision to Action (World Bank, 1997) and related policies establish sustainable land management at the heart of such strategies. It is increasingly recognized that well designed, farmer-centered, sustainable land management interventions have distinct advantages as vehicles for pursuit of joint agriculture-environment objectives. The pillars of sustainable land management (Smyth and Dumanski, 1993) are the application of agroecological principles to farming; an emphasis on human resource development and knowledge based management techniques; a participatory and decentralized approach; the value placed on natural and social capital enhancements in addition to economic efficiency gains; and the role of strong and self reliant rural institutions.

Agriculture that is truly sustainable will not be business as usual. It will be a type of agriculture that will provide environmental, economic and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the resources that support agricultural production. This will not be the agriculture of to-day or of the recent past, with its emphasis on maximizing yields and economic returns, but rather one with the objectives of optimizing productivity and conserving the natural resource base. The objective of optimization implies trade offs in the production systems to ensure maintenance of environmental quality and global life support systems. Experience indicates that these tradeoffs will be defined and implemented voluntarily by farmers and other rural land users, or they will be implemented through policies and legislation. Society is beginning to demand that agriculture become more than simply putting food on the table; it is beginning to demand that it also becomes the steward of rural landscapes.

The objective is to evolve sustainable systems in which appropriate technological and policy interventions have created resilient production systems that are well suited to local socio-economic and physical conditions, and that are supported by affordable and reliable policies and support services. However, these systems cannot be static systems, but must be carefully designed to be flexible and responsive to change, that is, systems in transition. Sustainability of any system cannot be assured unless the production technologies and associated management practices continuously evolve to accommodate changes in the agroclimatic, economic, and demographic environment in which agricultural intensification is being undertaken. The appropriate level of analysis of sustainability is at the level of the cropping or farming system on a relatively homogeneous agro-ecological resource base, within which similar choices of crop and livestock management decisions can be made.

Agricultural sustainability is a concept that is continuously evolving, and therefore, it is difficult to define and measure. In that it reflects our understanding of systems that in themselves are in continual transition, sustainability should be approached as a concept to strive for, like social well-being, rather than an objective that can be measured with common analytical techniques. In this sense, being able to track the performance of core indicators towards this goal is more useful than setting specific targets to be achieved (although setting targets is often useful to identify levels of satisfaction). This is not unlike tracking the performance of national economies, where in most cases this is done simply to know how we are doing and in what direction the economies are trending.

End Notes:
1. Also in this paper refered to as biodiversity goods and services. The stock of natural resources from which these goods and services flow is also refered to as “natural capital”. An important principle is that sustainably managed land constitutes a form of natural capital from which a variety of key services may be derived in the long term.
2. Biological diversity, often shortened to biodiversity, embraces the whole of “Life on Earth”; it encompasses the variability among living organisms from all sources, including terrestrial and aquatic ecosystems and their ecological complexes. This includes diversity within species, among species, and of ecosystems. Decline in biodiversity includes all those changes that have to do with reducing or simplifying biological heterogeneity – from individual members of a species to regional ecosystems.
3. Although the other conventions clearly identify global environmental benefits, the benefits under the various agreements on international waters are primarily national and transboundary.
4. The pillars are carefully designed so that they can be aggregated into the physical, economic, and social dimensions of sustainability.
5. Sustainability as Opportunity was first proposed by Serageldin (1995) as a definition for sustainable development: Sustainability is to leave future generations as many, if not more, opportunities as we have had ourselves.

6. For the extension agent, this means he and she must work more actively in a participatory approach with farmers, and develop an enabling atmosphere for local farmer innovation as to what will work and what is not acceptable. However, providing technological backstopping to the store of local farmer knowledge is often a critical component.

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