AGROFORESTRY PROJECTS FOR SMALL FARMERS: A PROJECT MANAGER'S REFERENCE

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PREFACE

This report summarizes major issues identified in the general literature on agroforestry and those being addressed in ongoing Agency for International Development (A.I.D.) projects. Section 1 provides an overview of A.I.D. support for agroforestry activities. Section 2 describes state-of-the-art agroforestry techniques that could be used to increase and sustain agricultural production. Section 3 discusses technical and nontechnical issues pertinent to designing and implementing agroforestry projects or projects with agroforestry components.

The report is part of the Project Manager's Reference series of the Center for Development Information and Evaluation (CDIE), which summarizes A.I.D.'s experience and the major issues associated with specific types of development activities. This report should be useful to project managers who are not agroforestry specialists but who need background information on the subject to guide their work in identifying and managing specialists in the design, implementation, or evaluation of an agroforestry project or component. The information in this report should also be useful to others interested in A.I.D.'s experience and ongoing efforts to address agricultural development problems. To facilitate access to the reports, the Project Manager's Reference series will be made available to USAID Missions through CDIE's computerized information retrieval system, MICRODIS.

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SUMMARY

Between l977 and l987, agroforestry activities funded by the Agency for International Development (A.I.D.) included 43 bilateral assistance projects, research projects at international research institutions, and community development projects implemented under the Public Law (PL) 480 Food Aid Program or cofinanced with private voluntary organizations (see list in Appendix A). The projects' common objectives are to encourage farmers to grow trees using species and techniques that can protect and sustain the productivity of topsoils, increase crop or livestock production, and, in most cases, also provide wood and other products to augment farmers' home consumption and cash income. Various tree-growing techniques are used, ranging from tree cultivation to form windbreaks or contour hedgerows to inter-cropping systems combining trees and crops. Such tree-growing techniques are especially relevant to agricultural and rural development programs directed to farming communities cultivating land generally unsuitable for sustained intensive monoculture and subject to soil erosion and environmental degradation (see Sections 1 and 2).

Issues Concerning Agroforestry Projects for Small Farmers

Because most A.I.D. agroforestry projects are experimental or are still being implemented, there is limited practical experience from which to draw more than general guidance on designing and implementing projects to promote widespread use of agroforestry technologies in developing countries. Nonetheless, useful observations have been made in evaluation reports of A.I.D. forestry projects and by researchers and practitioners involved in implementing agroforestry projects. These observations provide insights on issues that should be addressed in designing or implementing future agroforestry projects. The major issues are summarized below.

1. Selection of Tree Species and Agroforestry Techniques (Section 3.1)

Selecting the appropriate tree species is more complicated

than simply identifying trees that can be propagated and used for agroforestry purposes (i.e., trees that can stabilize and enrich topsoils and provide fodder, mulch, and other products). Other factors must also be considered:

-- Technical Criteria

The tree species must be adaptable to agroclimatic conditions at the project site (i.e., climate, soils, slopes, and elevation of farm sites) where the trees are to be planted.

In areas where trees are to be intercropped with food crops, project designers should also consider whether spacing and management requirements for associated crops can be met under existing farming conditions.

-- Economic Criteria

Selection of species and techniques should also be guided by the principal production strategy to be promoted (i.e., are trees to be grown as subsistence or cash crops or both?). A cash-crop strategy might emphasize selecting one or more commercially valuable tree species and promoting cultivation techniques to maximize productivity, whereas a subsistence strategy might focus on providing species for use in conjunction with crop or livestock production or as an additional food source.

The risks, benefits, and costs associated with planting and managing the tree component should be considered from the farmers' perspective. In particular, designers should take into account the land and labor available for adding a tree component to existing farming systems and the tree component's impact on other agricultural and off-farm activities of the target population. In areas where the trees are to be intercropped with food crops, the likely impact of the tree component on crop yields should also be considered. For example, if the trees are to be planted or harvested at the same time as crops, the likelihood of reduced food production and other opportunity costs should be considered.

Both the short- and long-term benefits expected from the tree component should be considered. In particular, project designers should be sensitive to small farmers' preference for trees that produce returns within a short period (less than 3 years).

If the tree products are to be sold, adequacy of market demand and marketing facilities should be assessed.

-- Sociocultural Factors

Decision-making concerning tree species and techniques to be promoted should take into account farmers' preferences and customary beliefs and practices that might discourage farmers from growing trees or certain tree species. A key lesson from experience is that most small farmers do not wish to grow trees exclusively for wood, but prefer species that serve a variety of other purposes as well, such as providing food, fodder, extracts, shade, or fertilizer or serving as a hedge. Moreover, the preferences of male and female farmers concerning tree crops often differ, reflecting their respective interests and roles in the farming system.

2. Policy and Land Tenure Constraints to Tree Growing (Section 3.2)

-- Government Policies

A desirable precursor to a large-scale or national effort to promote agroforestry is a commitment by the host country government to modify forestry legislation, pricing policies for tree products, and land development policies that inadvertently contribute to soil erosion and other related environmental problems addressed by agroforestry projects.

-- Land Tenure

Constraints associated with tenancy are significant in many developing countries where large numbers of farmers cultivate communal land under traditional tenure arrangements that do not allow them to claim ownership or exclusive use rights to the trees on their fields. Although land-tenure problems are not easy to resolve, recent A.I.D. experience suggests that not all land-tenure problems are intractable or require a major land reform program. Some, although not all, projects could introduce tree-tenure schemes or encourage landlords and tenants to work out sharecropping arrangements.

3. Institutional Issues (Section 3.3)

-- Capacity of Existing Line Ministries

Most agriculture or forestry services in developing countries have inappropriate or inadequate facilities and personnel to meet the technical and extension requirements of an agroforestry project. Therefore, it might be difficult for a host country counterpart agency -- for example, a forestry or agriculture ministry -- to implement and subsequently sustain an agroforestry project. Under these conditions, agroforestry project designers might have to consider supporting a long-term institution-building component to establish an agroforestry arm within an agriculture or forestry ministry extension service.

-- Role of the Private Sector

Voluntary development organizations and other private organizations can complement or provide a low-cost alternative to government agencies in establishing and maintaining nurseries and demonstration plots, developing and implementing extension strategies, and distributing plant materials to farmers. However, exclusive reliance on private organizations to implement an agroforestry project can have its drawbacks, and these should also be considered. In addition, private commercial firms or cooperative enterprises can assist farmers by providing a market for commercially valuable wood and other tree products, as has been demonstrated by A.I.D. projects in the Philippines.

-- Key Elements in Training and Extension Strategies

- Training Extension Staff and Farmers

  A key lesson from A.I.D. experience is that project designers and implementing agencies must provide for proper instruction on and close supervision of such aspects of the project as site preparation and planting techniques, spacing requirements, care of young trees, pruning methods and schedules, and proper harvesting and use of tree products.

  Extension staff should also work closely with farmers to familiarize themselves with actual conditions on project sites. One effective strategy has been to locate residential extension staff on project sites. Another effective strategy, used by the International Council for Research in Agroforestry (ICRAF), is to encourage extension staff and farmers to work closely not only with one another but also with researchers to help the latter adapt the project-supported technology and extension program to local conditions.

- Encouraging Farmer Participation

  Examples of efforts that encourage farmer participation include training and recruiting farmers to assist in extension work, sponsoring farmer visits to demonstration sites and farmer-to-farmer visits, encouraging groups to share the labor required for agroforestry-related activities, and training farmers to establish their own nurseries and species trials.

4. Incentive Policies (Section 3.4)

Anecdotal evidence indicates that although the incentives frequently used in A.I.D. forestry projects -- providing seeds/ seedlings free of charge or at subsidized prices or using food as payment for trees planted -- might encourage farmers to plant trees, these incentives do not necessarily motivate farmers to nurture or use the trees as intended. Recent A.I.D. projects are experimenting with alternative incentives that address economic and social constraints at the farm level: providing secure land tenure or tree tenure; funding small community projects to improve living conditions; and providing partial, temporary subsidies to defray the costs of farm inputs and investments for agroforestry-related activities. Because these projects are still being implemented, the full impact of the various incentives is not yet known.

5. Information for Monitoring and Evaluation Purposes (Section 3.5)

Weaknesses in the information systems of past A.I.D. forestry projects underscore the importance of providing adequate funding to support data collection activities for proposed agroforestry projects. At the very minimum, the information systems of agroforestry projects should provide data on the survival rates of tree species, management and uses of trees planted, and farmer response to the agroforestry technique being promoted. Case studies or simple surveys using low-cost methods, apart from standard cost-benefit analyses, should be conducted to assess the economic and environmental impact of agroforestry projects.

6. Crosscutting Issues (Section 3.6)

-- Phased Project Implementation

Multicomponent, large-scale agroforestry projects might require more than 5 years to implement. One solution to this long implementation requirement that has been adopted by many large agricultural development projects is to design a project to be implemented in phases over 7 or more years. The initial phase would emphasize experimentation and communication among researchers, extension workers, and selected farmers to test tree species and cultivation techniques on a few representative sites in the project area. The subsequent phase would build on the experience gained from the first phase to implement an extension program covering the rest of the target population.

-- Agroforestry and Land-Use Planning

Broader, programmatic approaches might be necessary to improve and sustain land use in a particular area or region as a whole. For example, an agroforestry project aimed at on-farm improvement could be designed as part of a long-term, regional land use plan that will introduce several complementary projects (watershed management, reforestation, natural forest management, and so on) on a scale large enough to control deforestation, soil erosion, and other environmental problems in an area.

-- Donor Coordination

The following are examples of types of donor coordination currently being undertaken -- efforts that could benefit from continued support:

- Establishing cofinancing arrangements among several donors to support large-scale agroforestry projects in a region or a country, or a series of natural resource management projects (reforestation, watershed management) that have agroforestry components.

- Setting up committees of professionals who are involved in designing or implementing each donor's projects in the same region or country. The committees would meet regularly to share information on the activities of their respective projects, to identify common implementation problems, and to adopt collaborative measures for activities with overlapping or complementary objectives (e.g., locating germ plasm sources, procuring planting materials, or conducting adaptive research).

- Encouraging research institutions to collaborate on agroforestry research and to develop and share databases comprising data on research findings and other relevant information. Examples of such collaboration include the multidonor support that has enabled ICRAF to establish agroforestry databases, in collaboration with other research institutions in Africa (e.g., the International Livestock Center for Africa and the International Institute for Tropical Agriculture), and an Agroforestry Research Network for Africa (AFRENA). Collaborative research activities also are being sponsored under the forestry/Fuelwood Research and Development project.

GLOSSARY

AFRENA - Agroforestry Research Network for Africa

A.I.D. - Agency for International Development

DESFIL - Development Strategies for Fragile Lands project

F/FRED - Forestry/Fuelwood Research and Development project

ICRAF - International Council for Research in Agroforestry

ICRISAT - International Crop Research Institute for the Semiarid Tropics

IITA - International Institute for Tropical Agriculture

ILCA - International Livestock Center for Africa

1. OVERVIEW OF A.I.D.-SPONSORED ACTIVITIES AND CURRENT POLICY

1.1 What Is Agroforestry?

Agroforestry {1} is a long-established farming practice in many parts of the world. Broadly defined, agroforestry refers to a land-use system {2} in which trees are grown -- either simultaneously sequentially -- in conjunction with annual crops or livestock. The trees are cultivated primarily for agricultural uses, for example, to protect or enrich topsoils for the benefit of crops or to provide browse and fodder for livestock. In many countries, farmers have developed variations of such farming systems over centuries. Consequently, numerous species of trees and numerous cultivation techniques are associated with agroforestry practices in farming communities in many regions of developing countries.

Although the term "agroforestry" has been used since the late l970s, experts still debate over a concise definition of the concept. For example, at least 11 definitions were discussed at the l979 International Cooperation in Agroforestry conference sponsored by the International Council for Research in Agroforestry (ICRAF). ICRAF's own definition, although it has been revised several times, is frequently cited:

> Agroforestry is a collective name for land use systems and technologies where woody perennials (e.g., trees, shrubs, palms, bamboos) are deliberately used on the same land management unit as agricultural crops or animals either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economic interactions between the different components (Beets 1985).

The common element in the various definitions that have been used is that in each type of land use, naturally occurring or cultivated tree species constitute part of a mixed farming system. For the purpose of this report, agroforestry projects refer to activities intended primarily to encourage farmers to grow trees using species and techniques that can sustain or contribute to their crop or livestock production, and, in most cases, can also provide an additional subsistence or cash crop.

1.2 A.I.D.'s Support for Tree-Planting Projects and Agroforestry {3}

1.2.1 Background

The Agency for International Development's (A.I.D.) interest in encouraging rural communities to plant trees is not new. During the l950s and l960s, many small-scale tree-planting projects were sponsored under the Public Law (PL) 480 program. Project beneficiaries received food as payment for planting trees to support flood control efforts or to provide fuelwood and shade in refugee camps.

During the l970s, A.I.D.'s support extended to more broadly conceived forestry and rural development projects that addressed concerns over rapid deforestation in developing countries. Most projects implemented during this period typically focused on either reestablishing forests or encouraging rural communities to establish and maintain small tree plantations to produce fuelwood to meet local and urban demand (i.e., social forestry, community forestry, and village woodlot projects).{4}

1.2.2 A.I.D. Support for Agroforestry

A.I.D. support for agroforestry began in the late l970s. Between fiscal years l977 and l987, 33 bilateral assistance projects in the forestry and agriculture sectors had components ranging from agroforestry research and institution-building to pilot nursery development and extension programs. Funds provided under the PL 480 Food Aid program or cofinancing arrangements also have supported projects managed by private voluntary organizations, primarily community-level efforts to promote cultivation of tree species for erosion control purposes. (See Appendix A for a list and description of A.I.D. projects.)

The Forestry Support Program of A.I.D.'s Bureau for Science and Technology currently provides primary technical support in agroforestry for USAID Missions. The program assists Missions in recruiting forestry/agroforestry experts for project-related activities and disseminates information on tree species for agroforestry activities and forestry/agroforestry research findings (see Appendix E). Another ongoing project -- the Forestry/Fuelwood Research and Development project -- is jointly funded by the Bureau for Science and Technology and the Bureau for Asia and the Near East to strengthen the capacity of national research institutions in Asia to conduct research on multi-purpose trees, including species appropriate for agroforestry (see Appendix C). Under the Tree Crops Production project of the Center for Tropical Agriculture, Research, and Training (CATIE) in Central America, the Bureau for Latin America and the Caribbean has sponsored research on multipurpose trees and tree-commodity crops.

In addition, A.I.D. contributes to the following multidonor research and training projects:

-- The ongoing alley-cropping research and networking activities of the International Institute for Tropical Agriculture (IITA), the International Livestock Center for Africa (ILCA), and other agricultural research institutions.

-- ICRAF's Agroforestry Systems Inventory project, which is inventorying the features of existing agroforestry systems, including information on tree species being used, for input to a computerized database. The database provides a useful source for identifying tree species and agroforestry techniques for specific agroclimatic and farming conditions (see Appendix B).

-- The Agroforestry Research Network for Africa project (AFRENA), which is establishing a collaborative research network between international and national agricultural research institutes of African countries. ICRAF is implementing the project (see Appendix B).

1.3 Rationale for Supporting Agroforestry Projects

Agroforestry technologies are relevant to A.I.D.'s agricultural and rural development programs in three principal ways.

1. Targeting assistance to farmers who have minimal resources to invest in agriculture

In many developing countries, agricultural development activities are increasingly focused on helping small farmers who have not benefited from the Green Revolution. Experience indicates that most of these farmers do not have the land and financial resources to invest in the irrigated, high-input monocultures typically associated with the Green Revolution technologies. In most cases, these small farmers cultivate land under rainfed conditions in arid, semiarid, and hilly regions where soils are marginally arable, degraded, or generally unsuitable for sustained intensive monoculture. In these areas, many communities are engaged in diversified farming practices, usually producing a mixture of annual, perennial, and tree crops, as well as rearing livestock.

Agroforestry projects directed toward such farming communities aim to increase the contribution of the tree-crop component and the overall productivity of the farming system. One approach has been to introduce multipurpose and highly valued tree species that can be incorporated with mixed farming practices. Farmers have responded favorably to forestry projects that have introduced trees for such purposes. The trees provide an additional source of subsistence or cash and contribute to crop and livestock production. Such diversification reduces the risk of total economic disaster should the food crop fail, as would be the case if farmers specialized in growing a single food crop.

2. Protecting or rehabilitating cultivated lands and newly cleared tropical forest lands

Research and agroforestry experiments in the last decade have produced evidence demonstrating that farming practices based on agroforestry principles -- planting trees/perennials as a fallow crop or intercrop or in various configurations on culti- vated areas -- can restore tree cover and conserve and enrich topsoils. In this regard, widespread use of appropriate agroforestry practices is as important as conventional reforestation and afforestation projects in establishing a protective tree cover for environmental protection purposes.

This aspect of agroforestry is particularly relevant in conserving land in areas where soil erosion and general environmental degradation have occurred or are likely to occur. Such areas include upland watersheds, lands with fragile ecosystems and soils, land overused by shifting cultivators, and arid and semiarid regions, such as Sub-Sahara Africa where sustained agricultural production is highly dependent on proper soil and water conservation.

3. Contributing to the rural economy through increased production of fuelwood and other forestry products

In many developing countries, commercially useful tree products -- fuelwood, timber, poles, export commodities, raw materials for industry -- are derived from trees cultivated by small farmers. By increasing the production of tree crops by small farmers, agroforestry projects could generate benefits not only for individual farm households but the national economy as well.

1.4 A.I.D. Policy on Agroforestry

The Agency's policy on agroforestry was first articulated in a brief statement in a l984 publication "A.I.D. Sector Strategy: Forestry" as follows:

> A.I.D. will support agro-forestry as an integral part of farming systems development and research. Programs will strive to increase farm outputs of fuel, food, fiber, fodder and wood to satisfy the needs of small farm families, shifting cultivators and rural and national economies. The Regional and Central Bureaus will increase support for agroforestry research through existing agriculture, forestry and other specialized institutions. [Bureau for Science and Technology]-supported cropping systems research will give greater recognition to increasing farm production resulting from tree and woody vegetation interactions with soil and crops (p. 4).

A more recent statement by the Bureau for Africa in its "Plan for Supporting Agricultural Research and Faculties of Agriculture in Africa" identifies specific areas for A.I.D.

support in most African countries:

> There is general agreement that agroforestry will play a role in agricultural development in most African nations. Agroforestry has already been an accepted practice by farmers in many countries; interventions include alley-cropping, shelterbelts, random tree plantings, and tree border plots. A.I.D. assistance to agroforestry research should support and complement research on the priority commodities using tree planting technology already developed at the IARC's [international agricultural research centers] for soil and water conservation. The priority commodity and agroforestry work should be carried out at the farm level through national on-farm testing activities (1985, 12-13).

The Agency also identifies support for agroforestry as one of the strategies that it will consider in addressing the l986 amendments to the Foreign Assistance Act governing biological diversity and tropical forests. A.I.D.'s current position is expressed in the 1988 Policy Paper, Environment and Natural Resources. The paper states that, where appropriate in areas where tropical forests should be protected, A.I.D.-sponsored projects will emphasize the development of agroforestry and other environmentally sound techniques as alternatives to shifting agriculture.

1.5 Lessons Learned and Unresolved Issues

Research experiments and small pilot projects have so far indicated the potential benefits of agroforestry. Because most of these projects are still being implemented, there is limited practical experience from which to draw general guidance on designing projects to promote widespread use of agroforestry technologies in developing countries. (Major issues that should be considered in the design of agroforestry projects are summarized in Section 3.) Nonetheless, there is a consensus on the following issues among those currently involved in agroforestry research or pilot projects:

- -- Much more applied research is needed, and priority should be given to the development of site-specific technologies that take into account climatic constraints and actual farming conditions of the target population.

- -- There is limited practical knowledge for addressing policy, economic, and management issues that affect agroforestry. Yet experience with forestry and agricultural development projects indicates that these issues are at least as important in determining farmer response and project sustainability as is the potential performance of a new technology. Therefore, these issues should be given careful consideration in designing and implementing agroforestry projects.

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(1) Worldwide recognition of the term "agroforestry" can be attributed to two events: the promotion of the concept of agroforestry at the Eighth World Forestry Conference in Jakarta, Indonesia in l978 and the establishment of the International Council for Research in Agroforestry (ICRAF) in 1977 (Von Maydell 1985, 83-90).

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(2) Agroforestry encompasses several types of land-use classifications. "Agrisilviculture systems" or "silviagriculture" refers to the use of land for concurrent production of agricultural and tree crops. "Silvo-pastoral systems" or "pastoral-silviculture" refers to growing trees and shrubs as fodder crops for stall-feeding animals. (The term also refers to the traditional practice of allowing domesticated animals to browse on trees and shrubs that grow on savannah and rangelands.) "Agro-silvo-pastoralism" refers to concurrently producing food and tree crops and rearing livestock (i.e., a combination of agrisilviculture and silvo-pastoral systems). "Multipurpose forest tree production" refers to the maintenance and selective harvesting of cultivated trees or forests to produce not only wood but also other products for livestock or human consumption. ICRAF's agroforestry classification system includes "agriculture with trees, agriculture in mangrove areas, and multi-purpose tree lots" (Nair 1985, 97-128).

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(3) Watershed management projects and the establishment of government-owned tree plantations are excluded from this review.

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(4) From a conceptual perspective, agroforestry differs in several significant respects from "social forestry projects," that is, projects primarily designed to encourage rural communities to cultivate woodlots (see Appendix B for a discussion of these differences).

2. AGROFORESTRY TECHNIQUES FOR SMALL FARMERS: SOME EXAMPLES

2.1 Introduction

This section describes four examples of agroforestry techniques that illustrate how tree species could serve the following dual functions in a farming system:

-- Protect and sustain the productivity of soils by controlling erosion, conserving moisture, increasing organic content in the soil, recycling nutrients from deeper soil layers, and fixing nitrogen

-- Contribute to agricultural production by providing wood and nonwood products and enhancing crop or livestock production

Each example described in this section has attracted the attention of researchers and development practitioners because of evidence indicating that these techniques are appropriate for the agroclimatic and farming conditions they address. Nevertheless, they are by no means the only approaches that could be used.

For example, ICRAF's Agroforestry Systems Inventory project has identified hundreds of traditional and experimental farming systems combining trees and crops that fall within the definition of agroforestry systems.{5}

Furthermore, the research literature suggests that for each agroclimatic region, many intercropping strategies are possible, but their utility for development purposes remains to be more fully tested. For example, from an environmental perspective, multilayered, biologically diverse systems would be desirable for many regions of the humid tropics. However, they might not be practical or economical under small-farm conditions.

2.2 Intercropping Acacia Albida Trees With Food Crops

Intercropping Acacia albida trees with food crops is a traditional practice in semiarid areas of the Sahel (e.g., Chad, Burkina Faso, Mali, Niger, northern Nigeria, and Senegal) and in a few highland regions in the Sudan and Eastern Ethiopia (Felker l978; McGahuey l985; Miehe l986; Poschen l986). The practice involves growing food crops (e.g., millet, sorghum, corn, groundnuts) under naturally occurring A. albida trees in order to take advantage of the trees' biological properties, as follows:

-- Deep, nitrogen-fixing roots. The trees' deep taproots do not compete with the shallower root systems of food crops.{6} On the contrary, the trees' taproots benefit the roots of food crops grown in close proximity to the trees by enriching topsoils in two ways: by hosting bacteria that fix nitrogen and by drawing nutrients from deeper soil strata into the leaves, which fertilize the topsoil as they decompose. In most cases, the traditional practice is to allow naturally occurring A. albida to mature on fields cleared for cultivation, usually at a density of 20-50 trees per hectare (Beets 1985).

-- Nutritious and palatable leaves and pods. The trees produce pods during the hot dry season when fodder from grass and other shallow-rooted plants is insufficient for livestock. In addition, unconsumed leaves and pods are left to decompose in the fields and enrich topsoils with organic matter and nutrients.

-- "Reverse foliation" habit. In contrast to other tree species, A. albida trees shed their leaves just before the annual rainy season, when the crops are grown. Therefore, their canopies do not compete with crops for light.

Thus, intercropping with A. albida provides many benefits within the farming system. During the dry season, the trees provide livestock with shade, and the animals feed on the leaves and pods of the trees. The topsoils under the tree canopy are enriched by the organic matter contained in the fallen leaves, animal droppings, and nitrogen fixed by the tree roots. (Birds that use the trees to roost also contribute droppings to the soil.) As the rainy season begins, the trees stop growing, becoming practically dormant throughout the period when crops thrive on the enriched soils under the leafless canopy of the trees. In short, the trees provide the farmer with a reliable and cheap source of fertilizer and fodder, as well as useful by-products.

An A.I.D.-sponsored review of studies on the beneficial impact of A. albida on crops shows that, on infertile soils, yields of millet and peanuts increased almost 100 percent (from approximately 500 kilograms per hectare [kg/ha] to 900 kg/ha) when grown under the canopy of A. albida trees. The organic matter and nitrogen content of the soil can increase by as much as 50 to 100 percent. While pod yields range from 105 kg/ha to 5,400 kg/ha, depending on the age of the tree, the protein content of the pods is significant (10-15 percent). It is estimated that complete soil cover can be achieved with 45 large trees strategically scattered on a 1-hectare field (Felker l978). Other studies have demonstrated that soil fertility can be sustained over a long period solely through the enrichment effect of mature A. albida trees. For example, in the Sudan, it was reported that soils under an A. albida canopy have supported continuous millet cultivation for 15-20 years without requiring a fallow period. In contrast, on similar soils without A. albida trees, millet production can be sustained for only 3-5 years (McGahuey l985).

There is concern among Sahelian experts that in many places, acacia-based cereal production is no longer practiced or is likely to break down because too few A. albida are being regenerated. A primary reason for the decline is that as the population in these places increases, both farmers and transhumant herdsmen are using land more intensively. Bush formerly allowed to lie fallow for several years is recultivated after only 1 or 2 years. As more land is used for cultivation or grazing, less land is available for A. albida seeds to sprout and grow. Most seeds or seedlings are inadvertently destroyed, either by farmers as they clear the bush for cultivation or by grazing animals. Consequently, few young A. albida trees are found on cultivated fields, and as mature trees die, they are not usually replaced. Therefore the number of A. albida left in cultivated fields progressively dwindles. Eventually, the trees that remain will be too few to effectively sustain agricultural or livestock production.

To address the problem, several countries have implemented projects to encourage farmers to protect young A. albida trees and provide them with seedlings propagated in government-owned nurseries. For example, an A.I.D.-sponsored food aid project in Chad established eight nurseries that produced enough seedlings for farmers to establish A. albida stands at an effective density of 25 to 50 trees per hectare on 600-800 hectares (McGahuey 1985, and personal communication).

2.3 Alley-Cropping Experiments in Nigeria Conducted by the International Institute for Tropical Agriculture

Alley-cropping (also known as alley-farming) was developed during the l970s at the International Institute for Tropical Agriculture (IITA) to address the problem of soil depletion on land overused for traditional shifting cultivation and bush-fallow cultivation (Kang and Reynolds l986).

Shifting cultivation and bush-fallow cultivation are traditional agroforestry practices that rely on long periods of fallowness to restore productivity to cultivated sections of tropical forest land. Both practices are environmentally sound so long as the required fallow period can be maintained. However, in many parts of the humid and semihumid tropics, where the two agricultural practices are common, this is no longer possible. Rapid population growth of the farming communities, combined with extensive cutting of remaining forests for development purposes, has resulted in an increasing shortage of land that can be used for traditional shifting cultivation and bush-fallow systems. Consequently, farmers have been forced to intensify their cultivation of available land by shortening the fallow periods, thereby progressively depleting the soils and reducing crop yields with each successive cropping cycle. In short, traditional shifting cultivation or bush-fallow cultivation can no longer be sustained in many overpopulated areas of the tropics.

The alley-cropping technique involves growing annual crops in spaces (4- to 6-meter-wide "alleys") between rows of leguminous trees or shrubs maintained as hedges. The hedges are heavily pruned throughout the crop season to prevent them from shading the crops. The prunings and crop residues are used as mulch to conserve moisture and enrich the soil in the cultivated alleys. Soil nutrients and nitrogen fixed by the tree roots similarly enrich the soil in the alleys. The technique allows for continuous cultivation of food crops because soil productivity is restored throughout the cropping cycle, thus eliminating the need for a fallow period.

In the past decade, experiments have been conducted at IITA and elsewhere with different tree species and food crops to study the soil enrichment effects of prunings, particularly on the productivity of maize, cassava, and cowpeas (Kang and Reynolds 1986).{7} A.I.D.'s Africa Bureau reports that in l986, alley-cropping experiments were being conducted in at least 18 African countries (USAID/Lagos, Cable 11817, November 6, l986). Other experiments, such as those conducted by the International Crop Research Institute for the Semiarid Tropics (ICRISAT) and by Senegal's National Institute of Agricultural Research, are focusing on tree species appropriate for semiarid conditions.{8} Research on alley-cropping for livestock production, which is being conducted at ILCA, indicates that high-protein fodder can be harvested as a supplementary animal feed.{9} Although findings to date on the effects of alley-cropping on crop and livestock production are still being debated among researchers, there is a general consensus that the results demonstrate the potential of alley-cropping as a sustainable low-input production system -- that is, a farming practice that can increase and maintain crop or livestock production without requiring substantial investments.

The crop production potential of alley-cropping is best illustrated by the results of long-term field trials conducted at IITA since l976. For example, experiments in which maize is grown between hedgerows of Leucaena leucocephala indicate that significant increases in maize yield are possible and sustainable without additional chemical (nitrogenous) fertilizer. Maize yields in the experimental plots averaged 2 tons/ha, compared with 0.6 tons/ha in the control plot (ILCA-IITA l986). This finding is especially important for farmers who cannot afford chemical fertilizer. When chemical fertilizers were applied on experimental plots, the best results and highest net return (benefit-cost ratio of 1.59) were obtained with the addition of herbicides (Beets l985). Significant improvements in soil properties (higher soil organic matter, nutrient levels, moisture retention) are associated with the periodic addition of hedgerow prunings (Kang and Reynolds l986).

The adaptability of the alley-cropping technique to actual farming conditions is still being tested. The IITA results reflect the soil conditions, management inputs under experimental conditions, and input (labor, fertilizer, herbicides) costs in Nigeria. It cannot be assumed that similar results can be obtained elsewhere. For example, the IITA experiments with leucaena trees were conducted on low-acidity soils appropriate for the species; however, leucaena trees are known to perform poorly on many of the acidic soils typically found in the hot tropics.

Preliminary findings from an ongoing IITA on-farm research project also underscore the importance of modifying the basic model to accommodate the preferences of potential users. In l980, the project introduced leucaena/yam alley-cropping (alley-farming) to farmers in east-central Nigeria. The trunks of the leucaena trees served as stakes to support the yam vines. The trees' foliage, which initially provides shade for young yam plants, is subsequently pruned to provide mulch and to prevent shading the maturing yam plants. Although the farmers responded favorably to the alley-cropping concept, they rejected the spatial design initially devised by the scientists, which called for planting the leucaena hedgerows at 2-meter alley widths.

Farmer acceptance improved when the hedgerows in subsequent trials were spaced at 4-meter alley widths (Kang and Reynolds l986).

Refinement and testing of alley-cropping systems require more on-farm adaptive research and development of extension strategies. Currently, there are approximately 100 research sites (mostly in Nigeria); more will be established when ILCA and IITA implement a multidonor project to establish an alley-farming network for tropical africa (ILCA-IITA 1986).{10} The project will promote collaborative applied research among participating institutions and will develop training and extension strategies.

2.4 Contour Hedgerow Farming

Contour hedgerow farming was developed in the l970s by private voluntary organizations in the Philippines and Indonesia. The system is essentially the alley-cropping model adapted to hill-slope farming conditions. Its primary purpose is to conserve topsoil by reducing erosion and stabilizing cultivated areas.

Seeds of fast-growing, deep-rooted leguminous trees are planted densely in double rows along contour lines (i.e., lines connecting points at the same elevation on the hill slope). As the seedlings mature, a continuous hedge comprising hundreds of small, tough trunks is formed. The hedge acts as a barrier to anchor the soil and to divert and break the speed of water flowing down the slope. Where the soils are deep, canals are constructed on contours alongside the hedgerows to hold the water, allowing it to percolate into the soil. By keeping the water away from cultivated areas, the canals also minimize water damage to crops. Grasses and other groundcover perennials are cultivated at the base of the hedges to further absorb water and reinforce the soil-anchoring effect of the hedges. Additional reinforcement is provided by rocks and pruned branches and leaves piled at the base of the hedges.{11}

A hill slope thus contoured typically comprises a series of hedgerows and reinforcing structures (contour canals and rock walls), with 4- to 6-meter spaces between them (alleys) for growing food and other crops. Mature hedgerows are regularly pruned to prevent shading of crops and to obtain fodder, mulch, and wood. The grasses are cut for fodder. Pineapples or leguminous groundcover provide an additional food or soil-enriching crop.

In both the Philippines and Indonesia, an improved variety of L. leucocephala is most frequently used to establish contour hedgerows. The variety is fast growing and easy to propagate, which makes it ideally suited for establishing hedgerows in a short time (1-2 years). It also produces abundant nutrient-rich leaves and pods.

However, in the last 2 years, most of the leucaena trees have succumbed to an epidemic of psylla, which is a type of tree louse that defoliates and eventually kills leucaena trees. Private voluntary organizations are encouraging farmers to replace the L. leucocephala with several other fast-growing leguminous species (e.g., Calliandra tetragona, Gliricidia sepium, and Erythrina spp.) that are resistant to psylla. The objective is to establish hedgerows that, because of their biological diversity, are less vulnerable to total loss from an epidemic caused by insects or disease.

The benefits of contour hedgerow farming systems have yet to be systematically studied.{12} However, studies on the 1-hectare contour hedgerow demonstration farm established by the Baptist Rural Life Center in Mindanao, Philippines, provide some illustrations of the benefits (Watson and Loquihan l984). The studies demonstrated that for each peso invested in the hedge-rows and crops over a 5-year period, the net returns increased as follows:

Year 1: 5 percent	Year 4: 207 percent
Year 2: 10 percent	Year 5: 415 percent
Year 3: 131 percent	

Measurements of corn yields on the demonstration plot indicated that corn fertilized with leucaena hedgerow prunings yielded 3.3 tons/ha, compared with 1.5 tons/ha for corn grown without any fertilizer and 4.5 tons/ha for corn grown with commercial fertilizer.

Controlled experiments conducted elsewhere in the Philippines also show increased corn and rice yields (Prussner 1983). The experiments show that the fertilizer effect of leaf prunings on maize is the same as that of chemical fertilizer (i.e., nitrogen, phosphorous, potassium) applied at a rate of 90/40/40 kg/ha. Yields of IR36 upland rice grown under rainfed conditions and fertilized with leucaena prunings were equal to those obtained from control plots fertilized at a rate of 80/30/30 kg/ha.

Observers who have visited established contour hedgerow farming sites on the island of Flores in Indonesia have reported that the effects of well-contoured hill slopes can be easily observed: a permanent tree cover on the edges of farmed terraces, absence of gullies and land slides, healthy-looking crops, increased earthworm activity, and increased water supply (Benge l987).

2.5 Windbreaks (Shelterbelts) in Arid and Semiarid Areas

Rows of trees grown in bands perpendicular to prevailing winds are called windbreaks or shelterbelts. The general effects of windbreaks on crop production (increased and sustained yields) and soils (increased organic content and nutrients) are well documented (Hintz and Brandle 1986). The windbreak protects crops directly by shielding them against the scouring and drying effect of wind and indirectly by preventing erosion. In addition, soils under the tree canopy are enriched by microorganic life that thrives in the shade of the tree canopy and by the nutrients that are added to the soil as the fallen tree leaves decay. Where leguminous species are used for the windbreak, the nitrogen fixed by the tree roots further enriches the soil.

Although frequently used in many countries, windbreaks are rare in the Sahel (Hagen l987). A common belief is that the dry and arid conditions of the region and the existing land and tenure systems make it difficult to grow trees as shelterbelts. However, experiments in several countries have demonstrated that windbreaks can indeed be established in the region, and at relatively low cost. The projects introduced tree species that can also be harvested for other uses (e.g., fuelwood, fodder, and mulch), which provides an additional incentive for farmers to plant and maintain them.

An example of the establishment of successful windbreaks in the region is the A.I.D.-sponsored Majjia Valley Windbreak project in Niger, initiated by CARE and the Nigerian Forest and Wildlife Service in l975. By l985, the Majjia Valley project had established approximately 350 kilometers of windbreaks comprising the locally known but exotic tree species neem (Azradichta indica). The trees protect 3,000 hectares of millet and sorghum grown under rainfed conditions. Crop yields are estimated to have increased by at least 15 percent and perhaps as much as 23 percent (Rorison and Dennison l986). A by-product -- wood and leaf fodder from heavy pruning of the trees -- will be harvested periodically and distributed to farmers.

The windbreak principle has also been applied in a highly successful PL 480 (Title III) project in Senegal. Between l981 and l985, trees (Casuarina equistefolia) planted through the project stabilized sand dunes on 3,580 hectares in the coastal Kayar region, protecting thousands of hectares of adjacent agricultural land.

Recent findings of experimental projects conducted in Burkina Faso further demonstrate the benefits to crop production that can be derived from simple, on-farm application of the windbreak principle. Cowpea plants protected by sorghum-straw fences (20 meters long and 1 meter high) formed floral buds and flowered significantly earlier than unprotected plants. Moreover, seed yields of protected plants averaged 831 kg/ha, compared with 708 kg/ha for unprotected plants (Muleba l986).

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(5) Nair (1985) indicates that trees are incorporated into existing farming systems in so many ways that classifying them is itself a challenge to researchers at ICRAF.

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(6) When their taproots are pruned or when they are planted in holes that are too shallow, A. albida trees develop deformed root systems, that is, extensive lateral pseudo-taproots that do not grow as deep as undisturbed taproots. Trees propagated from cuttings or trees that have had their taproots "aerial pruned" also will not develop normal taproots. However, the roots will not compete for moisture with food crops because of the trees' "reverse foliation" habit (see text).

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(7) Tree species used in alley-cropping experiments include Leucaena leucocephala, Gliricidia sepium, Alchornea cordiflolia, and Acioa barterii -- the last three being indigenous to humid and semihumid tropical areas in Africa. The experiments indicate that L. leucocephala gives the highest crop yield, and both L. leucocephala and G. sepium prunings yield more nutrients (nitrogen, phosphorous, potassium, calcium, and magnesium) than those from A. barterii and A. cordiflolia (Beets l985). Promising but inconclusive results have been obtained from field trials on acid soils involving Cassia siamea and Flemingia congesta hedges.

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(8) For a more detailed discussion of alley-cropping experiments in Africa, see IITA 1986.

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(9) On-station experiments conducted by ILCA indicate that L. leucocephala and G. sepium can provide a high-protein feed supplement for use in a cut-and-carry system. For example, it was shown that a mixed feed comprising L. leucocephala and G. sepium leaves can raise the productivity of West African dwarf sheep by 55 percent (Reynolds and Adeoye 1986).

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(10) Funding for this project will be provided by ILCA and IITA through their budgets, as well as by additional donations from donors. The Consultative Group on International Agricultural Research recently approved the recommendation of its Technical Advisory Committee to allocate $513,000 from IITA's budget for alley-cropping research. The Canadian International Development Agency has agreed in principle to finance the project's administrative and networking activities. A.I.D. plans to contribute an additional $2 million for alley-cropping research activities, and IITA and ILCA plan to use part of this fund for collaborative research with U.S. universities. Other donor agencies such as the Canadian International Development Research Council, the United Nations International Fund for Agricultural Development, and the United Nations Development Program are considering contributing to this project (Personal communication from Michael Benge, Agroforestry Adviser, Bureau for Science and Technology.)

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(11) For a detailed, graphic description of the techniques, see Simple Soil and Water Conservation Methods for Upland Farms, a training manual published by World Neighbors and CARE, based on their project experience in the Philippines and Indonesia. A filmstrip version also is available. Both can be purchased from the World Neighbors Headquarters, Oklahoma City, Oklahoma 73112, U.S.A.

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(12) A.I.D.'s Bureau for Science and Technology recently approved funding for a study of the economic viability of the leucaena-based contour hedgerow systems developed in the Philippines.

3. THE DESIGN AND IMPLEMENTATION OF AGROFORESTRY PROJECTS FOR SMALL FARMERS: SYNTHESIS OF ISSUES

The following subsections summarize observations that have been made in evaluation reports of A.I.D. forestry projects and by researchers and practitioners involved in the implementation of agroforestry projects. These sources generally agree that the following issues need to be addressed in designing and implementing agroforestry projects or components.

3.1 Selection of Tree Species and Agroforestry Techniques

3.l.1 Technical Issues

Agroforestry Expertise in the Design Team. During the past decade, research has identified numerous tree species suitable for agroforestry uses. Experts familiar with this research should be included on the design team to provide guidance on a key issue: identification of species whose silvicultural characteristics, yields, and planting and management requirements would meet project objectives, and, in cases of exotic species, identification of sources of germ plasm and appropriate propagation techniques. Expert guidance is also necessary for an understanding of tree adaptability to site conditions and environmental considerations, as discussed below. (The Forestry Support Program maintains a roster of qualified professionals who can provide both short- and long-term technical assistance for agroforestry projects. See Appendix E for a description of the services available under this program.)

Adaptability to Site Conditions. Selecting the appropriate tree species is more complicated than simply identifying trees that can be propagated and used for agroforestry purposes. Specifically, the tree species and techniques to be promoted must be tested for their adaptability to agroclimatic conditions at the project site (i.e., microclimate, soils, slopes, elevation, and exposure of farm sites where the trees will be grown).

Projects that failed to consider the likely effects of local soil and rainfall variations on exotic species before introducing these species reported poor performance and low survival rates of trees. Evaluations of these projects identified several ways in which local agroclimatic factors were overlooked:

-- Project designers considered only general soil profiles and climatic characteristics of the country or the region where project sites were located.

-- Soil tests were not performed at different locations within the project site.

-- The projects did not provide for trials to be conducted on the adaptability of exotic species to local conditions.

-- Species trials were conducted on sites where agro-climatic conditions were not representative of those on actual farm sites.

The recent experience of two agroforestry projects further underscores the importance of prior identification of agro-climatic characteristics at the sites where the trees are to be grown. CARE/Niger reported that the neem tree, the tree species used to establish the windbreaks in the Majjia Valley Windbreak project, was also used on another site for the same purpose. However, most of the neem trees at the second site died or had stunted growth. Without the benefit of a pretest on agro-climatic conditions at the new site, the project designers had not been aware that the clayey and flood-prone site was not suitable for neem (CARE l983).

Experiments on the performance of tree species promoted by A.I.D.'s Agroforestry Outreach project in Haiti demonstrated that although all the tree species sponsored by the project are generally suitable for agroclimatic conditions in Haiti, micro-ecological site differences in soil, slope, elevation, and rainfall patterns greatly affect the survival rate and performance of individual species and trees (University of Maine l986)

Where trees are to be intercropped with existing crops, project designers also have to consider how the trees are to be spaced and managed in relation to other crops in the farming system.

Introduction of Several Varieties and Species Versus A Single Variety: Environmental Considerations. Experts caution against overemphasizing large-scale monoculture of a single tree variety, especially exotic varieties whose suitability for local ecosystems is not fully known. For example, a Food and Agriculture Organization study indicates that eucalyptus should not be planted on a large scale without careful consideration and monitoring of the positive and negative ecological effects associated with the species (Poore and Fries l985). The psylla epidemic that devastated the leucaena trees in Indonesia, the

Philippines, and elsewhere in Southeast Asia illustrates another likely repercussion of large-scale monoculture. For over a decade, the imported "Hawaiian Giant" leucaena variety had been established on plantations in these regions without knowledge of its susceptibility to the "jumping plant louse," Heteropsylla cubana. The pest has thrived in the monoculture setting, defoliating and eventually killing the trees on an epidemic scale (Benge l986).

Negative effects associated with monoculture can be avoided by encouraging the use of more than one variety or species and by including indigenous species.

3.1.2 Economic Issues

Clarification of Economic Objectives. Ambiguous or over-ambitious economic priorities in a project can lead to confusion and misguided expectations about the primary purpose for promoting a particular tree or agroforestry technology. Therefore, the project design should specify the primary economic objective of the project's tree component. Are the trees expected to increase farm income through cash cropping or to enhance a subsistence farming system by providing tree species that contribute to food production -- or both? This clarification is necessary not only for identifying the economic objectives of the project at both the farm and societal level but also for selecting the appropriate tree species and agroforestry techniques and for guiding decisions concerning the level and type of related project investments (in applied research, extension programs, marketing facilities, and so on) that would be necessary. For example, a cash-cropping strategy might emphasize investments in a few high-performance, commercially valuable tree species, whereas a subsistence strategy might focus on the introduction of tree species suitable for on-farm use (e.g., for fodder and mulch production, soil enrichment) and augmentation of household consumption (e.g., by providing fruit, oils, and other edible products.)

Financial Analysis. Experience with agricultural development projects shows that underestimation of the risks, input requirements, and opportunity costs associated with project-supported technologies can have disastrous consequences for small farmers when the performance of project-promoted crops fails to live up to expectations. The same results could occur with agroforestry projects when financial analyses are not based on realistic estimates of the benefits and costs of incorporating a tree component into a farming system. Therefore, project designers should consider information on yields, rate of return, inputs, and costs associated with planting and managing the tree component. (For example, if the trees are to be planted or harvested at the same time that crops are being sowed or harvested, what are the costs to the farmer of reduced food crop production, if any?) Such factors should be considered in relation to land, labor, and other agricultural and off-farm activities of the target population. When the trees are to be intercropped, the likely impact of the tree component on crop yields should also be considered.

Like annual crops, trees require proper planting and management to perform well. However, trees normally require several years before they can generate returns. In short, the tree component of a project constitutes a longer term investment. The risks, inputs, and cash outlays involved therefore need to be predicted with care.

Short- Versus Long-Term Benefits. Experience also indicates that both long- and short-term benefits expected from the tree component should be considered. Farmers -- especially subsistence smallholders -- have generally responded favorably to projects that have introduced fast-growing trees that produced returns within a short time period (less than 3 years). Conversely, projects that promoted only tree species with a long maturation period (5-7 years or more) or that stressed soil conservation benefits but no immediate short-term gains have generally received poor farmer response. When farmers realize that trees introduced by a project can produce both short- and long-term benefits, farmers' reactions have also been positive. For example, the high level of farmer response to the Haiti Agroforestry Outreach project is due primarily to the farmers' recognition that they can derive two types of benefits from the the trees introduced by the project. First, the trees can generate cash profits within 3 years if they are grown to produce firewood and charcoal for the urban market. Second, some trees can be allowed to grow beyond 3 years and used to generate cash as the need arises or to build houses for members of the family.

When a project is based on objectives that involve benefits only in the long term (e.g., establishment of a permanent tree cover on the project site to protect watersheds and adjacent or downstream agricultural land and irrigation infrastructure), the government and donor agency should consider sharing the risks and costs of planting and maintaining the desired tree species. For example, the government and donor can provide credit and implement measures that address economic and social constraints at the farm level (see Sections 3.2 and 3.4).

Demand and Marketing Facilities for Expected Tree Products. If tree products are to be sold, project designers should assess the market demand for the expected products, as well as the adequacy of existing marketing services and facilities. Experience indicates that the demand for and marketing of fuelwood and other tree products generated by a project cannot be taken for granted. Many projects aimed at generating income through fuelwood production succeeded because farmers were able to meet an existing urban demand or because project designers correctly anticipated an increase in demand for fuelwood. For example, the economic success of the Haiti Agroforestry project lies in large part in its market-oriented design and the expanding market for fuelwood in Haiti.

Conversely, projects that did not address marketing issues had limited success. They encouraged farmers to plant trees, but there was no market for the products. For example, a sub-project of the Haiti Tree Crops Improvement project increased the production of mangoes, but project designers had failed to realize that there was no commensurate increased demand for mangoes in either the local or the export market. These findings suggest that unless a tree crop is intended only to meet on-farm needs, a prior assessment of market conditions and facilities is essential to the effort and should be considered in conjunction with species selection.

3.1.3 Sociocultural Factors

Compatibility With Farmers' Preferences. A key lesson from A.I.D.-sponsored forestry projects is that farmers' preferences concerning the trees they wish to grow should be considered during project design. In the l970s, most forestry projects were designed exclusively to increase fuelwood production, and so the projects provided farmers only with species suitable for that purpose. It was assumed that since fuelwood was scarce in many rural areas, farmers would welcome the opportunity to grow trees to produce fuelwood.

However, the experience of many projects proved the contrary. Most farmers did not wish to grow trees exclusively for wood; therefore, such projects received limited farmer support. Forestry projects in the Sahel that tried to encourage farmers to grow neem, cassia, or eucalyptus trees for fuelwood had similar experiences (Catterson l984; Foley and Barnard l984). In contrast, farmers responded favorably to projects that provided trees that were a source not only of fuelwood but also of food, fodder, or commercially valuable fruit, extracts, or other commodity products. Farmers also appreciated planting trees for shade and mulch or as hedges to demarcate their house compounds or farms.

Customary Beliefs and Practices. Experience also indicates that project designers should be aware of local beliefs and customs that might discourage intended participants from growing trees or cultivating certain tree species. In many societies, farmers avoid planting species believed to host disease-bearing insects, farm pests, and evil spirits. Local customs may also govern the planting, use, and ownership of certain tree species (see Section 3.2.4). Many of these customary beliefs and practices are well established and should therefore be considered.

Gender Differences. Case studies of forestry projects have indicated that male and female farmers often have divergent preferences concerning the tree species they wish to grow. The preferences usually reflect the different roles of men and women in the farm and household economy. Because such differences significantly determine the priorities given by the respective sexes to planting and managing trees in the farming system, gender differences will also determine the economic and social impact of a project (Hoskins l982; Fortmann and Rochleau l985). For example, a major finding of a study of three projects by

Fortmann and Rochleau (1985) is that men were more responsive to growing fruit tress and commodity tree crops, whereas women were more interested in trees that contributed to household subsistence (e.g., by providing fruit and fuelwood for domestic use, fodder for livestock, and fiber and leaves for creating other usable products). Such findings suggest that project designers should be sensitive to gender differences when determining how to address farmers' production objectives and how to target project activities such as extension programs.

3.1.4 Project Design Implications

The findings discussed above have led observers to conclude that, ideally, the tree species and agroforestry techniques selected should be adequately tested to ensure that they meet the technical, economic, and sociocultural conditions described above. However, because a single species or agroforestry technique might not be able to meet all these conditions across a project area, a flexible approach should be taken in choosing the tree species and cultivation techniques. For example, project designers could consider introducing a mixture of fast-growing and slow-growing tree species or a combination of food and tree crops, which, as a package, will produce returns in both the short and long term.

Relevant information to guide decision-making concerning the issues discussed above should be collected and carefully considered in order to make an informed judgment on the appropriateness of species or techniques to be promoted. In many cases, the best way to determine what farmers prefer is to determine what trees and shrubs they already use. These include naturally occurring species from nearby woods, as well as those that farmers are growing on their fields and around their houses. Local residents (male and female) knowledgeable about the project site should be included in the decision-making process to provide information on species used by their communities.

When information is not readily available, adequate project support should be provided to collect the necessary information during project design and during implementation.

However, because of the following limitations, it might not be possible to resolve all these issues during the project design:

- Apart from a few well-known species from genera such as Acacia, Gliricidia, Leucaena, and Prosopis, knowledge of many tree species is still inadequate to provide practical guidance on their expected yields and cultivation requirements under small-farm conditions.

- Information on agroclimatic conditions on farm sites within the project area might not exist, or it may not be possible to collect the information during the project design stage. This problem is to be expected because potential sites for agroforestry interventions are likely to include scattered farm sites in remote regions. Furthermore, the ministries of forestry or agriculture of the host country might not have the personnel or facilities needed to conduct soil tests or collect meteorological data.

Several A.I.D.-sponsored agroforestry projects have dealt with these problems by phasing project design activities to allow for extensive feasibility studies. For example, project design has started with a pilot phase or has included an applied research component to test and adapt site-specific technical packages; or project implementation has been phased to allow feasibility studies and applied research to be undertaken on a site-by-site basis. Examples include the following projects:

-- The Haiti Agroforestry Outreach project, which funded extensive field studies of farming communities on proposed project sites during the design stage as well as a 2-year applied research component during project implementation

-- The Indonesia Upland Agriculture and Conservation project, which provides technical assistance under its farming systems research component to test various tree and grass species and hill-slope farming techniques on model farms at project sites

-- The Philippines Rainfed Resources project, which concentrated on testing different tree/crop mixtures on various project sites during the initial 3 years of project implementation

-- The Forestry/Fuelwood Research and Development project, which involves collaboration between Asian countries and USAID Missions to standardize field trials of multipurpose tree species and to computerize information systems for retrieval of field data

Researchers at ICRAF recommend using a diagnostic and design methodology to identify appropriate species and cultivation techniques for each project site. (Key elements of this approach are outlined in Appendix B; see also Raintree 1986.).

3.2 Disincentives to Investment in Tree Growing: Government Policies and Land Tenure Constraints

Many existing government policies inadvertently discourage tree growing or undermine efforts to promote agroforestry. Some of the major constraints are discussed in the following subsections.

3.2.1 Government Restrictions on Tree Growing

In many developing countries, the ownership, planting, and use of trees are governed by forestry legislation originally intended to protect certain tree species or regulate the use of public forests (Foley and Barnard l984; Shaikh l986). However, some policies inadvertently discourage farmers from growing trees or certain tree species on their farms. For example, in Honduras and the Dominican Republic, all trees, including those grown on private property, belong to the government, and individuals may not cut them without official permits. Consequently, many farmers do not consider it worth their while to cultivate trees that they cannot cut for sale as timber or other uses, and they associate tree growing with government harrassment (Murray l983).

3.2.2 Pricing Policies

Economists argue that pricing policies and taxes -- stumpage prices, permit fees, government subsidies for fuelwood and charcoal -- that undervalue wood and other commercially valuable forestry products create disincentives for farmers and the private sector to invest in tree growing (Taylor and Soumare l986; Shaikh l986; Bertrand l986).

3.2.3 Forest Land Development Policies

In many developing countries, government land development policies encourage indiscriminate clearing of forest land by commercial loggers and settlers. Land cleared by individual settlers or under large-scale, donor-sponsored projects is subsequently developed for intensive crop cultivation or cattle ranches. Environmentalists point out that apart from destroying the original forest ecosystem, the land-use practices encouraged by such policies often do not generate long-term economic benefits. In most cases, these practices subject the fragile soils typically found under tropical forests to rapid and irreversible erosion (The Ecologist 1986) and so contribute to the very soil erosion and other related environmental problems addressed by agroforestry projects. Therefore, a prerequisite to a national or large-scale effort to promote agroforestry is a consistent and comprehensive government effort to reexamine unsound development policies and to rationalize land use, particularly with regard to forest and other erodable lands.

3.2.4 Land and Tree Tenure

Fear of eviction and loss of claim to the trees being cultivated are often cited as primary reasons why most tenant farmers or farmers illegally cultivating on government land (squatters) are unable or unwilling to invest in tree growing and so have been uninterested in tree-planting projects. Tenancy constraints are especially significant in areas where most of the farmers cultivate communal land under customary laws that do not allow them to claim ownership or exclusive use rights to the trees -- whether cultivated by them or naturally occurring -- on their farms.

For example, in many African countries, farmers cultivating communal land may have rights to use only certain parts of trees for certain purposes, such as twigs and small branches for fuelwood or seed pods and leaves for domestic or animal consumption. Ownership of the trees is vested in the tribal leaders, who may claim the fruits and other commercially valuable tree products, grant usufruct rights to other members of the community, or allow livestock of nomadic tribesmen who pass through the region to have access to the trees. In other instances, farmers may have ownership claims to all plants grown on communal land but only for the duration of their tenure on that land. One effect of customary practices is that farmers may avoid growing trees or certain tree species on communal land. Another is that the tribal leaders themselves may prohibit tree growing on communal land to avoid disputes between occupants and other users or to prevent individuals from growing trees in order to claim permanent tenure.{13}

Such land and tree tenure issues should be examined and potential problems addressed when a proposed agroforestry project is directed to farming communities with a significant proportion of tenant farmers. Researchers have pointed out that during the project design stage, careful consideration of a project's likely effects on the existing land and tree tenure system will prevent undesired results such as the "destruction of existng rights, the exclusion of certain groups from project benefits, or the capture of the project by an elite for its own purposes" (Fortmann l985, 243).

A.I.D. projects have addressed the issue of tenant insecurity in two ways:

- Providing land leases to squatter farmers on government land. For example, the Mae Chaem project in Thailand and the Rainfed Resources Development project in the Philippines use 25-year land leases as incentives to encourage farmers cultivating government land in the project areas to adopt the agroforestry package sponsored under the projects.

- Providing tree tenure for landless farmers. The National Social Forestry project in India is experimenting with several tree tenure schemes that give landless farmers the right to plant and harvest trees on government land while the government retains ownership rights to the land.

Other projects have simply avoided land-tenure problems by limiting project coverage to farmers who have secure title to their land.

Clearly, land-tenure problems are not easy to resolve. In the past, many land reform programs introduced by well-meaning but ill-informed outsiders failed. Land-tenure patterns are closely tied to local political structures, and outside efforts to change the situation without the consent of those involved are likely to be rejected or undermined. However, the recent experience of agroforestry projects in the Philippines and Haiti suggests that not all land-tenure problems are intractable or require a major land-reform program. In both countries, tenants and landlords took the initiative in working out sharecropping arrangements to their mutual benefit. Observers concluded that the proven profitability of the agroforestry package promoted by the projects and the landlords' agreement to a sharecropping arrangement were sufficient incentives for the tenant farmers (Seymour l985; Conway l986).

3.3 Institutional Issues

Institutional issues concern the identification of appropriate institutions and strategies for establishing nurseries and extension services. Nursery management involves the prourement, propagation, and distribution of tree seedlings or cuttings to farmers. Extension services include the development of training programs for both extension staff and farmers on the proper planting, care, and use of trees.

3.3.1 Capacity of Existing Line Ministries

A key institutional issue is the capacity of the host country institutions to meet the immediate implementation needs of a proposed agroforestry project and, subsequently, to sustain an agroforestry program. In most developing countries, the host country counterpart agency is likely to be the forestry or agriculture ministry. However, as indicated below, it might be difficult for a ministry to integrate an agroforestry project into its existing organization and portfolio.

-- The research, extension, and other support services of most ministries of agriculture are usually organized by traditional crop sectors, that is, export tree crops, cereal crops, and secondary food crops. This crop-by-crop specialization might impede project-level efforts to establish nursery facilities for tree species that are not on a ministry's tree crop list or to implement extension activities to promote intercropping and mixed-farming strategies. Furthermore, most extension activities in agriculture ministries virtually exclude nonexport tree crops and tree growing for subsistence and soil enrichment purposes.

-- In most developing countries, the forestry service does not have the personnel or mandate to provide extension support to farmers. The traditional functions of forestry agencies concern commercial logging, reforestation, protection of watersheds and wildlife reserves, and enforcement of forestry legislation. This orientation typically excludes dealing with the public, except in such regulatory ways as keeping the public out of protected forests and collecting fines from lawbreakers. Moreover, because many farming communities associate the policing function of the forest service with regulation of the use of trees and associated corruption, efforts to change this image (e.g., by using forest guards to provide tree seedlings to farmers) have been viewed by farmers with suspicion (Seymour l985; Spears l986; Heermans l986; Shaikh l986.)

-- Many ill-conceived or poorly implemented donor-spon-sored farming system projects and forestry projects have discouraged agriculture and forestry agencies from investing in subsequent projects of this type. Because agroforestry projects are associated with both farming systems and forestry approaches, they might be viewed as another potential failure disguised under a new name. The lack of support within an existing bureaucracy for a new project can effectively sabotage the project, for example, by delaying the release of funds or staff for the project or by assigning unqualified personnel to the project. In short, few (if any) agriculture ministries or forestry services have the appropriate facilities and personnel to meet the technical and extension requirements of an agroforestry project.

An agroforestry project might have to support the establishment of an extension service in a forestry ministry or the training of agricultural extension personnel. However, project designers should resist any temptation to adopt "quick fixes" to address the problem of inadequate institutional capacity. A.I.D. forestry projects that "made do" with ill-equipped nursery facilities and hastily assembled, untrained personnel to implement extension programs have encountered numerous implementation problems. Anecdotes from such projects tell of nurseries that had more weeds than seedlings; projects that promoted pine or eucalyptus seedlings because only those species were available from the government nurseries; forest guards who threatened to punish farmers if they refused the seedlings offered; thousands of unwanted seedlings that rotted on farms and nurseries; tree seedlings that were planted upside down; and uninformed farmers who fed livestock with toxic amounts of leucaena leaves.

In dealing with the issue of institutional capacity, project designers might have to consider supporting a long-term institution-building component to establish an agroforestry extension service within the forestry or agriculture ministry. In some countries, it might be possible to carry out projects through an existing agricultural extension system. For example, the Kenya Renewable Energy project used the Ministry of Agriculture's network of nurseries and extension staff; the National Social Forestry project in India relies on an existing training and visit agricultural extension system. However, in other countries, successful agroforestry projects require training programs and technical assistance to develop a substantial extension force. Other institutional conditions that should prevail -- although they frequently do not -- are the existence of incentive policies to motivate extension staff in the agriculture or forestry ministry and a long-term government commitment and financial ability to support and sustain the institution-building component (Winterbottom and Linehan l986; Heermans 1986).

If a project is to include an institution-building component, project designers might have to choose between a forestry or agriculture ministry as the principal implementing agency. Alternatively, the project could be designed to establish an institutional linkage between the forestry and agricultural services. However, experience indicates that efforts to coordinate activities of the two services may be greatly constrained by organizational differences, competition, and often conflicting mandates and objectives for developing land resources.

An alternative strategy adopted by a few A.I.D. and other donor projects is to skirt the institution-building issue by designing projects with their own nursery network and extension staff. Many of these projects have successfully promoted agroforestry techniques and increased small-farm productivity. However, critics have questioned the cost-effectiveness and long-term sustainability of such projects, particularly large-scale projects. For example, some argue that such approaches in the Sahel have resulted in unnecessary proliferation of projects, lack of coordination and communication among projects, competition for qualified personnel, and lack of progress toward resolving the very problems they were established to avoid (Taylor and Soumare l986.)

3.3.2 Role of the Private Sector

Private Voluntary Organizations. Proponents of the active involvement of the private sector in agroforestry projects argue that private voluntary organizations (PVOs), farmer organizations, cooperatives, schools, and private entrepreneurs can establish and maintain nurseries and demonstration plots and provide technical assistance to farmers at minimal cost to the government or project (Gulick l985; Taylor and Soumare l986; Wright and Bonkoungou l986). Advocates of private sector involvement also argue that these organizations can complement or provide an alternative to government agencies in serving farming communities. Several examples illustrate the role of private organizations:

-- Adapting untested cultivation techniques and developing extension programs. PVO-managed projects successfully adapted contour hedgerow farming techniques for upland areas in the Philippines and Indonesia (see Section 2.4). The extension strategies of these projects have since been used by government agencies in the two countries to introduce contour hedgerow farming to other areas. The USAID/Philippines Rainfed Resources Development project has similarly benefited from the work of PVOs. In Burkina Faso, the Oxfam Microcatchment project is credited with developing an on-farm water conservation technique that is now commonly used in the Sahel.

-- Developing low-cost techniques to propagate, package, and plant large quantities of tree seedlings. Innovations developed under the PVO-managed Haiti Agroforestry Outreach project enabled the project to produce seedlings for less than 40 cents each, including all project costs, production costs for planting and packing materials, and extension, training, and supervision costs. At 40-60 percent survival rates for seedlings, the project cost per surviving tree is between 63-75 cents. These figures are significantly lower than the original estimates of project designers (i.e., $l.75 to $1.80 to produce each seedling and $2.88 -- $3.49 per surviving tree, at 50-62 percent survival rates) (University of Maine l986).

-- Establishing a decentralized nursery system to cover a large geographic area. The Haiti Agroforestry Outreach project relied on contractual arrangements with a network of 69 PVO-led local organizations to produce and distribute seedlings to farmers. Between l982 and l987, 27 million seedlings were produced, reaching ll0,000 farmers throughout the Haitian countryside.

With the assistance of Peace Corps volunteers and local schools, USAID/Kenya's Renewable Energy Development project established 67 community-managed nurseries and numerous small nurseries serving farmers in 27 administrative districts. The total annual production capacity of the nurseries is 7 million seedlings, comprising 125 tree species (Government of Kenya l985).

Although many A.I.D. projects have been successfully implemented by PVOs and other nongovernmental organizations, the following considerations should be noted:

-- Exclusive reliance on expatriate PVOs to implement an agroforestry program may prevent the development of an indigenous institutional capacity to manage and sustain agroforestry projects.

-- Uniform coverage of a geographic region might not be possible if the PVO is a locally based organization or if it serves only its own members or groups that meet its criteria. For example, some PVOs are based on religious affiliation, and others do not accept donor sponsorship or, like World Neighbors, concentrate their assistance exclusively on one group (e.g., progressive farmers).

-- The technical and management capabilities of very small or inexperienced organizations can easily be overwhelmed when sophisticated nursery management and timely, rapid delivery of inputs are essential to project implementation. Significant project investments might be required to strengthen the capability of such organizations. (Critics argue that such investments should be reserved for government or indigenous, not foreign, organizations.)

-- The positive attributes of well-organized PVOs (e.g., highly motivated staff, sensitivity to local needs, quick, cost-efficient delivery of services, and close rapport with clientele) should be balanced against their small size and ability to effectively serve only a small clientele. Also, PVOs might not be able to cope with situations that require a sudden expansion of their operations, at least not without decreased efficiency in serving their clientele. For example, in implementing the Dryland Farming Systems project, CARE/Indonesia could not expand its local office fast enough to keep up with the unexpected and overwhelming fivefold increase in farmer response in the project area. Consequently, CARE was forced to reduce the coverage of the project to a size commensurate with its resources, thus excluding a significant portion of the farming community that had responded to the project.

Private Commercial Firms and Cooperatives. Private firms or cooperative enterprises could assist farmers by providing a market for commercially valuable wood and other tree products. Projects in the Philippines provide examples of successful arrangements that have been established:

-- Under the Philippines Industries Corporation project, the Development Bank of the Philippines provided credit to farmers to purchase tree seedlings from a wood pulp mill at cost price. With technical assistance from the mill, farmers grew the seedlings until they reached maturity and could be sold as pulpwood to the mill.

-- The Philippine Dendrothermal Power Program organized farmers into associations that received financial assistance to grow trees for fuelwood to supply woodfired (dendrothermal) electric power plants operated by a network of rural cooperatives.

-- Under the Rainfed Resources Development project, a private entrepreneur is using technical assistance and funds provided by the project to set up a nursery to propagate seedlings for tree crops to be grown on l,800 hectares of deforested land leased from the Philippine Government. In return for the project's investment, the entrepreneur waived his claim to portions of the landholding already being farmed by 76 squatters. He provides them with free seedlings of both tree and food crops and technical advice on agroforestry techniques. In addition, the entrepreneur will purchase the crops grown by the farmers. The Philippine Government offers the squatters renewable 25-year leases to their farms on the condition that they adopt agroforestry farming techniques.

3.3.3 Key Elements of Training and Extension Strategies

Experience from A.I.D. projects, including PVO-managed projects, suggests that several points should be considered in designing extension strategies for agroforestry projects.

Training of extension staff and farmers. A recurring theme of evaluation reports is that extension staff must be knowledgeable about the technical recommendations for the tree species and agroforestry techniques to be promoted. In the past, poorly trained extension staff and inadequate supervision of extension activities have resulted in a host of problems -- for example, destruction of seedlings or young trees by livestock, improper planting and watering of seedlings, improper pruning of mature trees, inadvertent poisoning of livestock by feeding them toxic amounts of fodder, and sheet erosion caused by poorly constructed contour hedgerows. Thus, a key lesson from A.I.D.'s project implementation experience is that project designers and implementing agencies must provide for proper training of extension staff and farmers and close supervision of such aspects of the project as site preparation, seeding and planting techniques, spacing requirements, care of young trees, pruning method and schedules, and proper harvesting and use of tree products (Prussner l983; Mackie l986).

One strategy, which has been used effectively at ICRAF, is to include extension staff and farmers in the applied research stages and during implementation of a project. Their knowledge can provide feedback on the research, thus enabling researchers to refine their selection of tree species and technologies for testing (Raintree l986; also see Appendix C). Communication between extension staff and researchers is particularly crucial when the agroforestry technique to be introduced is unfamiliar to farmers or requires substantial modification of existing farming practices (e.g., from shifting cultivation to alley-cropping or contour hedgerow farming).

Development of effective strategies to encourage farmer support and participation. The best examples of strategies that have encouraged farmer support of agroforestry projects and have involved farmers in extension activities are community-level approaches that have been used successfully in projects in Asia and Africa. Descriptions of these approaches follow.

-- On-site training and residence of extension staff. Observers have pointed out that farming communities in remote areas are understandably wary of government officials and outsiders offering advice on how farmers should modify or change their farming practices, particularly when the advisers are infrequent visitors and do not understand local conditions. Consequently, farmers often ignore the advice of extension workers because they do not trust their intentions.

The Philippines Rainfed Resources Development project and the Thailand Mae Chaem Watershed Development project address this problem by requiring extension staff to live on or near project sites and to regularly visit farmers. The Rainfed Resources Development project extension teams live, work, and train farmers in offices that are also their living quarters on sites where their clientele are located. The teams are also encouraged to set up demonstration farms at their residence. Through this arrangement, both projects have apparently succeeded in overcoming a problem typically associated with standard extension strategies: lack of communication between extension teams and project participants.

-- Training and recruiting farmers to assist in extension work. A key element in successful agroforestry projects in the Philippines and Indonesia is their emphasis on selecting and training progressive farmers in each community. These farmers are subsequently included in the teaching staff as "farmer leaders," guiding other farmers during practical training sessions and facilitating communication between their counterparts and the extension staff. Observers noted that farmer leaders, as adopters themselves, can easily gain the trust of other farmers and, as neighbors, are an easily available source of support (Seymour l985). These advantages are especially relevant where achievement of benefits from an agroforestry technique, such as contour hedgerow farming in the Philippines, is not immediate, but requires several years of strict to adherence sound technical practices.

-- Encouraging group cooperation. An advantage that clearly worked in favor of the projects in the Philippines is the existence of the bayanihan or alayon group-help tradition in farming communities, whereby neighbors and relatives arrange to work as a group on each other's farms for a specified number of days a week. Such arrangements allowed project participants to pool their labor resources and tools for setting up nurseries and to help one another with the construction tasks required by the contour hedgerow farming technology -- for example, preparing the site, laying out contour lines, digging canals, and building rock walls.

The projects in the Philippines encouraged farmers to organize themselves into bayanihan or alayon groups. The varying success of projects in promoting contour hedgerow farming is closely associated with the benefits project participants derived from the groups: the amount of work accomplished by the group, access to tools, and the extent of mutual assistance and moral support that individuals received from the group (Seymour l985). Under the Arid and Semi-Arid Lands project in Kenya, members of women's self-help (mwethya) groups made similar arrangements to help one another build terraces, dams, and catchments to conserve soil and water on their farms (Carloni l987).

-- Sponsoring visits to demonstration sites and farmer-to-farmer visits. Trips by selected farmers (as well as extension staff) to agroforestry demonstration farms have been lauded as an excellent way to inspire would-be adopters because these farmers, upon their return, describe what they have seen to other farmers in their community. This strategy has been used effectively in the extension programs of projects in Indonesia, Kenya, Mali, Niger, and the Philippines. As an additional reinforcement or alternative strategy, projects in Indonesia and the Philippines have sponsored farmer-to-farmer visits. That is, the project sponsors an exchange of visits between farmers who have recently adopted an agroforestry technology and farmers on another site who have successfully adopted the same technology or are further along in the adoption process. The visits have encouraged farmers to educate each other and, according to some observers, are more persuasive than standard teaching methods used by extension agents.

-- Encouraging farmers to set up their own nurseries and experiments. Several A.I.D. and PVO-managed projects emphasize teaching farmers to construct small nurseries on their farms using simple, low-cost seeding and other propagation techniques. This approach has encouraged farmers to grow seedlings for their own use; the more enterprising farmers even grow seedlings to meet demand generated by the projects. With the assistance of project staff, farmers are also experimenting with more insect-resistant tree species to replace leucaena hedgerows destroyed during the recent psylla epidemic (see Section 2.4).

3.4 Incentive Policies

During the l970s, many A.I.D. forestry projects provided plant materials free of charge or at subsidized prices on the assumption that this practice alone would be a sufficient incentive for farmers to participate in a project. Other projects used food to pay farmers for the trees they planted. However, anecdotal evidence from projects that relied solely on such incentives indicates that, in many cases, farmers were motivated to plant trees but not necessarily to nurture or use the trees as intended. In some cases, a significant proportion of the tree seedlings that were provided free or planted under a poorly supervised food-aid program died from neglect.

In most cases, it was found that other factors that influence farmers' decisions to invest in tree growing are more important determinants of farmer response than free seedlings -- for example, farmers' production objectives, land tenure security (see Section 3.2 above), and economic returns from the trees planted. Therefore, experience suggests that measures to address economic and social constraints at the farm level are generally more effective than are price subsidies or food payment in encouraging farmer participation. That is not to say, however, that subsidizing the cost of plant material or providing food aid in exchange for trees planted is always inappropriate.

Recent A.I.D. projects are experimenting with alternative incentive policies. Such incentives include providing secure land tenure; directing tree tenure programs to the poor; funding small community projects to improve living conditions on project sites (such as building graded trails or fish ponds, installing electricity generators, and forming cooperatives); supporting "revolving seed fund" programs for project participants to purchase tools and livestock; and providing partial subsidies for farm inputs.

These projects are still being implemented and the full impacts of the various incentives are not yet known; however, preliminary findings indicate mixed results. On the one hand, favorable farmer response to the Philippines Rainfed Resources Development project and the Thailand Mae Chaem Watershed Development project is linked to their respective incentive policies (Mackie l986). On the other hand, project staff of the Indonesia Upland Agriculture and Conservation project are concerned that farmers' interest in the farming practices promoted by the project will not be sustained when the partial subsidies provided for farm inputs are withdrawn (Mackie 1986, personal communication).

In addressing this issue, project designers should also be aware that well-intentioned incentives often have unintended effects, for example, on the economic viability of a project (by increasing costs), on equity considerations (land leases might benefit mostly better-off farmers), or because of trade-offs between the economic and the environmental goals of a project. Therefore, the effects of project incentives should be carefully assessed initially and then monitored during project implementation.

3.5 Information for Monitoring and Evaluating Field Activities

Several evaluation reports have pointed out that early A.I.D. forestry and agroforestry projects did not provide adequate support for, or had poorly designed, information systems for monitoring and evaluation purposes. Consequently, assessments of the performance of those projects -- 10 in Asia, 1 in Haiti, and 1 in Mali -- were based on scanty, often unreliable data

(Mackie l986; USAID/Haiti l986; USAID/Mali l983). This finding underscores the importance of providing adequate funding to support data collection activities for proposed agroforestry projects, especially those with experimental components. Equally important, project information systems should include provisions for the collection of data necessary to answer key questions regarding farm-level activities and the project's economic and environmental impacts.

3.5.1 Basic Information on Farm-Level Activities

Early A.I.D. monitoring of the field activities of forestry projects emphasized collecting aggregate statistics to assess whether targets set for the distribution of trees were being met. Consequently, the data collected were mostly monthly and annual totals showing the number of seeds/tree seedlings distributed and planted and the number of farmers participating in project activities. Although such data are essential for monitoring the coverage of a project, they are insufficient for meeting the information needs of an agroforestry project. As indicated in Section 3.1., farmer response and the success of agroforestry projects are linked to many issues that not only should be considered at the design stages, but also should be monitored during project implementation. Therefore, an agroforestry project information system should also include data that would allow project managers to assess the adaptability of the trees to the project site (e.g., statistics showing the survival rates of trees planted), how trees are managed and used by farmers (male and female), and what types of products are used on the farm for household consumption or for sale in the market. Case studies or simple surveys using low-cost methods could be used to collect the data.

3.5.2 Analysis of Economic and Environmental Benefits

An appropriate methodology for assessing the multiple benefits -- direct and indirect -- of an agroforestry project should be considered. As indicated below, project designers should be aware of the limitations of standard cost-benefit analyses and consider other approaches for obtaining additional data on a project's impact.

Limitations of Cost-Benefit Analyses. Cost-benefit analysis based on price data is a standard technique used by economists to determine the value of wood and other commercially valuable tree products generated by a project. However, this technique is inadequate for assessing nonmonetary benefits or other benefits that cannot be easily quantified, for example, the trees' contributions to crop and livestock production and to household subsistence, and their effects on soils and the environment. Yet the economic significance of these benefits cannot be disregarded since the very justification of support for many agroforestry projects is argued in terms of the relevance of such projects to subsistence farmers and environmental conservation (see Section 1). Moreover, observers have noted the significant contribution of nonmonetary benefits of forestry projects. For example, a World Bank study showed that subsistence benefits generated by social forestry projects account for the projects' high average economic rate of return of 20 to 30 percent. The significance of this finding is further illustrated by the finding that the economic rate of return of industrial wood plantation projects averages only 10 to 16 percent (Spears l986).

Additional Approaches. In addition to case studies and low-cost surveys (see Section 3.5.1 above), other approaches should be used to collect relevant technical data to assess the environmental impact of the project. For this purpose, on-farm species trials and catchment structures could be used to provide indicators of the performance of trees and their effect on soils and water runoff. A few A.I.D. projects have included applied research components that employ these approaches for collecting the relevant technical and socioeconomic data. For example, the Indonesia Upland Agriculture and Conservation project funds a technical assistance team to guide farming systems research and data collection at selected sites in the project areas. Each site comprises several model farms, which are existing farms on which the technologies to be disseminated to the surrounding farming community are pretested and evaluated. Farmer response and the economic impact of the technologies will be monitored at each site. Check dams and other soil and water catchment devices installed on each model farm will generate data on soil and water runoff.

For some agroforestry projects, especially smaller scale projects, these approaches might be too costly, time consuming, and staff intensive. An alternative is to combine several low-cost approaches, for example:

- -- Preparing case studies of a few representative farms to identify the end-use and sale of products generated by the project
- -- Administering short questionnaires or conducting group interviews with key informants to obtain information on farmer response and observed socioeconomic changes in the community (see Kumar 1987)
- -- Installing soil and water catchment structures and simple yardsticks (such as calibrated steel bars) on representative slopes in the project area to collect data on soil erosion or accumulation

3.6 Crosscutting Issues

3.6.1 Phased Project Implementation

Multicomponent, large-scale agroforestry projects might require more than 5 years (the typical length of an A.I.D. project) to implement. In particular, experience indicates that such activities as species testing, nursery establishment, and development of training programs for extension staff and farmers often take up to 3 or 4 years to develop before they are ready to support farm-level activities (e.g., by producing seedlings of sufficient quality and quantity for distribution to farmers and providing farmers with adequate extension services).

One solution adopted by many large agricultural development projects is to design a project to be implemented over 7 or more years and to implement the activities in phases. For example, a project with applied research, extension, and farm-level components would be implemented in two phases. The initial phase would emphasize experimentation and communication among research ers, extension workers, and selected farmers to test tree species and cultivation techniques on a few representative sites in the project area. Insights gained from the first phase would provide feedback to guide implementation of an extension program and other activities covering the rest of the project population.

This approach underlies the design of the agroforestry component of the Philippines Rainfed Resources Development project and the Indonesia Upland Agriculture and Conservation project. The two projects are being implemented in two or more phases over 7 years. It is hoped that this strategy, by allowing project managers to implement activities in a proper sequence, ce, will prevent, or at least mitigate, some of the problems experienced by short-term projects. However, the success of such an approach to implementation will depend on long-term commitment by A.I.D. and the host country government to the support of such projects.

3.6.2 Agroforestry and Regional Land-Use Planning

Although the preceding subsections focused attention on on-farm agroforestry interventions, it should be noted that broader, programmatic approaches might be necessary to improve land use and sustain those gains in an area or region as a whole. For example, an agroforestry project aimed at on-farm improvement could be designed as part of a land-use plan for a water-catchment area. Other activities would also be included, such as reforestation, management of natural forests, and regulation of woodcutting and grazing in the area as a whole. This approach would allow project designers to introduce several complementary measures that address land-use problems on a scale large enough to control soil erosion and other environmental problems in an area.

The Philippines Rainfed Resources project is experimenting with this strategy. Apart from encouraging farmers to adopt agroforestry practices on their farms, the project also includes a program that encourages farmers to grow and plant tree seedlings in spaces between farms. Moreover, the project provides technical assistance to nongovernmental organizations to help them undertake reforestation activities on large tracts of deforested government land. Another A.I.D. project, the 7-year old Niger Forestry and Land-Use Planning project, successfully experimented with a pilot project that had two complementary components aimed at improving land use within a degraded natural forest (the Guesselbodi Forest). One component encouraged farmers in the area to grow trees to meet their domestic needs for firewood and to conserve soil and water on their farms; the other component introduced measures to rehabilitate the natural forest and to regulate farmers' woodcutting in the forest.

3.6.3 Donor Coordination

A.I.D. staff and their counterparts in other donor agencies generally recognize that donor agencies should coordinate their efforts to support agroforestry. Several efforts involving donor coordination are currently underway and could benefit from continued support. They include the following:

-- Establishing cofinancing arrangements to support large-scale regional or national agroforestry projects or a series of natural resource management projects (e.g., reforestation and watershed management) that include agroforestry components. By pooling resources (funds and political influence) and coordinating activities, donor agencies can foster communication among their project staff for the mutual benefit of their projects. By acting as a group, donor agencies also would have more leverage in encouraging host country governments to support agroforestry as part of a long-term national program to improve the management of natural resources and to resolve land tenure and policy issues in that context.

-- Setting up committees of professionals who are involved in designing or implementing each donor's projects in the same region or country. The committees would meet regularly to share information on the activities of their respective projects, to identify common implementation problems, and to adopt collaborative measures for activities with overlapping or complementary objectives (e.g., locating germ plasm sources, procuring planting materials, or conducting adaptive research). One example of a committee that performs this role is the Concerted Action for Development in Africa Forestry Committee established by A.I.D. and four bilateral agencies (those of Canada, France, Germany, and Belgium). The committee, which comprises key personnel in the forestry division of each donor agency, has a small secretariat (funded initially by A.I.D. and now by the Canadian International Development Agency) that arranges the committee's meetings and disseminates information on each donor's forestry portfolio in Africa.

-- Encouraging research institutions to collaborate on agroforestry research and to develop and share databases comprising data on research findings and other relevant information. The best example of such collaboration is the multidonor support that has enabled ICRAF to establish agroforestry databases and to collaborate with other research institutions in Africa (e.g., ILCA, ICRISAT, and IITA) to establish an Agroforestry Research Network for Africa (AFRENA) (see Appendix B). Under the Forestry/Fuelwood Research and Development project, A.I.D. is working with the Asian Development Bank, the International Development Research Council (a Canadian agency), and the U.N. Food and Agriculture Organization to support Asian research institutions in conducting research on and establishing germ plasm collections for multipurpose tree species. The World Bank is funding the secretariat for a multidonor project, Special Program for African Agricultural Research (SPAAR), to establish a system for collecting agricultural and related agroforestry research data from African countries. The Forestry and Natural Resources Division of A.I.D.'s Bureau for Science and Technology is proposing a project (Forum on Conservation Information Systems, FOCIS) to establish a worldwide database that will incorporate existing databases on two broad topics that subsume agroforestry: natural resource management and conservation of biological diversity. The project is envisioned as a collaborative effort by donor agencies, nongovernment organizations, private foundations, developing countries, professional organizations, and other private organizations.

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(13) For a detailed review of land and tree tenure problems and suggestions on how to address them, see Raintree (1987a) and Bruce (1985). For an annotated bibliography of publications on land tenure issues related to tree growing, see Fortmann and Riddell (1985).

4. CONCLUSION

This paper has attempted to summarize current thinking among agroforestry researchers and development practitioners on major issues pertinent to the design of agroforestry projects and the potential of agroforestry for resolving land-use problems in developing countries. Thus, the issues raised are not new (or at least, they should not be news) to the people who are directly involved in resolving them.

The paper does not address many research questions currently being explored by agroforestry researchers that will shape the evolution of agroforestry as a development activity. To provide the reader with a general idea of the research issues being addressed, Appendix B outlines the research activities of ICRAF and Appendixes C, D, and E describe those being undertaken through A.I.D.'s centrally funded projects, Forestry/Fuelwood

Research and Development, Development Strategies for Fragile Lands, and the Forestry Support Program, respectively. Requests for more detailed information on the activities mentioned can be sent to the addresses provided in the appendixes. The bibliography includes recent publications that summarize the activities of ICRAF and of the Forestry/Fuelwood Research and Development project.

APPENDIX A

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991

Implementation Years

Forestry Component ($000s)

1985-1988 1,000

Country and Project

Africa Bureau

Burkina Faso -- Southwest Reg. Reforestation

Project Description

Project activities focus on reforesting two provinces by strengthening infrastructure and initiating a village-level planting program. Activities are directed toward 3,000 villagers in 115 villages. Village-owned mini-nurseries are being established to produce 11,000 seedlings, including fruit and shade trees and species suitable for windbreaks, hedges, and interplanting.

1982-1987 1,144

Burundi -- Bururi Forest

Designed primarily to protect 1,000 ha of Bururi forest. The project includes seedling nurseries and an extension program for instructing farmers on seedling care, agroforestry, and other conservation measures. A long-term agroforestry program will be developed for the area.

1984-1989 1,700

Comoros -- Land and he project is training local

Soil Conservation

The project is training local staff in conservation and agroforestry and promoting village nurseries and on-farm tree planting, as well as the planting of grass strips and the introduction of other soil and water conservation measures.

1985-1992 1,800

Gambia -- Ag. Research and Diversification

The agroforestry component will provide training for Gambia Forestry Department officials. On-farm trials will be established to identify appropriate agroforestry interventions.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991

Implementation Years	Forestry Component ($000s)
1981-1985	460

Country and Project

Africa Bureau

Guinea -- Community Forestry

Project Description

Project developed an extension program to introduce fast-growing trees (for fuelwood, forage, soil enrichment, and erosion control) on 25 sites in the Pita region. Six small nurseries were established by villagers.

1979-1987 1,380

Kenya -- Arid and Semi-Arid Lands

Although primarily a land-use planning project, the project includes a 350-acre soil and water conservation demonstration farm and an agroforestry program. Approximately 400,000 trees from local nurseries have been planted, and 38,00 farmers have received instruction on soil and water conservation techniques.

1979-1987 2,000

Kenya -- Renewable Energy

The agroforestry component is generally considered the most successful in Africa. A key element is effective interministerial cooperation. By 1985, project achievements included implementation of extension programs from 6 agroforestry centers and the establishment of 67 nurseries and 55 on-farm agroforestry demonstration plots; 200 nongovernmental organizations were given assistance in establishing local nurseries.

1985-1991 1,000

Lesotho -- Ag. Production and Inst. Support

The $1 million agroforestry component will enable farmers to grow trees in orchards and on the farm. However, the empha- sis so far has been on planting fruit trees.

1985-1990 750

Malawi -- Agricultural
Research and Extension

This second phase of the project was developed in cooperation with the World Bank and Malawian Government Master Plan; it includes $750,000 for agroforestry trials and demonstrations.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991

Implementation Years

Forestry Component ($000s)

1980-1987 655

Country and Project

Africa Bureau

Mali -- Village Reforestation

Project Description

The project is establishing nurseries and experimental and demonstration plots. The species being tested will be distributed to establish woodlots, windbreaks, and fruit and shade trees.

1980-1988 4,000

Niger -- Forestry and Land-Use Planning

This project successfully introduced two complementary components to improve land use in the project area. One component encouraged farmers to adopt agroforestry techniques on their farms to grow trees for fuelwood for their own use and for soil and water conservation purposes. The other component focused on rehabilitating a degraded natural forest and regulating forest woodcutting by farmers. A follow-on phase of the project will emphasize collaboration with other donor agencies, such as the U.N. Development Program, to ensure that support for its institution-building objectives will be sustained, and development of an extension program to disseminate its land-use planning techniques and farmer participation program to other areas in Niger.

1983-1987 500

Rwanda -- Communal Afforestation

The project is developing an institutional capacity to manage communal nurseries (25 have been established) and transfer silviculture and agroforestry techniques to farmers. Various tree species have been planted on 240 ha of communal woodlots and 450 ha of privately owned land.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991 (cont.)

Implementation Years	Forestry Component ($000s)
1984-1988	2,500

Country and Project

Africa Bureau

Rwanda -- Gituza Forestry (OPG)84-88

Project Description

Project is reforesting 3,600 ha of degraded hillside and watershed, developing institutional capacity to produce wood products, promoting agroforestry technologies, and reducing fuelwood consumption in Kibonda refugee camp. In 1986, eight agroforestry nurseries were operating and producing 20,000-40,000 seedlings each. Twelve extension agents have been trained. CARE is the prime contractor.

1985-1987 2,029

Senegal -- Cereals Production II (Agroforestry)

An agroforestry component was added to this long-term cereals research program. Objectives of the agroforestry component include (1) starting a series of agroforestry activities in 60 villages in the Thais and Dourbel regions to introduce trees into the agricultural system, (2) testing agroforestry techniques, and (3) obtaining adequate information for monitoring and evaluation purposes.

1979-1988 747

Somalia -- Central Rangelands

A small forestry component is providing tree seedlings for nine shelterbelts, establishing four nurseries, and planting trees to stabilize three sand dunes.

1982-1986 4,000

Somalia -- Cooperation for the Development of Africa (CDA) Forestry I

This was a multidonor forestry/fuelwood program for a million resettled refugees from the war with Ethiopia. Subprojects carried out by private voluntary organizations (PVOs) established nurseries and supervised tree planting to establish woodlots and windbreaks on farms. Training for Somali forestry extension personnel included agroforestry study tours in Kenya. The project has generated significant support from farmers in both project and nonproject areas.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991

Implementation Years	Forestry Component ($000s)
1983-1988	4,500

Country and Project

Africa Bureau

Sudan -- Eastern Region Reforestation

Project Description

Project is located near two heavily deforested refugee settlements. It has established two nurseries with an annual production of 600,000 indigenous tree species and has reforested 1,260 ha during 1984. An additional 11,900 ha will be reforested between 1986 and 1987. It has mainly provided employment to refugees and rural Sudanese. Experimental agroforestry trials are being used to develop local farms.

1987-1991 14,500

Asia and Near East Bureau

Bangladesh -- Homestead Agroforestry Research

Project will develop institutional capability to assist small farmers to increase production of trees, shrubs, bamboo,and ground cover species. An agroforestry component will be introduced to existing cropping systems research sites.

1985-1990 83,500

India -- National Social Forestry

This program comprising three projects is being implemented in six states to increase production of timber, fodder, fuelwood, and other forestry products. To date, over 100,000 trees have been planted on public lands to provide fuel, livestock fodder, and timber needed by neighboring cities. Although the primary target population comprises private farmers, a tree tenure scheme will enable the landless poor to plant trees on government land.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991

Implementation Years	Forestry Component ($000s)
1981-1988	3,240

Country and Project

Asia and Near East Bureau

Indonesia -- Citanduy II

Project Description

The upland agricultural component supports the establishment of model farms on project sites to develop a variety of trees and grasses that can stabilize terraces on hillside farms at the sites and increase farm production and income. Experimentation is underway to develop economically viable technical packages for each site. Preliminary results at one site identified one package capable of increasing farm income fivefold.

1984-1991 18,900

Indonesia -- Upland Ag. and Conservation

A.I.D. funding for this project includes support for two components: (1) a farming systems agroforestry research component to develop technologies to increase agricultural production and promote soil and water conservation on upland farms and (2) a pilot program to establish demonstration farms and distribute tree and food crop seedlings.

1985-1990 3,300

Nepal -- Agricultural Research & Production

The research component is developing appropriate agroforestry technologies for farmers cultivating hill slopes.

1979-1985 1,500

Philippines -- Bicol Integrated Area Dev.

The small forestry component included PVO-managed community-based agroforestry and reforestation activities on degraded land in the watershed.

1982-1989 8,660

Philippines -- Rainfed Resource Dev. Project

The primary forestry component is the application and integration of agroforestry techniques to upland farming systems.

1981-1987 3,500

Thailand -- Mae Chaem Watershed Development

Land leases are provided to enable farmers in the watershed to cultivate trees and crops using agroforestry techniques.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991 (cont.)

Implementation Years	Forestry Component ($000s)
1979-1985	700

Country and Project

Asia and Near East Bureau

Thailand -- Renewable Non-conventional Energy

Project Description

A small research component focused on investigating combined tree/crop farming systems.

1980-1987 4,850

Sri Lanka -- Reforestation & Watershed Mgt.

As part of a major reforestation program for a watershed area, local farmers were encouraged to adopt agroforestry practices.

1982-1987 8,100

Latin America and Caribbean Bureau

Ecuador -- Forestry Sector Development

A subproject has successfully developed commercial agroforestry systems for colonists cultivating 50-ha lots in the Amazon region. Strategies are being developed to include indigenous communities in agroforestry program.

1983-1989 4,200

Guatemala -- Highlands Ag. Development

The project is establishing demonstration plot on 124 ha of municipal land to encourage 40,000 farmers to grow trees for on-farm fuelwood and other purposes.

1981-1987 11,500

Haiti -- Agroforestry Outreach

The PVO-managed project has successfully achieved its primary goal: to establish a nursery and extension network to provide Haitian farmers with trees to be grown as a cash crop in an agroforestry system. The project also funded a research component to conduct studies on existing agroforestry practices in Haiti, including economic analysis and the compilation of technical information on tree species. A follow-on phase is being implemented to improve the quality of trees distributed to farmers and to build on achievements of the initial phase.

Table A-1. A.I.D. Projects With Agroforestry Components, 1979-1991 (cont.)

Implementation Years	Forestry Component ($000s)
1980-1987	4,498

Country and Project

Latin America and Caribbean Bureau

Honduras -- Natural Resources Management

Project Description

One component included training for farmers who wished to plant trees in order to protect soils on their farm land and to produce fuelwood and fence posts and other products.

1983-1986 24

Honduras -- Small Farmer Ag. Development

The project worked to improved productivity of small farms on marginally arable land through soil conservation and agroforestry techniques.

1977-1987 550

Panama -- Integrated Rural Development

The project included a small forest conservation program to develop alternative technologies for farmers engaged in slash and burn agriculture.

1984-1987 600

St. Kitts/Nevis -- Resources Management
Caribbean

The project attempted to establish in demonstration areas appropriate soil and water conservation practices in the areas of terracing, agroforestry, and nursery management. Small farmers received long-term leases on land.

Table A-2. Centrally Funded A.I.D. Projects With Agroforestry Components, 1979-1991

Implementation Years	Forestry Component ($000s)
1981-1992	19,800

Project Title

Central Bureaus

Forest Resources Management Support (Forestry Support Program and Peace Corps Forestry)

Project Description

This project provides technical assistance to mission in identifying, designing, managing, and evaluating field projects and country strategies in forestry, agroforestry, and other activities related to natural resources management. Forestry Support Program consulting services are available for review of Mission portfolios and assistance in the design of agroforestry and forestry projects or project components.

1985-1988 40,000

Forestry/Fuelwood Research and Development

The objective of this project is "to develop and disseminate technology to increase productivity and usefulness of multipurpose tree species in sustainable land-use systems to enhance the income and supplement basic needs of rural people." (For summary of activities sponsored under this project, see Appendix C.)

1986-1996   42,000

Development Strategies for Fragile Lands (DESFIL)

This project is jointly funded by the bureau for Science and Technology (S&T), the Bureau for Latin America and the Caribbean, and the Latin American Missions. It has three objectives: (1) to assist USAID Missions and host country governments to develop the relevant national policies to support sustainable development of fragile lands (e.g., lands with steep slopes and endangered tropical forests), (2) to assist specific countries to develop their fragile lands, and (3) to improve the general welfare of people living on fragile lands. (For a description of recent activities, see Appendix D.)

Table A-2. Centrally Funded A.I.D. Projects With Agroforestry Components, 1979-1991 (cont.)

Implementation Years	Forestry Component ($000s)
1987-1990	8,500

Project Title

Central Bureaus

Natural Resource Management Support

Project Description

The project provides technical assistance to USAID Missions to support the Bureau for Africa's effort to increase the quality and level of natural resources management activity in A.I.D.'s country and regional programs in Sub-Saharan Africa and in PVO programs supported by A.I.D. Activities funded under the project are basically "services" in response to Mission requests, for example, to provide short-term technical experts to design or evaluate natural resource management projects and related training programs, studies, and research. The project is managed by the Agriculture and Rural Development Division in the Africa Bureau.

1986-1989   6,200

Environmental Planning and Management

The project provides short-term technical assistance on request (on a "buy in" basis) to USAID Missions for environmental and natural resources planning, including the conduct of studies to produce "environmental profiles" of a country. The prime contractor for the project is the International Institute for Environment and Development, l7l7 Massachusetts Ave., N.W., Washington D.C. 20036.

1986-1989 2,900

Technology for Soil Moisture Management

The project provides expertise from USDA's Agricultural Research Services to conduct technical and economic feasibility studies of soils and water and crop management systems. The project has funded applied research and studies that identified practical strategies for addressing run-off and erosion problems in semiarid regions in Africa.

Table A-2. Centrally Funded A.I.D. Projects With Agroforestry Components, 1979-1991 (cont.)

Implementation Years	Forestry Component ($000s)
1986-1996	9,690 (S&T) 10,300 (Regional Bureaus)

Central Bureaus

Improved Biological Nitrogen Fixation Through Biotechnology

Project Description

Under a cooperative agreement with the university of Hawaii, the project aims to use biotechnology to increase the efficiency of nitrogen-fixing micro-organisms adapted to conditions in developing countries and to increase the countries' capacity to make and distribute inoculants used for biological nitrogen-fixation. The project also funds training programs and subgrants for collaborative research projects involving scientists from host countries.

1982-1988 5,900

Energy Initiatives for Africa

This project provides technical assistance to USAID Missions and host country governments in Africa on fuelwood production, renewable energy technologies, forestry, agroforestry, and natural resource management.

1985-1989 9,000

Tree Crop Production (Central America)

This project is funded by the Regional Office for Central America and Panama. Under the project, the Center for Tropical Agriculture Research and Training (CATIE) has identified 14 fast-growing varieties of trees suitable for cultivation on small and medium-size farms. CATIE also developed training and extension programs to promote commercial agroforestry using multipurpose trees.

Sources: A.I.D., Bureau for Africa (1986); Forestry Sector Database, Forestry Support Program, S&T/FENR;
A.I.D. Congressional Presentation, FY 88.

APPENDIX B

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY: SUMMARY OF ACTIVITIES, 1977-1987

1. INTRODUCTION

The International Council for Research in Agroforestry (ICRAF) is an autonomous, nonprofit international organization formed in l977 with the following objectives:

-- To improve the social, economic, and nutritional wellbeing of the peoples of developing countries by the promotion of agroforestry systems designed to result in better land use without detriment to the environment

-- To encourage and support research and training relevant to agroforestry systems

-- To facilitate the collection and dissemination of information relevant to such systems

-- To assist in the international coordination of agroforestry development (ICRAF l986)

ICRAF's activities since its formation are described in a special, tenth anniversary issue of Agroforestry Systems (1987), a journal published by ICRAF.{1} Aspects of ICRAF's activities that are relevant to designers and implementers of agroforestry projects are summarized below.

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(1) References cited in the following section (except for Raintree

l986) are to articles published in this issue. Abstracts of articles in this issue may be requested from the A.I.D./Washington Library.

2. ICRAF'S AGROFORESTRY DIAGNOSIS AND DESIGN METHODOLOGY

ICRAF's Agroforestry Diagnosis and Design Methodology can be used by researchers, extension workers, and community development workers to diagnose land-management problems and obtain relevant information from farm sites and farmers to guide applied agroforestry research. A manual describing the principles and procedures of the methodology is available from ICRAF (Raintree l986). The methodology involves an iterative process of data collection and analysis through five stages (these are shown in the excerpt from the manual in Table B-1).

Table B-1 ICRAF'S Agroforestry Diagnosis and Design Methodology

Diagnosis and Design	Basic Questions to Answer
Prediagnostic	Which land-use system should be chosen and on which site should it be implemented? (Which system to focus on?)
	How does the system work? (how is it organized, how does it function to achieve its Objective?
Diagnostic	How well does the system work? (What are its problems, limiting contraints, problem-generating syndromes, and intervention points?)
Design and Evaluation	How to improve the system? (what is needed to improve system performance?)
Planning	How to develop and disseminate the improved system?
Implementation	How to adjust to new information

Key Factors to Consider

Prediagnostic	Distinctive combinations of resources, technology, and land-use objectives
	Production objectives and strategies; arrangement of components
Diagnostic	Problems in meeting system objectives (production shortfalls, sustainability problems)
	Causal factors, constraints, and intervention points
Design and Evaluation	Specifications for problem solving or performance-enchancing interventions
Planning	Research and development needs, extension needs
Implementation	Feedback from on-station research, on-farm trials, and special studies
	Mode of Inquiry
Prediagnostic	Seeing and comparing the different land-use systems
	Analyzing and describing the system
Diagnostic	Diagnostic interviews and direct field observations
	Troubleshooting the problem subsystems
Design and Evaluation	Iterative design and evaluation of alternatives
Planning	Research design and project planning
Implementation	Rediagnosis and redesign in light of new information

Source: Taken from Raintree (1986, 6).

Based on ICRAF's experience, the methodology has served several useful purposes:{2}

-- It provides an easy, quick means to determine appropriate agroforestry interventions for a given farming system (e.g., to identify basic needs of resource-poor, subsistence-oriented farmers, and income-generation and savings/investment opportunities for commercial farmers).

-- It can be used to identify land-use problems and solutions at the community, watershed, and regional levels (i.e., "larger-than-farm" spatial units).

-- It can be used in conjunction with ICRAF's computerized Agroforestry Systems Inventory and Multi-Purpose Tree and Shrub database (see Section 2 below) to identify appropriate technologies and species for on-site conditions.

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(2) For a more detailed description of how ICRAF has used this methodology, see Raintree (l987b).

2. INFORMATION AND RESEARCH DATABASES

ICRAF has also developed computerized information databases and models that are useful analytical tools. Some of these are described below.

2.1 Agroforestry Systems Inventory

The ongoing Agroforestry Systems Inventory project, which is partially funded by A.I.D., has been in operation since l982. The project's purpose is "to systematically collect data on important and promising agroforestry systems throughout the developing world in order to bring relevant information on these systems together for evaluation and dissemination" (Nair l987a, 301). The project has produced a computerized database, the Agroforestry Systems Register; a series of papers (entitled the Agroforestry System Description Series) published in Agroforestry Systems; and numerous miscellaneous articles, slides, and other visual presentations.

The Agroforestry Systems Register contains 150 entries, each describing an existing agroforestry system. Data on each system consist of ecological, management, and socioeconomic variables. An assessment of each system's merits, weaknesses, and research needs is also included. The database is programmed for easy retrieval of information.

2.2 Multipurpose Tree and Shrub Information System

The Multipurpose Tree and Shrub Information System is an inventory of multipurpose tree and shrub species (including palms and bamboos). The database provides information on the biophysical requirements, tolerances, and intolerances of each species. To the extent that data are available, the following information on each species is also entered in the database: phenology, morphology, environmental characteristics, propagation and establishment methods, tree manipulation and cultivation problems, yield data, and other relevant economic data.

A companion directory, the Multi-Purpose Tree and Shrub Seed Directory, was published in l986. The directory lists species, addresses of suppliers, and information on seed prices, number of seeds per kilograms, germination rates, and pretreatment of seeds. It also describes 115 species whose specific site requirements are known; a "master list" identifies an additional 1,400 species and their reported uses. The directory also includes a chapter on the principles of inoculation (for nitrogen-fixing microorganisms) and addresses of suppliers of inoculants. The contents of the seed directory are also stored and maintained as a set of computerized databases. (For more details, see Von Carlowitz l987.)

2.3 LANMODEL

The LANMODEL is a computerized model that allows the user to create three-dimensional graphs or tables depicting possible tree/crop combinations under given environmental and soil conditions and plant characteristics. The model helps the user to determine possible configurations in cultivating tree and crop components and to assess their relative merits. ICRAF has learned from users in various parts of the world that the LANMODEL is especially useful in identifying research priorities during initial stages of on-site experimentation to determine an appropriate intercropping strategy (e.g., in addressing the question of which variables to test and which to control for in species trials). (For more detail, see Huxley l987.)

2.4 The Environmental Database

The environmental database provides users access to two internationally accepted classification systems -- the Koppen climatic classification and the Food and Agriculture Organization's soil classification -- to identify and describe the environment (climate and soil) of a given site. The information from the classification systems allows users to assess the environmental parameters of a site and to identify agroforestry practices that, from a biophysical perspective, are appropriate for environmental problems at the site (e.g., soil erosion, thin topsoils, low natural fertility, proneness to drought). The information is equally important in helping agroforestry researchers or project designers select sites suitable for agroforestry interventions. (For more details, see Young l987.)

3. DEMONSTRATION AND TRIAL PLOTS AT MACHAKOS FIELD STATION

ICRAF's research station at Machakos (70 kilometers from Nairobi) is used for demonstration and experimental purposes. The station has a large collection (approximately 60 species) of trees and other woody perennials suitable for agroforestry uses. Some of the species are used in field experiments (e.g., alley cropping, windbreaks, lopping trials, phenology studies, nodulation assessment studies, hedge cultivation). Apart from providing useful scientific information, the station also serves as a teaching and demonstration center for agroforestry, especially for the participants in conferences and workshops conducted by ICRAF. (For more detail, see Nair l987b.)

4. COLLABORATIVE RESEARCH AND RESEARCH NETWORKING: ICRAF AND AFRENA

ICRAF has a program aimed at fostering cooperation and collaboration among research institutions -- international and national -- in the generation of agroforestry technologies and in improving institution building (Torres l987). The program's operational strategy is best illustrated by ICRAF's role in the multidonor Agroforestry Research Network for Africa (AFRENA) project.{3}

ICRAF provides the conceptual framework that enables national research institutions to develop and agree on a common research agenda for each agroclimatic zone and to complement each other's research efforts.{4} To strengthen the research capacity of the participating institutions, ICRAF's researchers train personnel from the institutions through ICRAF's workshop and training program and provide technical assistance to the project (see Section 5 below). (For more detail, see Torres l987.)

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(3) Besides A.I.D., other government donor agencies sponsoring the project include those of Belgium, Canada, France, the Netherlands, and Switzerland. The International Fund for Agriculture and the Near East Foundation of New York have also made contributions. International institutions collaborating with ICRAF include the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the International Institute for Tropical Agriculture (IITA).

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(4) The participating countries (Benin, Burkina Faso, Burundi, Cameroon, Cote d'Ivoire, Gambia, Ghana, Kenya, Malawi, Nigeria, Rwanda, Senegal, Tanzania, Uganda, Zambia, and Zimbabwe) comprise four major agroclimatic zones: the subhumid highlands of East

Africa, the subhumid upland plateau of Southern Africa, the humid lowlands of West and Central Africa, and the dry lowlands of West Africa.

5. TRAINING AND EDUCATION PROGRAM

Since l982, ICRAF has operated an international training program at its premises. In l987, the program included 3-week residential nondegree training courses on agroforestry research; a 6-month "learning-by-doing" internship program for young professionals; a 12-month, nondegree research fellowship for professional staff from national institutions of developing countries to work with ICRAF's researchers; and an International Workshop on Professional Education in Agroforestry, a forum for discussing manpower and training issues. Under the AFRENA project, in-country training courses were also provided for host country research personnel. (For more detail, see Nair l987c.)

APPENDIX C

THE FORESTRY/FUELWOOD RESEARCH AND DEVELOPMENT PROJECT

The Forestry/Fuelwood Research and Development (F/FRED) project's primary objective is to strengthen the capability of research institutions in Asia to develop and disseminate technology that will increase the productivity and usefulness of multipurpose tree species. The project provides funds for applied research and training and for conferences and workshops to encourage communication and collaboration among the region's scientists. Other project activities include the following:

-- Information management system: F/FRED has a subcontract with the University of Hawaii to develop the F/FRED Information and Decision Support System database. The database will allow Asian scientists easy access to data on multipurpose tree species collected from F/FRED field experiments and to the databases of other research institutions, such as that of the International Council for Research in Agroforestry (ICRAF), the Center for Tropical Agriculture Research and Education (CATIE) in Costa Rica, and the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). The system also includes a Multipurpose Specialist Database, which lists specialists in multipurpose tree species management, research, and training. The project team is currently developing a simulation model that will include a user-friendly computer software package for assessing the production and management alternatives for producing multipurpose trees under a variety of site-specific conditions. Another ongoing project is the design of a standardized methodology for socioeconomic data for use in conjunction with the multipurpose tree database.

-- Agroforestry handbooks: F/FRED is preparing handbooks on management of agroforestry research, social science research on agroforestry problems, biophysical research on agroforestry problems, and social forestry case studies of the management of common-access forests.

-- Biotechnology studies: Studies on the following topics will be commissioned to Asian scientists: tissue culture, mycorrhizae, rhizobium, gums and resins, small farmer access to biotechnology, and socioeconomic impacts of biotechnology on small farmers. A.I.D.'s Bureau for Science and Technology is managing this project. The prime contractor implementing the project is Winrock International. Requests for further information on the project may be sent to the following addresses:

Ian Morrison, F/FRED Project Officer
Bureau for Science and Technology/Office of Forestry,
Environment, and Natural Resources
Agency for International Development
SA-18, Room 503
Washington D.C. 20523
U.S.A.

F/FRED Project Management Office
Winrock International
1611 N. Kent Street, Suite 600
Arlington, VA 22209
U.S.A.
(tel.:703-525-9430
telex: 248589 WIDC)

F/FRED Global Research Unit
University of Hawaii
P.O. Box 186
Paia, HI 96779
U.S.A.
(tel.: 808-579-8481
telex: 4900008339 DBS UI)

F/FRED Coordinating Unit
Faculty of Forestry
Kasetsart University
P.O. Box 1038
Kasetsart Post Office
Bangkok, 10903, Thailand
(tel.: 66-2/579-1977
telex: 4900008037 MPT UI)

APPENDIX D

DEVELOPMENT STRATEGIES FOR FRAGILE LANDS PROJECT

The Development Strategies for Fragile Lands (DESFIL) project has five objectives:

1. Through workshops and conferences, to develop public and donor awareness of the problems of soil depletion, erosion, and degradation of fragile lands (defined as steep slopes and humid tropical lowlands) in Latin America

2. Through USAID Mission buy-ins, to provide technical assistance in the design of projects to improve the use of fragile lands in each country

3. To encourage both private and public sector participation in implementing projects

4. To identify incentives to encourage farmer cooperation in project activities

5. To identify and adapt appropriate land-use practices (including farming) for fragile lands

The project's recent activities have included the following:

-- Publication of a quarterly newsletter: The first quarterly newsletter on DESFIL activities was published in the summer of l987. The newsletter is available free of charge from the following address: DESFIL Newsletter, 624 Ninth Street, N.W., Sixth Floor, Washington D.C. 20001, U.S.A. (tel: 202-783-9110; telex: DAI UI).

-- Technical assistance to USAID Missions in the following countries:

  - Bolivia: Funding a team to design the Valles Altos project, which will introduce ecologically sound agricultural practices and reforestation in an area where improper irrigation resulted in poor drainage and soil salinization.

  - Costa Rica: Identifying experts for the Center for Tropical Agriculture Research and Education/Regional Office for Central America and Panama Regional Watershed Management project.

  - Guatemala: Preparing terms of reference for the design of the Highlands Agricultural Diversification project.

  - Haiti: Providing two long-term advisers to assist the Technical Secretariat for Watershed Management in the Ministry of Agriculture on a project to identify appropriate intervention strategies, including agroforestry practices, for the management of watersheds in Haiti.

- St. Kitts: Providing a technical assistance team for the Southeast Peninsula Area Development project.

-- Organization of workshops and conferences:

  - DESFIL organized the workshop on Sustainable Uses for Steep Slopes, held in Jamaica and Ecuador, which reviewed past research and project experience in addressing land use and farming problems on steep slopes.

  - DESFIL wrote the terms of reference for a workshop on the Agricultural Production Enhancement project, Honduras.

  - Plans are underway for a workshop on sustainable uses for humid tropical lowlands.

-- Studies: A series of studies is being conducted on Andean agriculture in Ecuador, Peru, and Bolivia.

For further information on DESFIL, write to Hugh Plunkett, Office of Rural Development, Bureau for Science and Technology; or Robert Mowbray, Office of Development Resources, Bureau for Latin American and the Caribbean, U.S. Agency for International Development, Washington D.C 20523, U.S.A.

APPENDIX E

THE FORESTRY SUPPORT PROGRAM

The Forestry Support Program was established in l981 to provide technical assistance to USAID Missions in identifying, designing, managing, and evaluating field projects and country development strategies concerning forestry development and related natural resource management. The program is managed jointly by the Forest Service and the Office of International Cooperation and Development (OICD) of the U.S. Department of Agriculture (USDA).

Activities sponsored by the Forestry Support Program include the following:

-- Providing A.I.D.'s bureaus and Missions with technical advice on tropical forestry, agroforestry, biological diversity, and natural resources for project design, management, and evaluation

-- Providing short-term technical advisers to USAID projects at no cost to the country Missions

-- Managing a roster of experts in forestry and related subjects who are available for short-term consultancies or longer term employment on project technical assistance teams

-- Publishing a quarterly newsletter containing pertinent technical information on topics relevant to A.I.D. forestry and agroforestry projects (e.g., silvicultural research results, tree species that have agroforestry uses, watershed management, wood industries, workshop announcements, and recent publications on relevant topics) (The newsletter is sent to USAID Missions, Peace Corps Offices, private voluntary organizations, and other implementors of A.I.D. projects.)

-- Identifying and assessing forestry institutions for participation in A.I.D. forestry projects

-- Organizing forestry training courses, developing training materials, advising overseas forestry schools on curriculum design, assisting A.I.D. in designing adequate training components for forestry projects, and providing a communications link between A.I.D. and U.S. education institutions

-- Identifying strategies to encourage private forestry industries in the United States and host countries to participate in A.I.D. forestry projects

-- Promoting linkages between forestry and agriculture in natural resources management projects and related research

The Forestry Support Program staff comprises nine professional foresters (including experts in social forestry and agroforestry) who are based in the United States, but who are available for short-term consultant work for USAID Missions. Through an agreement with A.I.D., other USDA Forest Service employees may also be made available for short-term assignments (during which their salaries are covered by USDA, while the Forestry Support Program pays their travel and per diem costs). USDA Forest Service employees may also accept longer term assignments (up to a maximum of 5 years) to work on an A.I.D. project.

Requests for Forestry Support Program assistance may be sent to A.I.D. regional bureaus (Technical Resources or Development Resources Offices) or to the following address: Forestry Support Program, Bureau for Science and Technology, Office of Forestry, Environment, and Natural Resources, U.S. Agency for International Development, SA-18, Room 503, Washington, D.C. 20523, U.S.A. (tel. 703-235-2432; telex. UR258217 FSPW).

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(The contour hedgerow farming technique described in this booklet has been developed since 1978 under hill-slope conditions in Bansalan and the surrounding districts. Data on the tree species and crops grown and on estimated yearly investment costs and returns from a one-hectare farm are also provided. Copies can be ordered from Reverend Watson at this address: Mindanao Baptist Rural Life Center, P.O. Box 94, Davao City, Mindanao, Philippines.)

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