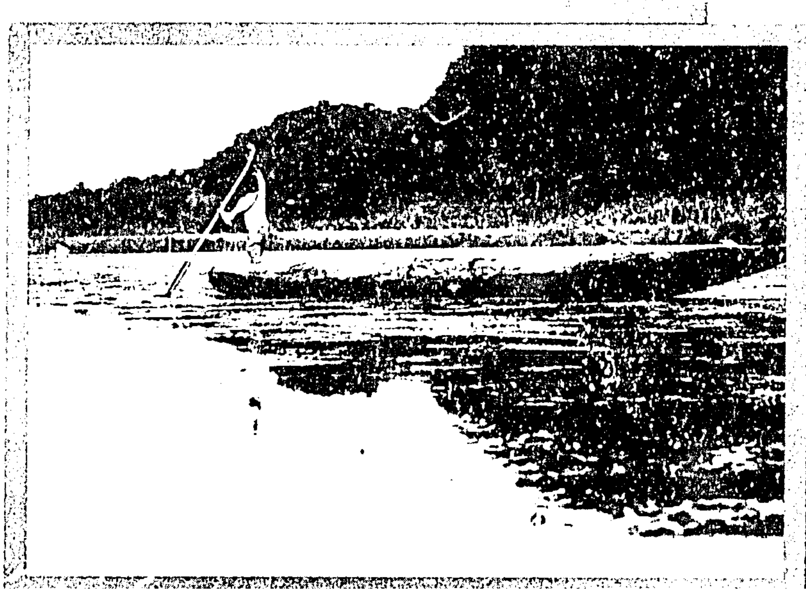
Tropical Tree Planting & Global Climate Change



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TROPICAL TREE PLANTING & GLOBAL CLIMATE CHANGE

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Executive Summary

There is increasing concern worldwide about the threat of global climate change. Human activities, including burning fossil fuels and deforestation, are causing a build up of gases in the atmosphere that could change the earth's temperature and life on earth as we know it today.

Tropical forestry activities have the potential to help reduce and mitigate global climate change. Reducing deforestation and increasing sustainable production of tree products can contribute to decreased emissions of carbon dioxide while increasing carbon fixation and storage. However, to be adopted on a global scale, activities need to focus on enabling local people to meet their basic needs and improve their economic situation on a sustainable basis from farmlands and natural forests. A wide variety of environmental and social benefits are possible through forestry initiatives.

This report examines some of the approaches to increasing tropical forestry activities through the direct involvement of local people in appropriate forestry development activities. Forestry programs started in the past few decades have provided valuable information on local people's participation in forestry. Technical considerations for tropical forestry activities, including natural forest management, tree growing technologies and spaces, and cost considerations are reviewed. The potential benefits of tropical forestry activities are examined.

The United States Agency for International Development and other donors play an important role in forestry programs in tropical countries. Their involvement in forestry activities is discussed as well as some of the major international initiatives that impact tropical forestry including the Tropical Forestry Action Plan and the Man and the Biosphere Program.

Past tropical forestry activities have provided some important lessons on which to base future initiatives. These lessons, which can serve as reminders of important factors to consider in planning future programs, are outlined below.

- Understanding local culture and local environmental conditions is necessary for the success of forestry activities.
- The participation of local people in all aspects of project design, implementation, and evaluation is crucial.
- Because of the central role women play in forestry activities, attention to their needs and encouragement of their participation is important for longterm benefits.
- Extension services staffed by agents who communicate well with local people and follow through on initiatives is important.
- The perceived potential economic and financial returns from tree planting and other forestry activities are key concerns to farmers considering the adoption of new practices.
- A thorough understanding of land and tree tenure and the changes they are undergoing is essential for devising strategies for working with local people.
- Incentives used in forestry projects have both positive and negative effects and should be used with care.
- Policy reforms which remove disincentives to tree planting and serve as a stimulus for action are needed.
- Forest product prices should reflect their true cost.
- Equity issues must be addressed if tropical forestry programs are to succeed.
- Pilot projects or the phasing-in of projects are important means of using limited resources to learn of potential appropriate interventions.
- Success in forestry projects may take a long time to become evident.
- Integration of forestry activities with national goals and local institutions (public or private) is important to assure continuity and reach long-term conservation and development goals.
- People's survival is tied to the availability of local resources.
- Local people can play an important, positive role in natural forest management and should be included in initiatives whenever appropriate.
- The use of inappropriate species and practices threatens the success of forestry projects.
- Increased information about natural resources and their use should contribute to land-use planning activities at the national level.
- Industrial organizations can play an important role in improving the forestry situation in a country.

This report concludes with the following recommendations and actions for increasing tropical forestry activities to help reduce and mitigate global climate change.

RECOMMENDATION:

Implement Policies that Support Increased Forestry Initiatives

Actions:

- Conduct policy analyses to determine the appropriateness of the various policies that impact, directly or indirectly, forestry activities.
- Adopt policies that provide secure land and tree tenure to rural farmers.
- Encourage initiatives to set up local markets for wood products, including markets for underutilized species.
- Adopt prices for forest products that reflect their true value.
- Strengthen support for forestry and agriculture ministries and improve coordination between ministries.
- Increase land-use planning initiatives.

RECOMMENDATION:

Improve and Protect Existing Forests

Actions:

- Improve the management of natural tropical forests that produce timber.
- Encourage the management of secondary forests.
- Increase the number of forests designated as extractive reserves and protected areas.
- Improve the effectiveness of protection given to already designated protected areas and natural forests.

RECOMMENDATION:

Reduce Deforestation

Actions:

- Increase sustainable agricultural practices including agroforestry.
- Increase small-scale woodlot production through community forestry and farm forestry activities.
- Increase peri-urban and bioenergy plantations to produce firewood and charcoal.
- Increase the use of fuel-efficient stoves for firewood and charcoal.
- Develop and promote sustainable economic activity in and around natural forests.
- Decrease land clearing for cattle ranching and forest conversion to other uses.

RECOMMENDATION:

Increase Existing Forest Area

Actions:

- Increase reforestation and afforestation of appropriate areas.

RECOMMENDATION:

Increase Responsible Funding for Tropical Forestry

Actions:

- Increase bilateral and multilateral funding of tropical forestry activities.
- Ensure that funded projects will have a positive impact on the local environment.
- Explore alternative funding sources.
- Increase support for the Tropical Forestry Action Plan.

RECOMMENDATION:

Increase Research

Actions:

- Increase research in sustainable forestry including natural forest management for timber and non-wood products.
- Increase research in sustainable agriculture including agroforestry practices.
- Increase research into social and economic considerations in forestry activities.
- Increase research in culturally acceptable, low-cost energy efficient stoves.

Introduction

Contemporary global climate change has the potential to irreversibly alter life on earth as we know it today. Human activities, particularly the burning of fossil fuels and deforestation with subsequent land-use conversion, are leading to a build up of gases in the atmosphere that could induce increasing temperatures on earth, a phenomenon commonly termed global warming (Abrahamson 1989; Ciborowski 1989; Hammond *et al.* 1991; Schneider 1989; Sedjo 1990; Woodwell 1989). Global warming may result in climatic zone shifts, altered rainfall patterns, rising sea levels, extreme weather events, and reduced fresh water availability (Abrahamson 1989; Flavin 1989; Gable *et al.* 1990; Hair and Sampson 1991; Hansen 1989; Postel 1988; Schneider 1989;). These climatic changes are likely to result in associated changes in biological and social systems including changes in vegetation patterns and animal distributions, destruction of fisheries resources, interference with agricultural activities, reduction of biological diversity, deterioration of air quality, public health problems, and changes in energy demand (Cohn 1989; Flavin 1989; Hair and Sampson 1991, Peters 1989; Postel 1988; Schneider 1989; WRI 1990).

Although the greatest changes likely to occur with global warming will be in the middle and higher latitudes (Graham *et al.* 1990; Hair and Sampson 1991), possible effects in the semi-arid tropics include increased temperatures combined with a decrease in precipitation rates during some seasons, leading to effects on food, water, and fuelwood availability, human settlement patterns, and unmanaged ecosystems (Jaeger 1989). In the humid tropics increasing temperatures may be accompanied by increasing precipitation, though changing patterns of precipitation and increased potential evapotranspiration could lead to drought in some regions. Industry, human settlement, agriculture, forestry, livestock raising, and fisheries will all be impacted (Jaeger 1989).

The "greenhouse effect" is a well-established scientific theory that explains how, while the earth's atmosphere allows heat to radiate out, the build up of certain gases in the atmosphere re-radiates some heat back to earth (Abrahamson 1989; MacDonald 1989; Schneider 1989; WRI 1990). The major greenhouse gases responsible for this effect are water vapor, carbon dioxide, methane, nitrous oxide, tropospheric ozone, and chlorofluorocarbons (Abrahamson 1989; Ciborowski 1989; Hair and Sampson 1991; Hammond *et al.* 1991; WRI 1990). Human activities have led to increases in the amount of most of these gases in the atmosphere. Scientists widely acknowledge a plausible link between the build up of greenhouse gases in the atmosphere and global warming (Gable *et al.* 1990; Hansen 1989; Hair and Sampson 1991; Schneider 1989; WRI 1990). However, there is still considerable uncertainty about the magnitude and timing of climate change (Abrahamson 1989; Graham *et al.* 1990; Hair and Sampson 1991; Schneider 1989; WRI 1990).

Carbon dioxide is responsible for about 50% of the earth's warming (Abrahamson 1989; Ciborowski 1989) and is the only greenhouse gas for which there are credible methods to remove it from the atmosphere (Abrahamson 1989). There has been a 25% increase in the amount of carbon dioxide in the atmosphere in the last hundred years or so (Hair and Sampson 1991; Schneider 1989; Woodwell and Ramakrishna 1989). While most of the increased carbon dioxide comes from the burning of fossil fuels, estimates range from 20% (Schneider 1989) to 33% (USAID 1990; WRI 1990) of the increase is a result of deforestation.

Deforestation rates in the tropics are increasing (Henninger 1990; USAID 1990; WRI 1990). Deforestation, followed by land-use conversion, affects the build up of carbon dioxide in the atmosphere in two ways. First, it leads to a reduction in the potential for long-term carbon storage (Emanuel *et al.* 1984): forests can store 20 to 100 times more carbon than agricultural lands (Andrasko 1990). Second, while carbon may be sequestered in durable forest goods (Hammond *et al.* 1991), the burning or decomposition of forest biomass emits carbon to the atmosphere (Emanuel *et al.* 1984; Woodwell 1989).

Tropical Countries with an Average Annual Deforestation Rate of Over 100,000 Hectares in the 1980's

Country	Hectares Deforested
Bolivia	117,000
Brazil	9,050,000
Cameroon	190,000
Colombia	890,000
Costa Rica	124,000
Côte d'Ivoire	510,000
Ecuador	340,000
India	1,500,000
Indonesia	920,000
Lao	130,000
Madagascar	156,000
Malawi	150,000
Malaysia	255,000
Mexico	615,000
Mozambique	120,000
Myanmar	677,000
Nicaragua	121,000
Nigeria	400,000
Paraguay	212,000
Peru	270,000
Philippines	143,000
Sudan	504,000
Tanzania	130,000
Thailand	397,000
Venezuela	245,000
Viet Nam	173,000
Zaire	370,000

Source: WRI 1990:292-293

Deforestation in the tropics is fueled by an ever-increasing population in search of land for agriculture, livestock, and urban development as well as forest products (Barnes 1990; Cook *et al.* 1990; Rudel 1989). Annual population growth rates in tropical countries are rising (WRI 1990). The population in Africa, Asia, and Latin America is expected to grow by nearly 3 billion people by the year 2025 (WRI 1990). This expanding population, in search of the means of improving their livelihood, will put increasing demands on forests and other natural resources.

Natural forest cleared for farming, Mt. Elgon, Uganda
Photo: L. Lear and D. Forester

Shifting cultivation, once a sustainable means of agricultural production, is breaking down. Farmers no longer have wide expanses of forest in which to carry out their activities. Fallow periods have shortened making the system much less viable (Miller and Tangley 1991; Peters and Neuenschwander 1988) and increasing the degradation of the forests. New settlers are moving into forested areas and clearing plots that must often be abandoned for new virgin forest after only a few years (Caufield 1985; Miller and Tangley 1991). Sedentary populations, using unsustainable agricultural practices in marginal areas, are impelled to clear more forest to meet their basic needs. This situation is tied up in political and economic systems that deny people secure tenure to the land they farm, concentrate the best lands in the hands of the wealthy few, and leave people little recourse but the forest (Caufield 1985; Goodland *et al.* 1990; Miller and Tangley 1991; Repetto 1988). In some areas people are awarded tenure to land only after they have cleared it of forest cover (Repetto 1988).

Favorable economic incentives to timber companies encourage massive logging operations to extract only a few of the most valuable species while causing considerable damage to the remaining forest (Hatchinson 1987; Johnson *et al.* 1991; Repetto 1990). Unfortunately little of the money gained from such enterprises makes its way to government treasuries (Repetto 1990; WRI 1991). In addition to the direct effects, logging activities open forest land to other uses. Roads built for timber extraction allow easy access into otherwise remote areas that are then converted from forest to other uses (Caufield 1985; Postel and Ryan 1991).

Present forestry, livestock, and agricultural practices account for a large portion of tropical country greenhouse gas emissions. Expanding energy use and industrial development, combined with increasing populations, will lead to an ever-increasing share of those gases being emitted from tropical countries. Energy conservation plans and alternative energy sources used now, as these developments unfold, may help to limit increased greenhouse gas emissions from industrial activities in tropical countries (Hammond *et al.* 1991).

The allocation of land to different uses in tropical countries is often determined based on opportunity, incentives, or sometimes conflicting government policies (OTA 1991). Yet inappropriate land uses can further increase the activities that contribute to global warming. Land-use planning initiatives in tropical countries can help direct activities to the lands most capable of supporting a particular use. Present land-use information, a least at a rough scale, is collected in most countries (WRI 1990). But assessments of the potential of most land to support present or future activities are often lacking. Activities are likely to be more productive and less environmentally destructive if they are carried out on lands for which they are suited (Dasmann *et al.* 1973; FAO staff 1990). Fragile lands can best be protected if they are identified and compatible activities carried out in surrounding areas. This calls for coordination of different sectors - agriculture, forestry, livestock, water resources, urban development, parks and protected areas, etc. - in assessing land capability and suitability and coordinating development activities (Grainger 1987).

Forestry activities in the tropics have the potential to help reduce carbon build-up and mitigate global climate change (Moomaw 1989; Myers 1988; Trexler *et al.* 1991; USAID 1990; WRI 1991). Activities designed to reduce deforestation can help to maintain and increase the carbon storage capability of those areas. Tree planting activities can increase overall carbon storage while helping to reduce pressure on the natural forest (Trexler *et al.* 1989; Trexler *et al.* 1991; USAID 1990). Increased forestry activities in the tropics now can help to assure that sufficient forest products are available to meet the needs of future populations.

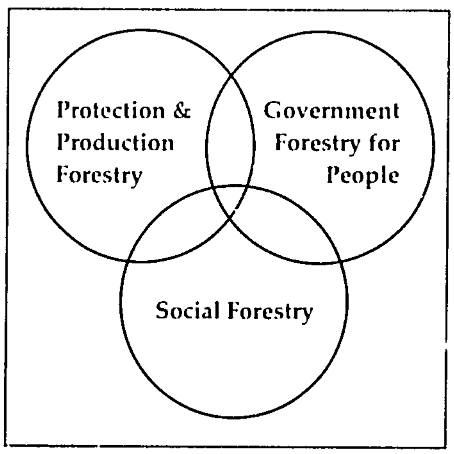
Any tree planting activities in the tropics to mitigate global climate change must take into account the social, political, and economic situation of the area (Trexler *et al.* 1991; USAID 1990). The greatest success may be reached through working on a small scale with local people, rather than by establishing large plantations. Additional ecologic, social, and economic benefits to local people are possible through carefully planned and executed forestry activities (Moomaw 1989; USAID 1990).

This report explores social approaches and technical considerations for tree planting activities and natural forest management in the tropics. Current initiatives and some of the lessons already learned illuminate possible approaches to increasing tropical forestry activities to help mitigate global warming while providing a myriad of other benefits to local people and the global community.

Tropical Forestry Considerations

Social Approaches to Forestry

Traditionally forest departments and foresters in tropical countries have been concerned with the protection of natural forests and the production of timber, often for export lumber markets. The last twenty to thirty years has seen a gradual shift in forest department roles towards producing wood products, including trees for charcoal and firewood, for rural and especially domestic urban markets. The forester's role has evolved from one of protecting forests from people to include producing wood products for people. Social forestry, which involves local people directly in the production of trees and associated products, is playing an increasing role in forest department agendas. While traditional protection and production forestry continue to be an important part of forest department activities, this report focuses on forestry activities to meet social needs.



Forest departments' overlapping roles

Social forestry refers to the growing of trees by local people to provide products for their own use or income generation (Gregersen 1988; Gregersen *et al.* 1989). It differs from traditional forestry approaches in that local people are involved in all aspects of planning and managing resource use. Social forestry includes producing trees for personal use as well as markets; it involves the direct participation of the intended beneficiaries; and it implies that foresters work with people to plant trees rather than in primarily policing forestry activities (Noronha and Spears 1985).

A recurring theme in development projects is that they have little chance of success if the local population does not derive tangible and sustained benefits from them as well as play an active role in planning activities and managing resources (Simon 1989). Only through the active participation of the intended beneficiaries can goals related to wood products production and environmental conservation be achieved and maintained (Noronha and Spears 1985). Social forestry offers many advantages over traditional approaches to tree growing which have involved government-paid workers establishing plantations. When successful, social forestry programs are a relatively inexpensive way to establish trees. By enabling local people to make their own choices about tree planting and use, they have a vested interest in the success of those activities (Foley and Barnard 1984; Gamser 1987; Gregersen *et al.* 1989). Well planned and implemented social forestry programs can increase the productive capacity of the land, promote sustainability, improve the local environment, and strengthen the socioeconomic well-being of rural people (Gregersen *et al.* 1989; Vergara *et al.* 1986). There has been a shift in emphasis from plantation forestry to social forestry in government and donor sponsored development programs (Fortmann 1988a; Hoskins 1979).

People's participation in forestry projects can take several forms from paid labor to all aspects of decision-making (Fortmann 1988a; Uphoff 1985). In social forestry programs people should be involved in the design, implementation, and evaluation of activities. This approach is only possible through understanding the local situation and effectively communicating with people

Extension worker explaining the use of leucaena pods as food, India Photo H. Force

(Noronha and Spears 1985). Governments involved in social forestry programs need to establish a top down commitment to enabling people to undertake bottom-up development activities (Fox *et al.* 1990; Uphoff 1985).

Forestry extension workers are often responsible for involving local people in social forestry activities. While extension is recognized as important, traditionally-trained foresters often lack the training and skills to communicate effectively with local people (Casey and Muir 1986; Fortmann 1988a; Shepherd 1985). An important step in building social forestry programs in tropical countries is establishing a framework for extension, staffed by agents who are able to communicate effectively with rural people. In many cases this implies new training for present foresters and extension agents to encourage them to develop needed communication and technical skills (Foley and Barnard 1984; Mahony 1987). Extension agents must be able to reach and work with farmers in different socioeconomic positions within a community (Foley and Barnard 1984). They must also be able to understand traditional practices in order to assist farmers in integrating new practices onto their farms (Rocheleau *et al.* 1988).

Land and tree tenure are important considerations in tree planting programs. A failure to understand local situations can lead to unintended consequences or failure of social forestry programs (Cernea 1989). Traditional tenure arrangements are changing in many areas as common property gradually becomes privatized. In some cases planting trees may help people to secure tenure over land (Bruce *et al.* 1985; James and Fimbo 1988). The size of a plot as well as its ownership status can influence the social forestry activities implemented (de Ceara 1986).

Tree tenure may be wholly different from land tenure (see Fortmann and Bruce 1988). The right to use and own trees may vary based on species, product, method of establishment (planted seedling or wildling), or location (Fortmann 1988b; Leach 1988; Obi 1988). Governments may allow people to plant trees while also regulating their rights to cut trees, even on their own land (Fortmann 1988b). Rights to use trees on communal land may be regulated (Turner 1988), and men and women may have different tree-use rights (Fortmann 1988b). An awareness of local land and tree tenure arrangements and the implications of tree planting on those rights can help in designing social forestry activities (Bruce *et al.* 1985).

Social forestry programs are often more economically efficient than government or donor-sponsored plantations (Spears 1987; Zida 1989). While in some cases they may take longer to establish, the potential long-term implications are favorable. It may take several years before the success of social forestry interventions can be ascertained (Shaikh *et al.* 1988a). However, a well planned and implemented project can lead to spontaneous adoption and adaption of social forestry practices: the product may become greater than the sum of the parts.

The role of women in social forestry programs needs to be identified and their participation fostered. Women have often been neglected in development efforts, yet they play an important role in farming activities and rural life. Women are users of forest products, one of the most obvious examples being firewood collection for cooking. Women rely on forests and trees for a number of other functions including fodder for livestock and collecting fruits, nuts, bark, and leaves for food and medicine (Gakou 1992; Hoskins 1979; Molnar and Schreiber 1989). Women may be involved in tree nursery or tending operations, yet have little say in species selection or planting arrangements that can affect their other activities (Hoskins 1979). Women's access to wood products and other products associated with trees may change as a result of tree planting activities (Rocheleau 1987) and women may have different rights to use trees than men (Fortmann 1988b). Women can be powerful forces in forestry initiatives if their participation is encouraged and fostered (Molnar and Schreiber 1989).

Social Forestry Initiatives

A variety of terms have been used to describe social forestry activities. Many of the terms are synonymous and all are overlapping. In this paper social forestry is used as a generic term for all forestry activities carried out by people for their own benefit. The emphasis is on tree planting activities that originate with the beneficiaries of those activities. The activities may take place on private or community land and may involve a family, small group of people, or entire rural community. The box defines the key terms used. Government-sponsored initiatives may aim to create a social forestry environment after a period of time and those activities are described later.

Community Managed Forestry

Community managed forestry implies community control of the resources and community management of these same resources, including effective and equitable conflict resolution, by the community undertaking the activity. In some cases whole villages may constitute a community, in others a smaller more homogenous group of people may be more appropriate and easier to work with as they may already have some common goals and there are likely to be fewer conflicts (Cernea 1989; Gregersen *et al.* 1989).

There have been problems with attempting to manage common property resources such as communal land. Trends in the privatization of the commons have led to misunderstandings about land availability and hindered attempts at community initiatives (Cernea 1989, 1990). People may have little incentive to participate in community-based programs that offer them only uncertain benefits (Shanks 1990). Many of these projects have often failed to reach a desired outcome (Gregersen *et al.* 1989). In the past few years emphasis has shifted from community

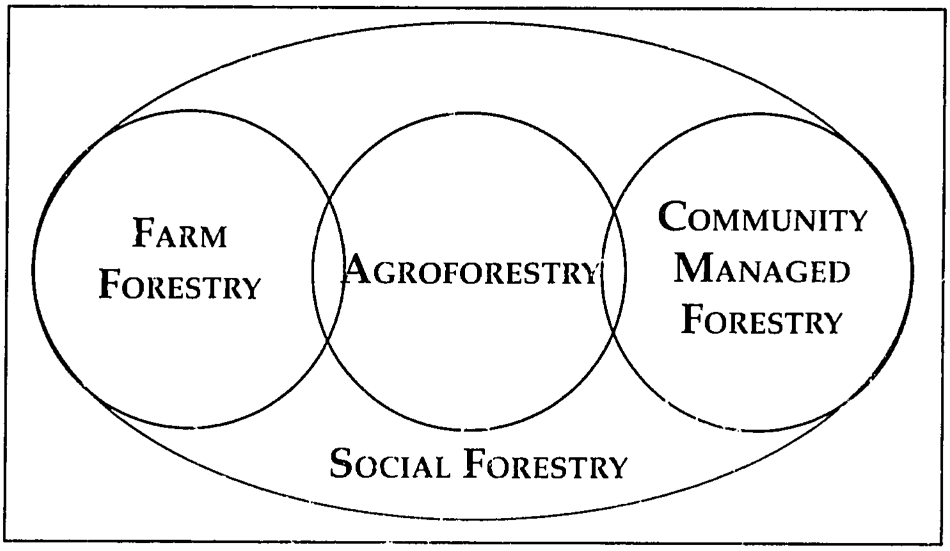
Definition of Key Terms Used

Social Forestry: a general term for the planting of trees by and for local people

Community Managed Forestry: forestry activities undertaken by distinct groups of people who plan, manage, and benefit from their activities

Farm Forestry: the planting of trees on a farm or part of a farm

Agroforestry: the spatial or temporal integration of trees with agricultural crops or livestock activities on one piece of land (can be part of farm or community managed forestry)



Relationship of terms used to describe social forestry activities.

managed programs to individual farm forestry (Cernea 1989, 1990).

Nevertheless, community managed forestry may play an important role in many areas. Landless and land-poor people in particular may only be able to participate in and benefit from forestry activities on communal or government land (Gregersen *et al.* 1989). For example, in West Bengal, India, a group of landless or marginal farmers were given usufruct rights to degraded government land. Incentives were used to encourage them to plant trees, with ownership of the trees guaranteed to participants. Collective action, such as tree protection, was facilitated by this approach (Cernea 1990). In Sudan villagers interested in establishing windbreaks applied for and received a small grant to initiate forestry activities. Working together the first year they started a nursery, planted, watered, and protected the trees. Though a modest beginning, the village has established ways to move forward in improving their local environment (Gamser 1987).

Community managed forestry is becoming important as an appropriate means to manage natural forests. Advantages of this approach include better monitoring and protection of the forest as well as more equitable distribution of benefits (Johnson *et al.* 1991). Some initial problems may have to be overcome, such as those natural forests most in need of management are also under the greatest human pressure (Gregersen *et al.* 1989) and legal and institutional arrangements may have to be worked out (Johnson *et al.* 1991). Nonetheless, some positive initiatives, many based on past experiences, have already begun and may be the best hope of conserving forest resources while meeting people's needs (see WRI 1991).

Farm Forestry

Farm forestry includes the growing of trees for commercial purposes and all other forestry activities on private land (Foley and Barnard 1984; Gregersen *et al.* 1989). Agroforestry is a term used to describe many farm forestry activities and is discussed in greater detail below.

Families constitute the social actor in farm forestry initiatives (Cernea 1989). Decision making and tree planting and management are carried out by family units. The size of the family and whether it is nuclear or extended varies in different regions.

Woodlots may be established on all or part of a farm to provide materials for home consumption, for sale, or both. In areas where land is plentiful and markets nearby, considerable returns to farmers may be realized from woodlots. For example, the Paper Industries Corporation of the Philippines (PICOP) guarantees a market and a minimum price for trees grown for pulp on private land. Farmers, however, are not obligated to sell their trees to the company (Gregersen *et al.* 1989). On a much smaller scale families in Sudan are establishing woodlots to provide materials for use at home. Lack of water limits the size of many of the woodlots, and all home needs can not be met (Wilson and Connelly 1990). Nonetheless, family expenses in terms of time to collect wood or money for purchasing it should be less.

One criticism of farm forestry activities is they may benefit the rich, sometimes at the expense of the poor

Community tree plantation, central India

Photo: J.F. Force

(Foley and Barnard 1984). There is often little opportunity for poor, landless people to participate in farm forestry activities. When large farmers convert whole farms to woodlots it may displace agricultural laborers or sharecroppers, leading to increased unemployment and the potential for greater poverty and may affect food self-sufficiency in the country. Consequences such as this illustrate the need to understand the socioeconomic situation in any area where social forestry activities are being promoted and the effect that those activities may have on the intended beneficiaries as well as other members of the community.

Tree planting on rice bunds, India Photo: J.E. Force

Agroforestry

Agroforestry refers to the growing of trees on the same piece of land as agricultural crops and/or livestock. In an agroforestry system there are ecological and economic interactions between the trees and other components (Nair 1989a). Agroforestry is a new name for an old practice, as people have been managing trees along with their other crop and livestock resources for centuries. Many agroforestry efforts focus on ways of improving traditional systems and adapting appropriate systems to new areas.

Agroforestry is not just a series of techniques or practices, but rather a whole approach to land use (Rocheleau *et al.* 1988). Agroforestry systems are sets of practices within specified settings that are described based on their biological, technical, economic, and social aspects (Young 1984). Various methods of classifying agroforestry systems have been developed to help in evaluating and improving programs and sharing relevant experiences between programs (Nair 1989c). The adoption of agroforestry systems can help farmers to increase the total productivity of their land by diversifying the possible products and at the same time they can lessen farmers' exposure to risk (MacDicken and Vergara 1990b).

Agroforestry is most often discussed in terms of a farm forestry initiative, with the family as the central decision-making unit. Many of the systems described so far are based on family endeavors (see Nair 1989b). However, important agroforestry systems are also carried out on communal lands. Pastureland management in arid and semi-arid environments is a common example, but even the growing of fodder grasses under a community tree plantation constitutes an agroforestry system as the components are being deliberately mixed with definite interactions between them.

Government forestry initiatives

While much attention in recent years has focused on social forestry programs, the role of government forest services is crucial to these and other tropical forestry activities. Governments are becoming more and more involved in trying to provide appropriate services to rural people interested in carrying out social forestry activities. This has necessitated a re-evaluation of government roles in providing technical and material support to rural people and communities interested in tree growing. Traditional forest service activities, such as establishing plantations, are still appropriate and needed in many areas. Though not a major focus of this report, some government activities related to tree growing for people are briefly described below.

Community Forestry

Some government forestry work, particularly in Asian countries, has focused on establishing woodlots intended to benefit a particular community. Forest departments plant and initially manage trees on communal property, with management eventually turned over to local community institutions. In India, communal responsibility for woodlots has not been assumed as anticipated in all regions (Arnold 1990). Nevertheless, there are regions where this approach has been successful and lessons learned there might be applicable in other areas (Arnold 1990). An understanding of the present uses of community property and the needs of community members combined with effective communication with local people at all stages of a project are necessary.

Peri-urban and bioenergy plantations

Government forestry departments have been involved in establishing peri-urban plantations for supplying wood,

Pandaygaon Community Forest Management

In 1978 the Nepal-Australia Forestry Project began establishing forest plantations in Kabhre Palanchok District, Nepal, in response to the pressure on local forests for various products. Local villager cooperation and assistance was essential for seedling production, plantation establishment and protection. In 1986 project activities shifted emphasis to developing forest management plans that were socially and technically appropriate. Importance was placed on encouraging village-level management of the plantations and natural forests.

Initial efforts to involve villagers through village-wide meetings and the formation of village committees proved ineffective. Project personnel had assumed that this method would provide essential village input into planning and lead to village-based management of the plantations and natural forests. In the end planners were faced with a lack of reliable information on which to base management activities and little concrete participation from the local people.

A new village-centered approach attempted in Pandaygaon has proved more valuable. Project personnel sought to understand the villagers through informal visits and discussions of forest management priorities with different user-groups. Initial forest management planning was done with villagers once they had a certain understanding of the concepts and benefits of forest management. This approach fostered participation by traditionally less-vocal users such as women and low caste people. The forestry committee formed in Pandaygaon has begun making and implementing decisions regarding forest management.

While villagers did not initially consider the forest as "theirs" this feeling has now been fostered. Villagers have now begun planting trees on private land and organizing village afforestation activities. The long-term sustainability of this approach is not yet tested, but it holds promise for encouraging participation in forest management in other parts of the District.

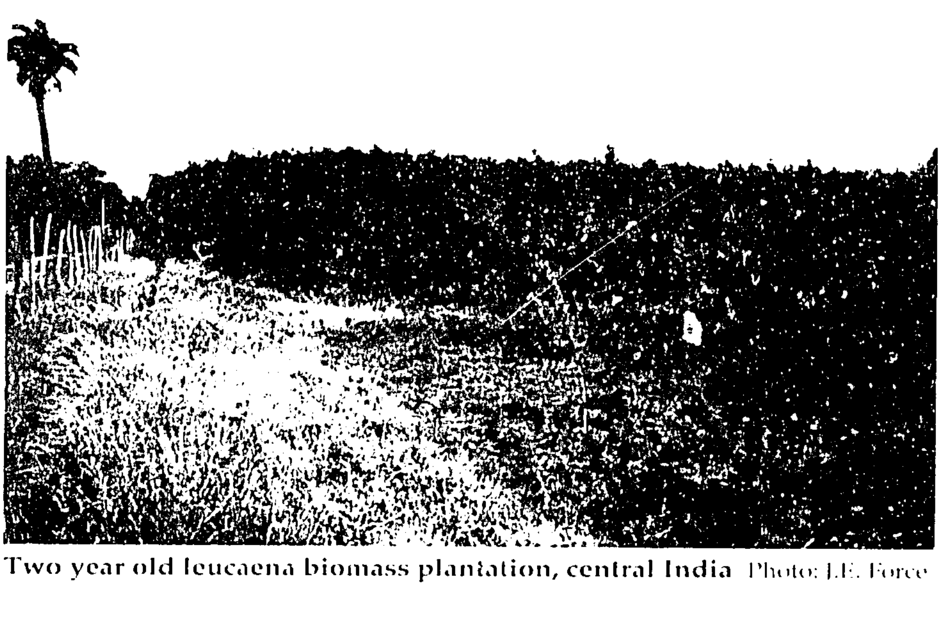
Source: Paudyal *et al.* n.d..

especially for fuel, to nearby urban centers in many countries. These types of woodlots are part of a broader category of bioenergy plantations, or tree plantations to provide biomass for energy. In most cases this involves using trees as firewood or converting them to charcoal. Conversion of biomass to gas or ethanol, or directly to electricity are other potential uses of bioenergy plantations (Davidson 1987; Wright *et al.* 1991). Bioenergy plantations may help to reduce exploitation of natural forests for energy needs and replace the use of substantial amounts of fossil fuel (Davidson 1987; Trexler *et al.* 1991).

Available land for these kinds of endeavors may be limited in many areas. Other sources of biomass, including parts of trees not used after harvesting and waste from wood processing operations, could also be used (Davidson 1987). The role that bioenergy plantations could play in national energy strategies and reducing deforestation will vary considerably based on country resources. They may however be one means to provide people with energy without continuing to deplete natural forests.

Natural Forest Management

Management of natural forests in the tropics has been occurring for generations. Traditional systems of forest use provided people with wood, fruit, and other products while assuring that the resource base remained (Caufield 1985). Shifting cultivators farmed cleared plots in the forest for a few years and then left the plots to regenerate for 10 or 20 years or more (Miller and Tangley 1991; Peters and Neuenschwander 1988). Pastoralists in some parts of Africa practiced "shifting pasturage" - after heavily grazing a woodland it was left to rest for 10 to 50 years (Niamir 1990). But these traditional practices are breaking down as pressures on the forest resource increase through population growth, increasing demand for forest products and agricultural land, changing land tenure, government policies and institutions, and economic incentives that place more value on one-time forest goods than the long-term productivity of the forest (Caufield 1982, 1985; Goodland *et al.* 1990; Johnson *et al.* 1991; Miller and Tangley 1991; Peters and Neuenschwander 1988). Forest areas are no longer given time to recover



Two year old leucaena biomass plantation, central India Photo: J.E. Force

Natural forest, Anjouan, Comores Photo: T. Tear and D. Forester

from use as fallow periods become shorter; more forests are constantly being converted to permanent cropping, agriculture, or other uses.

While most considerations of traditional forest management concentrate on shifting cultivation there are examples of other forest management activities. For example, in parts of Mexico special forests were set aside for the management of preferred species (Gómez-Pompa and Kaus 1990). In the Amazon floodplain people continue to practice "tolerant" forest management in which a wide variety of products are gathered in forested areas that are carefully managed to favor desired species (Anderson 1990).

Commercial timber production from tropical forests, especially tropical moist forests, is an important national and international economic activity in many countries (FAO 1989c; Laarman 1987). Yet the forest resource is shrinking: up to 20.4 million hectares of tropical forest are lost annually (WRI 1990). At the same time demand for tropical timber is increasing. "Tropical forests supply about 30 percent of the world's log exports, about 12 percent of the sawnwood exports, and about 60 percent of plywood and veneer exports" (Miller and Tangley 1991:29). Forest harvesting practices in many countries may destroy more timber than is harvested (Johnson *et al.* 1991; Postel and Ryan 1991). There is an urgent need to implement sustainable timber management practices in the tropics if this resource is to continue (Goodland *et al.* 1990).

At a recent colloquium on sustainable tropical forest management some of the key problems associated with present activities were discussed including (WRI 1991:2-5):

1. The undervaluation of forest resources which leads to under-investment in sustainable management and over-exploitation of the resource. A realization of the true economic and environmental value of forests may help to encourage better management.
2. The value of conserving biological diversity in tropical forests suggests that large areas should be protected while activities in the surrounding region are implemented so as not to threaten species in those natural areas. One of the opportunity costs in biological diversity protection is the value of timber foregone.
3. Initiatives to include local people in forest management should be explored. Governments are often ill-equipped to control access and use of forest lands while local people lack the institutions and technical knowledge to manage large areas.
4. The policies of industrial forest concessions need to be re-evaluated in terms of their role in fostering destructive logging practices.
5. Attention needs to be paid to farming activities on land surrounding forests to increase their productivity without expanding their range into the forest. The role of plantations and secondary forests in providing wood products needs to be strengthened.

There is an urgent need to implement sound management practices on tropical forest lands to help conserve the resource base while at the same time providing products and income to local people that depend on the forest (WRI 1991). Sustainable harvesting of timber combined with a continuing supply of non-wood forest products is essential. While there is a need for more information on how to manage tropical forests, experience from past and on-going management activities provides valuable knowledge for designing forest management strategies (FAO 1989d).

"Silvicultural system" is the technical term for forest management strategies. The methods used in a system take into account the ecological requirements of the species being managed and are concerned with the growth, harvest, and regeneration of the forest. Four general harvesting methods are often identified (FAO 1989d). In a *selec-*

tion system isolated trees or small groups of trees are cut throughout the forest. In a *uniform* or *shelterwood system* a proportion of trees distributed over the entire stand are cut. With a *seed tree* or *standards system* most of the trees are cut, while in a *clearcut* or *clear felling system* all trees in the stand are cut. Natural regeneration is possible in all of these systems. Artificial regeneration may supplement natural regeneration or be the sole method of regenerating the stand (FAO 1989c). Tending operations, including thinnings, are sometimes carried out between harvests. The complexity of tropical forests makes the designing of silvicultural systems appropriate to individual forests challenging and more research needs to be done in this area (FAO 1989d).

Examples of past silvicultural systems that were potentially sustainable lend insight into future possibilities. The Malayan Uniform System was first used in Malaysia in the late 1940's and was practiced with modifications until at least the 1970's. It involves transforming the forest to an even-aged stand of desirable species through release cuttings, poisoning undesirable species, harvest, and tending operations (FAO 1989d; WRI 1991). The system was used in the lowland dipterocarp forest, it was tried and found unsuccessful in hill dipterocarp forests (FAO 1989d). Much of the land on which the Malayan Uniform System was practiced has now been converted to agriculture and cash crops (Goodland *et al.* 1990; WRI 1991).

Based on experience in Malaysia a similar Tropical Shelterwood System was begun in Nigeria. While there were some problems with application of the system to species in Nigeria increased research may have helped to improve it. But the system was abandoned in 1966, mainly for political reasons related to converting the land for agriculture and urban and industrial development. Some of the forest was to be converted to fast-growing plantations (FAO 1989c).

Other silvicultural systems used in parts of India, Burma, the Philippines, Uganda, Côte d'Ivoire, and elsewhere have shown promise as sustainable ways to manage tropical forests (FAO 1989c,d). The practice of many of these have faced fates similar to the Malayan Uniform System and the Tropical Shelterwood System in Nigeria as land is allocated to other uses and institutional and economic support for natural forest management decreases (Johnson *et al.* 1991).

Selective logging with apparently little regard for future forest productivity is practiced in many tropical forests today (Hutchinson 1987). According to a 1989 study done for the International Tropical Timber Organization (ITTO), less than 0.1 percent of all tropical logging is being done on a sustained-yield basis (Postel and Ryan 1991; Repetto 1990), to mention nothing of the sustainability of the forest itself. Efforts are devoted to removing all commercial trees, which may be only a few species. Damage to residual stands is often heavy, resulting in poor growing stock for future harvests (Repetto 1990). Corrective measures may not be difficult, in some areas just cutting all lianes two years before logging has reduced damage to the residual stand (Wadsworth 1987).

Secondary forests, those that have been cut over relatively recently and not converted to other uses, could be an important source of tropical timber needs (Postel and Ryan 1991). Improvement practices can help to promote the growth of desirable species in these forests. Tending activities designed to identify crop trees and liberate them, through overstory removal and girdling and poisoning of undesirable trees, may help to improve the returns possible from these forests and bring them back into productive use (Hutchinson 1987; Wadsworth 1987). These secondary forests could play a vital role in providing forest products in the future. With proper management they can be returned to a productive state, providing the myriad of benefits available from natural forests. Putting these areas under sound management programs may decrease the amount of virgin forest cut to satisfy the growing demand for tropical forest products.

Policies and laws that reflect the true economic value of forest products and long-term sustainable forest management need to be implemented and enforced (Johnson *et al.* 1991; Repetto 1990). Logging damage can negatively impact the ability of the forest to continue producing timber and also impact other forest activities such as commercial fruit collection (Postel and Ryan 1991). Indigenous cultures worldwide are threatened by the shrinking forest resource (Miller and Tangley 1991). Those costs are not measured in most timber harvesting evaluations. The awarding of forest concessions needs to be revised to assure a minimum level of stand quality after logging and to reflect the true cost of the timber harvested (Johnson *et al.* 1991). While some have called for discarding concessions altogether (WRI 1991) others have suggested that long-term concessions providing incentives to practice better forestry should be used (Miller and Tangley 1991).

It is suggested that markets need to be developed for tree species that are presently left after harvesting operations. This would lead to a decrease in the area being logged to gain the same revenue while helping to improve the logged forests silviculturally (Plumptre 1990). An estimated 93% of tropical forest volume is made up of "underutilized" species (Duke *et al.* 1991). While some knowledge may exist on a local level about many of these species, further investigation is needed into local, and potential international, markets for many of these species. Developing markets for these species could contribute to short-term monetary payoffs as well as long-term social and economic development (Duke *et al.* 1991). While market development for presently unused species might increase the financial returns of natural forest management, the risk of

Yanesha Forestry Cooperative

In the Lower Palcazu Valley at the eastern base of the Peruvian Andes a local forestry cooperative is working to manage a tropical rain forest. A project funded by USAID has been working with indigenous Yanesha Indians to help increase their socio-economic well-being through sustainably managing the forest. The Yanesha are involved in all aspects of forest management from decision-making through harvesting, processing, and marketing the wood products.

A strip clearcut system is used, with long clearcuts 30-40 meters wide surrounded by natural forest. Steep slopes, swamps, riparian zones, and primary forest are not harvested. Animal extraction minimizes damage to the residual stand. Initial results suggest that the system is sustainable as natural regeneration has been abundant. Tending activities should improve the value of regenerated strips.

Forest products are processed in a local mill. Wood that can be turned to no other use is made into charcoal. Initial net returns of $3500 per hectare for harvesting and local processing have been calculated. A planned expansion and diversification of processing capabilities, using specialized equipment, should increase potential net returns to $27,500 per hectare.

The project has helped to assure legal recognition of native land claims and helps to protect the social and cultural integrity of the Yanesha. Success of this project may help in demonstrating that indigenous communities interested in the long-term sustainability of their resources are invaluable partners in natural forest management.

Sources: Hartshorn 1990; WRI 1991.

stimulating short term timber mining exists (Johnson *et al.* 1991; FAO 1989d).

The inclusion of local people in managing the resource could be a powerful force in assuring sustainability. Recent initiatives suggest that numerous possibilities exist (see WRI 1991 and box). By building on past experiences lessons learned in one area can be applied elsewhere. Local communities may be more committed to sustainable use of the forest and its perpetuation as a resource than government bureaucracies or outsiders (Johnson *et al.* 1991).

Extractive reserves, in which traditional cultures sustainably harvest forest products such as rubber and nuts, are becoming increasingly appealing as an appropriate use of the tropical rain forest. Extractive reserves can have several positive impacts on regional development and conservation including reducing migration from rural to urban areas for employment or other purposes, increasing chances for success and sustainability of activities as local people play a direct role in designing programs, and low forest protection costs due to the presence of resident populations seeking to preserve their livelihood (Allegretti 1990).

At present most tropical timber exploitation, for both domestic use and exports, is from the Asian countries. As resources there disappear export activities are expected to shift to Africa and Latin America, which will also be experiencing increased domestic consumption (Grainger 1987). Steps need to be taken now to assure that all regions of the world will be able to produce adequate timber and non-timber products from their natural forests now and in the long-term future.

Tree Planting Spaces

Opportunities for tree planting in the tropics exist on a variety of different lands that are privately owned, common property resources, or government owned. Trees may be planted singly or in various configurations designed to meet the specific goals of the landowner. Tree planting programs in tropical countries will vary by land ownership patterns, owner objectives, and ecological conditions. Any planting program should take into consideration the variety of different spaces available for tree planting and growing activities.

Enrichment planting in natural forests

Enrichment plantings offer a technique to greatly improve the biological and financial productivity of natural forests through artificial regeneration. It is the planting of single trees or small groups of trees of desired species in gaps or other appropriate spaces in degraded forests (FAO 1989c; Weaver 1987). Enrichment plantings are done to increase the availability of certain species which may take a long time to regenerate after forest harvesting or for which young growth or seed sources are sparse.

Several different techniques for enrichment planting based on the site preparation and planting configuration have been used (see Weaver 1987). In savanna areas of Africa enrichment plantings have proved costly with limited success (FAO 1974). Work done in the neotropics has shown the potential for enrichment plantings if appropriate species and sound establishment techniques are used (Weaver 1987). Further research with enrichment plantings is needed in all parts of the tropics to develop sound practices appropriate to various species that are cost effective.

Eucalyptus trees grown along field edges, Pakistan

Photo: T. Tear and D. Forester

On-farm tree planting

Farm lands are one of the largest sources of potential tree planting spaces in the tropics. Farms that are owned by those who farm them offer the greatest possibility for this type of activity as the long term nature of tree growing activities has a greater chance of success when land and tree tenure are secure (Bruce and Fortmann 1988, Foley and Barnard 1984). Trees can be integrated into farmlands with annual crops or farm lands can be converted to woodlots for personal use and sale.

Agroforestry involves the integration of trees and other woody perennials into crop and pasture lands. Several arrangements, or configurations, of trees are often identified: in rows or lines, around the perimeter of a field, dispersed in fields, or evenly spaced. The exact arrangement will depend on the farmers' needs, species availability, and ecological conditions in the area. Techniques for managing the trees vary based on the configuration and the species used. Research is still needed on the effectiveness of agroforestry practices in different ecological zones using different species (Kerkhof 1990; see MacDicken and Vergara 1990a).

Alley cropping or hedgerows involve the closely-spaced planting of trees, often nitrogen-fixing, in lines with agricultural crops grown between the lines. The trees are regularly cut back to avoid severe shading of crops, with the organic matter incorporated into the soil (Rocheleau *et al.* 1988; Weber with Stoney 1986). Alley cropping methods are adapted and changed by farmers in different areas (Kerkhof 1990). In steep areas trees may be planted along contour lines to stabilize soil and reduce water runoff. To be more effective these trees may be planted with grasses or other plants such as pineapple or combined with structural measures such as contour ditches, bunds, or terraces (Rocheleau *et al.* 1988; Weber and Hoskins 1983). The trees are managed to provide an effective barrier against eroding soil and to facilitate water infiltration.

Windbreaks or shelterbelts are one or more rows of trees and shrubs planted perpendicular to the prevailing wind. The trees protect cropland from wind erosion and desiccation of agricultural crops. Exact design specifications will depend on the number of farmers involved in the effort, from one to many, and other desired products from the windbreaks (Rocheleau *et al.* 1988).

Living fences are trees planted around the perimeter of a farm or field. They protect cropland from unintended livestock entry or can serve to keep livestock in an enclosed area. They help to demarcate property lines and may also function as windbreaks. Trees that reproduce from cuttings can be a practical way to establish a quick and effective fence (Rocheleau *et al.* 1988).

Dispersed trees in farmlands may serve a variety of farmers' needs. They may help to increase agricultural yields as well as provide various products including wood, fruits, or nuts. Farmers may allow wildlings of beneficial or desired trees to grow in their farms or plant trees from nursery stock (Kerkhof 1990). Trees may be planted to provide shade for other crops such as coffee or cacao (MacDicken 1990).

Whole farms or parts of farms may be converted to tree growing on a temporary or permanent basis. Improved fallow systems, where trees are planted on fallow land to improve soil fertility for subsequent annual crops and provide products are often carried out with fast growing nitrogen fixing trees. Trees are allowed to grow for several years depending on land availability and species, the entire area is then harvested and replanted to annuals (Rocheleau *et al.* 1988)

Farms or portions of farms may be converted to woodlots, with trees grown to produce wood products for home consumption, or for sale in the local market or to industrial concerns such as pulp mills. Some woodlots may be small and provide only a portion of wood needs (Wilson and Connelly 1990). Larger woodlots may be established where people have ample land and access to capital. Farmers establishing woodlots may use their own design, adapting information from forestry services to fit their needs (Kerkhof 1990). Woodlots are particularly appropriate on steeply sloping land where the potential for income is greater from tree products than agricultural crops.

Homesite and urban tree planting

Trees may be planted around the homesite for a variety of purposes. In some cases trees provide shade or a ready source of fruit, fodder, or vegetable material in addition to wood. Planting trees around homes can be an especially easy method to increase tree production as tending is easy.

While they are not necessarily located adjacent to homes, elaborate home gardens are maintained in many areas. They are layered gardens of trees, shrubs, grasses, and annual crops, including vegetables. Small livestock or chickens are not uncommon. The complexity of home gardens and the components used vary in different regions (MacDicken 1990; Rocheleau *et al.* 1988). In some areas home gardens are an important source of family nutritional, material, and income needs (Anderson 1986).

Tree planting may also take place around schools, office buildings, public meeting areas, or along roads and stream, river, or canal banks. These plantings provide amenity benefits like shade and reduced dust in adjacent areas. They help to protect stream and river banks from erosion as well as providing wood and other tree products (Rocheleau *et al.* 1988).

Communal lands

Community owned lands offer another opportunity for tree planting activities. A distinction needs to be made between common property resources that are owned and managed by a group of people and community land that is *de facto* private land (Cernea 1989). Customs will vary between areas, but efforts at promoting community managed forestry have failed when organizers failed to understand the true nature of land tenure arrangements (Cernea 1989; Noronha and Spears 1985).

Nevertheless, common property lands may be planted to trees and managed by a group of people interested in producing trees for a variety of purposes. Most of the planting to date on communal lands seems to have been carried out by forest services, particularly in Asian countries. After a period of time management of the established plantations is to be handed over to local groups (Arnold 1990; Foley and Barnard 1984).

Pastoral lands are often common property resources. Tree planting in these areas is an expensive activity, which hampers widespread adoption (Kerkhof 1990). However, pastoralists in parts of Africa have been known to plant cuttings of trees or transplant wildlings (Niamir 1990). Controlling grazing and other range use may be the most effective way to encourage tree growth on pastoral lands (Kerkhof 1990).

Government lands

Government lands have been a traditional site for tree planting activities in tropical countries. Plantations have been established on these lands to provide wood products for rural and especially urban populations, and for national industry as well as for the export market.

New strategies to increase the potential returns from reforestation on government lands are needed. While in the past government forests were cleared to make way for plantations there is recognition that natural forest management may be more financially sound in addition to its environmental benefits (Casey and Muir 1986; Fortmann 1988a; Gregersen *et al.* 1989). In areas where reforestation is the only alternative to bring an area back into production approaches involving local people have been tried.

A plantation establishment arrangement begun in Burma called the taungya system is used in several countries to reforest cut over government forest land. The system has been adapted to different conditions and goes by a variety of names (Nair 1984). Landless or land poor farmers, including shifting cultivators, are given temporary usufruct rights over a piece of land. They are required to plant and tend trees for several years. At the same time they can cultivate annual crops between the trees. Once the trees have become established farmers must move to new areas. Taungya systems can reduce the cost of establishing plantations (MacDicken and Vergara 1990b; Oduol 1986). Land tenure constraints can limit its effectiveness (Barke. 1990) and the practice sometimes exploits cheap labor (Gregersen *et al.* 1989).

In some areas where taungya-type systems are practiced, incentives in the form of land for houses, building materials, schools, medical facilities, electricity, and money are provided (Barker 1990; Boonkird *et al.* 1984; Oduol 1986). In the Philippines farmers have been granted tenure over the land they plant, and sell some of their tree crop to a local pulp mill (Barker 1990). In Thailand a taungya system is promoted as Forest Villages for settling shifting cultivators and landless people on degraded lands by the Forest Industries Organization. The program has proved slightly more costly than traditional plantation establishment but has helped to settle some people who would normally practice shifting cultivation (Boonkird *et al.* 1984). The program has had less than the anticipated adoption rate and faces several socioeconomic constraints (Boonkird *et al.* 1984; Vergara *et al.* 1986).

Wastelands or marginal lands

Wastelands and other marginal lands may exist on sites held by individuals, communities, or governments. They are severely degraded with little or no productivity, often due to past human actions. These lands offer some of the largest potential for bringing land into productive tree cover (Gregersen *et al.* 1989), though attention must be paid to other current uses of the land, such as grazing (Shepherd 1985).

The reclamation of wastelands through tree planting activities may involve simple technologies already well-tested. In other areas cost effective means of planting appropriate species are being developed (Shah and Weir 1987). Examples of wasteland rehabilitation in India (see box) illustrate the potential for increasing tree cover and the economic standing of the rural poor, including women, through these activities.

Rehabilitating Wastelands in India

Activities to rehabilitate wastelands in India serve to bring degraded lands into tree production while increasing the economic well-being of poor and landless people. Several approaches in different ecologic and social settings have been used.

In West Bengal poor farmers near the village of Nepura have been planting trees on degraded lands since 1981. In a land redistribution scheme farmers were allocated plots of land that were generally of poor quality and proved unsuitable for agricultural crops. Groups of farm families are encouraged to plant trees in blocks of 20 hectares or larger. They are provided with free seedlings and some fertilizer and pesticides. Initially, financial incentives based on tree survival were also provided. Protection of plantings from livestock is facilitated by the vested interest participants have in the trees. Over one million trees were planted on over 1600 plots between 1981 and 1986.

In Gujarat women are working with a local NGO, Mahiti, to rehabilitate saline wastelands along the west coast of the Gulf of Khambhat. The women collect the seed of a species of *Salvadora* for sale to local traders. This tree grows well in saline areas and oil from the seed is used in soap and varnish manufacturing. They plan to establish plantations of this important species on public wastelands and eventually extract the oil themselves. This effort helps to increase the economic standing of the women and their families while bringing otherwise unproductive land into tree cover.

In eastern Gujarat villagers are working with the Aga Khan Rural Support Programme to plant trees on public wastelands. These lands are primarily used for livestock grazing, the program aims to increase their productivity through tree planting. Villagers are employed to prepare the land and plant the trees. For the most part employment is spread equitably throughout the villages, though landless families and those with small holdings are able to work more during peak farming times. Further financial gain can be realized by raising seedlings for wasteland rehabilitation. Protection of the planted wastelands has lead to regeneration of grasses which have been harvested for fodder by villagers. Efforts are being made to ensure that villagers have legal rights to these trees.

Sources: Shah and Weir 1987; Shah 1987.

Tropical Tree Planting Technologies

Nurseries are a primary source of seedlings for most tree planting activities. In some areas local farmers may already be raising many of their own seedlings in small nurseries. In many countries large centralized nurseries have been established for raising seedlings. While large nurseries may help in coordinating nursery management they generally pose problems when it comes time to distribute seedlings, as they may be far from potential planting sites and expensive transportation may be needed. Nonetheless, particularly in the semi-arid tropics where water availability is limited, they may be the only means of raising seedlings (Jagawat 1989).

In areas where water is plentiful, small, decentralized nurseries, controlled and run by the people who will be planting the trees provide a much better and less costly alternative (Buck 1989). In these nurseries local people can become involved in all aspects of species selection and raising seedlings, thus there is a greater chance of producing trees that will be planted. The seedlings will also be closer to planting sites and easily accessible to the local population when they are ready for planting (Jagawat 1989).

Species Selection Considerations

The first consideration in any tree planting program is the selection of species to be used. The determination of which trees to be planted should depend on the use of the trees and their products as well as the environmental suitability of the species being considered (Foley and Barnard 1984; Webb *et al.* 1984; Weber with Stoney 1986). Local customs and legal constraints may influence species choice (Weber with Stoney 1986). The final choice should be made by the people who are going to use the trees, a point that is all too often overlooked (Foley and Barnard 1984).

The tree species used in woodlots, various agroforestry configurations, and urban plantings may very well be different. In the case of a woodlot farmers might prefer species that provide high quality fuelwood or building poles; while a species suitable for hedgerows might be nitrogen-fixing, produce fodder, and readily coppice; a large shade tree might be appropriate in an urban setting. Selecting trees for social forestry purposes, particularly agroforestry, may be more difficult than for industrial plantations as the trees are expected to fill a variety of needs, while knowledge of the multipurpose trees often promoted for these purposes is just emerging (Wood 1990). In addition, farmers in different areas may have different tree species preferences. A study done in the Philippines found that upland and lowland farmers preferred different species for fruit, fuelwood, and lumber (Ponce *et al.* 1991). The areas where trees are to be planted - around the home, as fencing, or in fields -also influences farmer tree preference (Wickramasinghe 1991).

Sources of Information on Appropriate Tree Species for Different Uses and Sites

Davidson, J. 1987. *Bioenergy Tree Plantations in the Tropics*

Little, E.L. 1983. *Common Fuelwood Crops*

NAS. 1980. *Firewood Crops*

NAS. 1983. *Firewood Crops, Vol. 2*

Rocheleau, D. *et al.* 1988. *Agroforestry in Dryland Africa*

Webb D.B. *et al.* 1984. *A Guide to Species Selection for Tropical and Sub-Tropical Plantations*

Weber, F.R. with C. Stoney. 1986. *Reforestation* in Arid Lands

(Complete references are in the literature cited.)

Information on known environmental requirements and potential products and uses of a wide variety of tropical tree species can be obtained from organizations such as the Nitrogen Fixing Tree Association, Hawaii, USA. Some books with useful information are listed in the box.

Environmental considerations in species selection include the following (Webb *et al.* 1984; Weber with Stoney 1986):

- climate (rainfall amount and seasonal distribution; humidity, temperature and incidence of drought);
- soil chemical and physical properties;
- elevation, slope, and topography;
- species susceptibility/resistance to disease, pests, and fire; and
- species palatability to livestock.

The availability of seeds or planting material is also critical (Foley and Barnard 1984; Webb *et al.* 1984). If material is not available locally it may be difficult or costly to bring it in from elsewhere. Careful tracking of any seed provenances used can help in selecting the best genotypes for a particular area (Webb *et al.* 1984; Wood 1990). Local information on yield and growth rate, or published information from elsewhere, may help in determining potential returns from any tree planting activities (Foley and Barnard 1984).

Indigenous species, already adapted to local conditions and familiar to local people may be the best choice in many circumstances and should always be the first tried (Ffolliott and Thames 1983; Foley and Barnard 1984; Kamweti 1982; NAS 1980; 1983). Nonnative trees already used in an area or well known from areas with similar ecological characteristics may be appropriate. However, care must be taken in using them, as they may adversely affect the local area or may not perform as well as anticipated. Local trials of any new species should always be carried out (Ffolliott and Thames 1983; Kamweti 1982; Wood 1990) before widely promoting them among farmers.

Seed Collection and Storage

Proper seed collection and storage is essential to successful tropical tree planting initiatives. Whenever possible seeds should be collected from trees in the area where they will be planted. Such trees have already shown themselves to be adapted to local conditions.

Trees for seed collection should have the appropriate characteristics to provide the final use of the tree (Teel 1984; Weber with Stoney 1986). For example, trees that are to be used for building poles or timber should be tall and straight. Desirable trees for fodder production may be fast growing and coppice readily. Trees that produce little shade might be preferred in farmlands. In all cases tree species or genotypes that are free of disease or insect problems or identifiable growth problems should be selected.

The identification of potential seed sources before the trees set seed can help to ease the coordination of collection activities. In general, the pods or fruits should be collected just as the seeds ripen and before they fall. Seeds of different species will be ready for collection at different times of the year and collection activities must take this into account (Teel 1984).

Once collected most seeds need to be extracted from the fruit or pod and dried before storage. Extraction of seeds usually involves soaking pulpy fruits until the flesh can be removed or pounding or thrashing dry pods or cones and then winnowing them to separate out the seeds (Kamweti 1982; Weber with Stoney 1986) Seeds can then be sun dried on large tarps during the cool part of the day for several hours or days before storage.

Many problems have been encountered in seed storage in the tropics. Seeds should be kept in a dry, cool area, free of potential insect or disease attacks. Techniques for storing tree seeds may benefit from local experiences storing agricultural seeds. In most areas sophisticated seed storage facilities are unavailable. Dry seeds can be placed in labeled jars or tins and stored in a cool place, such as a shaded cement room (Mbonye and Kiambi n.d.; Weber with Stoney 1986). In some cases it may be necessary to treat seed with pesticides before storage to protect them against possible insect and disease attacks. Locally made pesticides may prove appropriate and offer a cost savings over commercial products.

Some seeds do not store well, these species should be identified so that they may be sown as soon after collection as possible (FAO 1974; Kamweti 1982). In some cases refrigeration may be used to store those seeds where facilities are available (Kamweti 1982). Species to be tried that are not available locally may be obtainable from other areas in the country or from commercial suppliers.

In areas where land is available seed orchards of selected species may be started to assure a continuous supply of high quality seed of desirable species (Namkoong 1990). Some trees reproduce quite well from cuttings and the availability of sources of those cuttings near seedling distribution centers (nurseries) can help in their distribution.

Private tree nursery, Sri Lanka Photo: J.E. Force

Nursery operations

Nursery Site

The first essential ingredient for tree nurseries is an adequate and reliable source of water. Water must be available throughout the nursery season from a pipe, well, river, or lake. While a gently sloping, well-drained site is desirable, successful nurseries have been established on terraced hillsides.

The nursery site needs to be protected from severe winds and wandering livestock. Live or dead fences made from local materials can keep animals out; in regions where this material is not available fencing may have to be purchased. The area necessary will depend on whether bare root or potted seedlings are to be raised in the nursery and the number of seedlings needed. As a general rule an area of 10 square meters will be necessary for every 1,000 bare rooted seedlings and 7 square meters for every 1,000 potted seedlings to be raised, plus land for walkways, work areas, and storage (Weber with Stoney 1986).

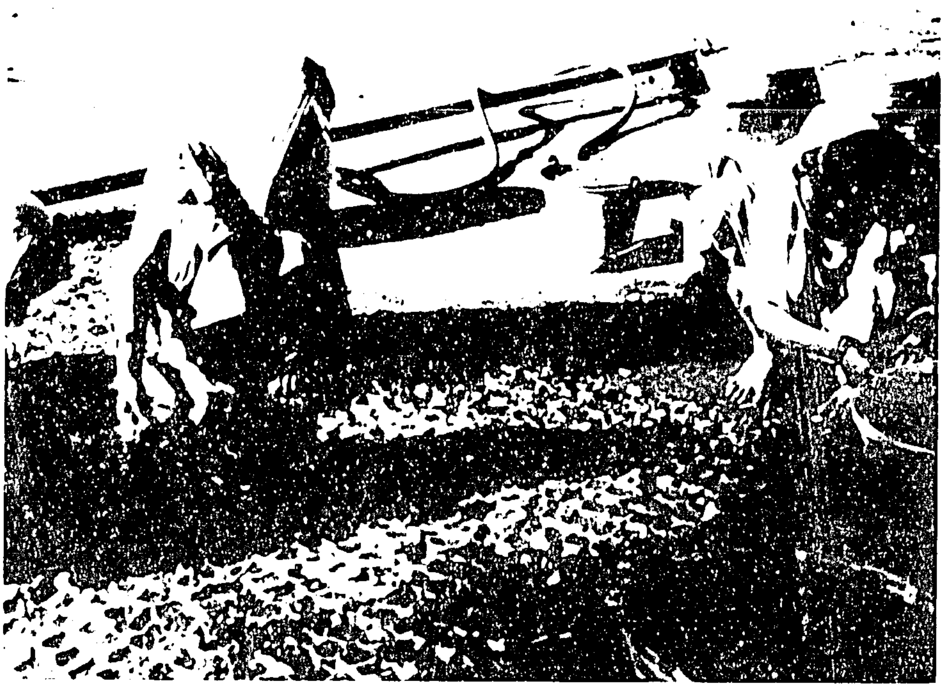
Adequate quantities of fertile soil, either in the nursery or nearby, is necessary for raising seedlings. Compost or manure can be added to soil to improve fertility. In some areas truck access may be necessary for transporting materials, such as soil for filling pots, or for distribution of seedlings.

Producing Seedlings

The seeds of some species may need pretreatment prior to sowing. In some cases this may involve physical or acid scarification of the seed, or soaking them in a hot water bath for 12 - 24 hours or longer (Teel 1984). Certain species may benefit from inoculation with organisms with which they have symbiotic relations, particularly if they are not already present in the soil. Many legumes fix nitrogen in association with the proper rhizobia bacteria (Roskowski 1987; The Nitragin Company, n.d.); other trees such as alder and casuarina are nodulated by a nitrogen-fixing actinomycete, *Frankia* (NFTA 1986). Different pine species require mycorrhizae for growth (Webb *et al.* 1984). Seeds may be inoculated before planting with commercially available inoculum. In some areas soil that contains the appropriate nodules or mycorrhizae can be incorporated into the nursery beds or pots to help inoculate the trees.

Seeds may be sown directly into pots or bare root beds. Alternately they may be sown in seed beds for later transplanting into pots or bare root beds. In general, large seeds (e.g. leucaena) may be suitable for direct seeding while smaller seeds, such as eucalyptus, may be better sown in a seed bed first.

After sprouting, seedlings may be raised in pots or in bare root beds (Weber with Stoney 1986). Different techniques are used in different areas depending on the availability of materials, the distance to planting sites, and feasibility of the different methods. Pots can take a



Transplanting eucalyptus seedlings into pots, India Photo: J.F. Force

number of different forms. Commercially available plastic pots or tubes are used in some areas. These pots are available in different sizes which can be chosen based on the time the seedlings will be in the nursery and the nature of the tree. Pots can also be made from local materials, such as banana leaves or stems, tin cans, or milk cartons. Locally made pots may be cheaper than commercial ones and may work just as well. Pots may be transported to the planting site several days before planting and must be removed at the time of planting.

Seedlings are also raised in nursery beds as bare root stock. At planting out time these seedlings are lifted from the bed. This type of system is better suited to regions where there is little concern about root damage. Plant roots must be protected after they are lifted out of the nursery and before planting. Large numbers of seedlings may be easily transported.

In parts of east Africa "Swaziland beds" are used to raise seedlings (Abell and Armstrong n.d.; Forester n.d.). These are nursery beds bordered by logs or planks. Root pruning is done periodically along the bottom of the planks with a wire and between the seedlings with a machete or knife. Seedlings are lifted out of the beds for planting.

In the nursery seedlings need to be watered regularly and kept free of weeds. During seedling establishment some type of shade may be necessary, especially during the hottest parts of the day. As they get larger the shading is discontinued. A few weeks before planting out watering is gradually reduced to harden the seedlings off. Seedling size at planting out will depend on the species and the area in which it is to be planted. Sizes of from 30 cm. to 50 cm. in height are not uncommon.

Nursery seedlings must be protected against disease and insect attacks (Weber with Stoney 1986). Damping off, the generic term for a fungal infection, is common in some areas. Decreased watering may be effective in controlling it. Bacteria and viruses as well as insect and other pest problems can cause nursery losses. Locally derived pesticides may help in controlling problems, though commercially available chemicals may be necessary. In some cases soil sterilization may be necessary (Briscoe 1990). Integrated pest management, which stresses the use of biological and cultural control of pests and diseases when they can supplant chemical treatment (Weber with Stoney 1986), holds promise as a cost-effective way to deal with nursery problems.

New Technologries

New tree nursery technologies are constantly being evaluated. For example a low technology non-mist propagator for use in vegetative reproduction of trees may prove promising in dry areas (Leakey *et al.* 1990). Micropropagation with tissue cultures and clone banks can be used to produce large quantities of seedlings from good root stock (Madoffe and Chamshama 1989; Tingsabadh and Phutataporn 1989). Continuing work on inoculums can help to improve tree growth and assure that appropriate materials are used (Roskowski 1987; Tingsabadh and Phutataporn 1989). These technologies, however, may prove too costly and knowledge-intensive to be widely disseminated for small scale nursery production (Tingsabadh and Phutataporn 1989).

Fruit Trees

Techniques for raising fruit trees in nurseries are often quite different than techniques used for multipurpose and timber trees. Specially trained personnel, capable of choosing rootstocks and scions, with knowledge of grafting techniques are necessary to manage fruit tree nurseries (Camacho-Bustos 1983). Good sources of information on raising fruit trees include *The Propagation of Tropical Fruit Trees* (Garner *et al.* 1976) and *Orchard Management* (DRC 1969).

Outplanting

Outplanting is usually undertaken at the onset of the rainy season. Some areas may have two rainy seasons while others receive rain nearly year round. Requirements for different species will vary by area, and local knowledge is essential in determining the best time to plant. The onset of the rains tends to be a busy time for farmers who must also be concerned with their agricultural crops. Strategies designed to minimize farmers' time requirements for tree planting can help to increase farmer planting.

Holes for tree planting can be dug from several days to several weeks before the trees are to be planted. Holes should be large enough to accommodate the seedling and the soil inside the bag or to place the bare root tree so that the roots approximate their arrangement in the nursery bed.

Supplemental watering of planted trees in most areas is not necessary. Micro-catchments can be constructed to help channel water to trees (Briscoe 1990). In drier areas irrigation may be necessary. One method that has been used in arid regions to sink a clay pot or tin can with small holes in the bottom of it next to the seedling. The pot can be filled with water which will trickle into the soil next to the seedling's roots (Buck 1989; Weber with Stoney 1986).

Tree Protection

During the first few years trees will need to be protected from grazing livestock. In some areas a fence can be constructed or live fences planted around the entire field, while in some instances individual tree fences may be appropriate. Guards are sometimes employed to keep cattle, goats and other livestock away from plantations. In farmers' fields protection may only be necessary when there are no agricultural crops in the field.

Young trees need to be weeded to assure the best possible growth (Briscoe 1990). This task is facilitated on trees grown in farmlands because they are weeded as the crops are. In woodlots trees will need to be weeded once or twice a year for the first few years of growth.

Termites can be a problem to young trees. Spreading wood ash around the base of the tree can repel them, though new applications may be necessary after a heavy rain. In Botswana a local remedy combining tobacco, soap, water, and "Jeyes fluid" proved 100 percent effective in controlling termites around young seedlings (Nickerson 1989).

Tree Management Considerations

How the trees will be managed depends on their purpose. Trees planted in a hedgerow configuration can be pruned to facilitate agricultural crop growth (Vadivel *et al.* 1984). In the Majjia Valley in Niger windbreaks are pollarded to supply poles and fuelwood (Kerkhof 1990). Trees planted for timber may be periodically pruned to provide fuelwood and improve the quality of the wood and thinnings may be necessary (Briscoe 1990).

Consideration also needs to be given to management of areas under the trees. For example, grass collection for fodder or roofing may be an important activity in a community woodlot. Consideration of how collection will be done can help to improve management of the plantation while assuring access to secondary products.

Packing persimmons for sale, Pakistan

Photo:
T. Fear and D. Forester

Costs of Tree Planting

The costs of tree planting activities in the tropics are difficult to evaluate. There are scant data on the actual costs of raising trees. Project proposals sometimes give an estimate of how much tree planting is expected to cost, but actual costs could be quite different. Reliable information with which to base analyses of costs and financial returns of projects is difficult to collect in many countries (Chew 1990).

Analyses can be complex when deciding how to allocate costs such as administrative personnel or extension agents who are involved with more activities than simply tree planting. Many factors need to be considered in calculating the costs of tree planting activities (see box). Actual costs will vary based on the ecological region and country in which activities are taking place as well as by the type of project. In food-aided projects costs may be particularly difficult to unravel as the food may be used for a variety of purposes. Productivity and tree survival on food-for-work projects are generally low, which tends to increase costs per tree (Nembot 1990).

Sedjo and Solomon (1988 in Grainger 1990) estimate plantation establishment costs at between US$230 and US$1,000 per hectare with an average of US$400 per hectare. In Burkina Faso, Zida (1989) estimated first year start-up costs of an industrial fuelwood plantation of around US$400 per hectare and those of a village fuelwood plantation at about US$650. The higher village start-up costs were mainly for protection activities on smaller plantations. However, over the 21-year period of his analysis industrial plantation costs, including harvesting, were US$3,500, while village plantation costs were US$1,000. A financial analysis of both systems found that neither was efficient, though an economic analysis showed the village plantation to be efficient (Zida 1989).[1]

In some cases costs may be extremely high. Land preparation and plantation establishment costs with a trickle irrigation system in Niger were estimated to cost approximately US$7,700. It was calculated that the plantation could still have positive economic returns, however, if halting cutting on large expanses of savanna woodlands was considered (Spears 1980).

In projects funded by development banks, agroforestry and fuelwood plantations have generally had higher economic rates of return than industrial plantations. World Bank reports showed that agroforestry/fuelwood projects had economic rates of return between 15 and 30 percent while the rates for industrial plantation forestry were between 10 and 15 percent (Spears 1988).

A comparison was made of the financial and economic returns of completed loan- and grant-funded projects supported by the four development banks (Laarman and Contreras 1991). Most of the projects were of the forest-based industry type, while a few projects were concerned with fuelwood needs. In most cases economic returns were higher than financial returns. Project appraisals of anticipated rates of returns were almost always higher than the actual returns experienced.

Farmers in tropical countries generally aim to reduce risks. While economic analysis is often considered ap-

Firewood for sale along the road, Uganda Photo F. Tear and D. Forester

Factors to Consider in Determining Costs of Tree Planting Activities

Administrative

- Administrative personnel salaries
- Extension agent salaries
- Travel (including vehicles and per diem)
- Overhead

Nursery Costs

- Pots (local or manufactured)
- Tools
- Transport of materials to nursery
- Water
- Chemical inputs
- Labor (or how to account for unpaid labor)

Planting Costs

- Planting site preparation (including fences and holes)
- Transport of seedlings
- Planting (including unpaid labor)
- Seedling maintenance and protection
- Tree management (including harvesting)

1 Financial analysis deals with monetary costs and returns; how much does it cost in terms of materials, labor, etc., and how much of a product can be sold and for what price. Economic analysis looks at costs and benefits to society; costs represent other opportunities foregone and benefits are increased goods and services (including environmental services) available to society (Larrman and Contreras 1991).

propriate (Hosier 1989), interventions must make financial sense to the farmer considering investing time and/or money in them (Shaikh *et al.* 1988b). Spears (1987:54-55) lists four reasons why agroforestry projects demonstrate high financial rates of return:

- Investment in infrastructure development for farm and community forestry is generally low, much of it is already in place;
- Farmer adoption of fast-growing short-rotation trees for sale or which they recognize as beneficial has been fairly quick;
- Establishment costs, particularly through methods such as direct seeding, can be low; and
- The prices of tree products (poles, fuel, timber) have generally been rising in real terms at a faster rate than other commodities.

Donor organizations and national governments interested in investing in forestry projects may be interested in the financial and economic return rates. Economic rates of return for bank-financed projects are comparable to other World Bank funded projects (17.9% for forestry, 17.8% for all World Bank projects) (Laarman and Contreras 1991).

A number of different approaches have been used to analyze agroforestry practices, though most studies to date appear to be part of feasibility studies. These analyses could be useful in project planning and for comparison with actual returns after an appropriate number of years (see Swinkels and Scherr 1991 for a list of studies). Using a financial break-even analysis to examine activities in part of Sahelian Africa, Shaikh *et al.* (1988b) found that windbreaks would have positive effects on agricultural yield after five years and living fences after four years. It was assumed the higher crop yields would decrease over time at the same rate as they would have without the interventions. The agroforestry techniques therefore help the farmer to "buy additional time" before fallowing the field (Shaikh *et al.* 1988b). In addition to their effects on agricultural yields, windbreaks and living fences would also provide wood products.

Hosier (1989) used benefit-cost analysis to examine a woodlot program in Kenya and an agroforestry project in Haiti. He found that in Kenya by giving inadequate attention to the market for poles, rather than fuelwood, the analysis neglected to consider the strong incentive farmers may have for raising cash. Benefit-cost analysis of the Haiti agroforestry project showed that 15% of the farmers had negative returns. While there may be several reasons for their continued participation in the project, or farmers may discontinue the practices, the analysis may not have included adequate information for a thorough evaluation (Hosier 1989). Issues in carrying out financial and economic analyses of forestry projects remain, including how to account for environmental and social factors (Laarman and Contreras 1991).

Benefits of Tree Planting

Tree planting and growing activities in the tropics offer a myriad of benefits to individuals and the global community. At the same time that tree planting can help to mitigate global warming other environmental and social benefits at the local and regional level are possible. Production of wood and non-wood products from individual trees and forested areas are an important source of subsistence materials and income generation for rural people in the tropics. Social and economic benefits can accrue to people involved in tree planting and management activities. Improved natural forest management in the tropics may help to mitigate global warming by improving the growth and productivity of forests (USAID 1990).

Global warming mitigation

Tree planting activities in the tropics can help to mitigate global warming through carbon fixation and long-term carbon sequestration. Reducing the deforestation rate in the tropics could be the single most important contribution of tropical forestry to decreasing and mitigating global warming (Trexler *et al.* 1991). Halting deforestation globally would reduce carbon emissions by 0.9 to 2.7 billion metric tons (Woodwell 1989).

Plantations are estimated to annually fix between 2 and 10 metric tons of carbon per hectare (OTA 1991). But they will not necessarily stop deforestation of natural forests (Trexler *et al.* 1991). The adoption of agroforestry practices may make a greater contribution to reducing deforestation through reducing demand on natural forests for products and agricultural land (USAID 1990). Rough estimates indicate the potential for storage of up to 4.3 metric tons of carbon per hectare per year for various agroforestry practices in the tropics. Those estimates do not include carbon stored in soil or not released through deforestation (USAID 1990). An innovative tree planting program

Majjia Valley Windbreak Project, Niger

Windbreaks, or trees planted to protect crops from the wind, are an agroforestry practice that has the potential to decrease wind-caused erosion, improve soil moisture, and provide a variety of products for farmers. The Majjia Valley Windbreak Project in Niger began in 1975 as a response to farmers' complaints about wind erosion. The objective of the project is to help increase crop yields through slowing down wind speed, and consequently reducing soil moisture loss and damage to plants.

Windbreaks composed of two rows of neem trees (*Azadirachta indica*), and more recently neem and *Acacia nilotica*, are established at 100 meter intervals. The windbreaks extend for two kilometers across the width of the valley. By the end of 1988, 463 kilometers of windbreaks protecting over 4,600 hectares of farmland had been established. The windbreaks have been shown to decrease the average wind speed by 42%.

While studies to document crop increases have shown differing results, it appears that there is at least a slight increase in grain production. Wood harvested through pollarding the neem trees has provided both fuelwood and building materials. The overall economic benefits of the project look favorable. Recently the project has been attempting to find ways to more fully involve local farmers in managing the windbreaks and sharing the financial benefits from wood product sales.

Source: Kerkhof 1990.

in Guatemala is expected to sequester 16.3 million metric tons of carbon over 35 years through agroforestry practices, woodlot establishment, and reduced deforestation (Trexler *et al.* 1989).

Urban tree planting in the United States is important in reducing carbon emissions through energy conservation (Sampson *et al.* 1991). Urban trees could play a similar role in tropical countries, especially as energy demand increases. Sound energy development projects in tropical countries, including the use of bioenergy as a substitute for fossil fuels, could help to limit future carbon emissions (Trexler *et al.* 1991).

It is difficult to predict the overall role tropical forestry activities could play in reducing and mitigating global warming. Uncertainties due to biological, social, and political factors remain (Trexler *et al.* 1989; Trexler *et al.* 1991). Nonetheless tropical forestry activities could play an important role in dealing with global warming (OTA 1991).

Environmental benefits

In addition to the global environmental benefits of tree planting activities in the tropics, substantial local and regional benefits may be evident in areas with active tree planting programs. As discussed previously, trees can help decrease the effects of wind and water erosion on farm and pasture land (Kerkhof 1990; Rocheleau *et al.* 1988; Weber with Stoney 1986 (see box)); and improve soil fertility through nitrogen fixation and/or increasing the organic matter content of the soil (Gregersen 1988; Nair 1984). This may have favorable impacts on the growth of agricultural crops in the immediate vicinity, though trees do take some land out of agricultural production. Certain trees are used for the beneficial effects of shade on particular crops (MacDicken 1990).

Trees grown for fuelwood or where fuelwood is a by-product can help to take the pressure off of other fuel sources. For example dung and crop residues that are used for fuel may be returned to the field when an alternative fuel source is available, thus adding to the fertility of the soil.

On a regional scale tree planting can help to improve the environment. Tree planting on a large scale in watersheds, sometimes combined with other measures, can lead to benefits that include better natural regulation of water flow and reduced downstream sedimentation (Gregersen *et al.* 1989).

House construction, Papua New Guinea
Photo: T. Tear and D. Forester

Tree planting can also play a role in controlling and reversing desertification through helping to increase the productive potential of arid and semi-arid lands (see FAO 1989e). Urban trees may help to ameliorate the effects of pollution (Sampson *et al.* 1991).

Tree planting can help to take pressure off of protected and other natural areas for supplying wood products and increased land for agriculture. The concept of promoting agroforestry practices in buffer zones around protected areas is gaining acceptance as a method to improve local living standards while preserving unique natural resources (Van Orsdol 1987). Biological diversity and unique ecosystem processes and functions are better maintained in natural areas without large human disturbances.

Production benefits

The production benefits of trees are many and varied. Trees provide fuel in the form of firewood and charcoal throughout the tropics. Small farmers may not plant trees specifically for fuelwood though it may be an important by-product of trees grown for other purposes. In other instances trees may be grown for sale as fuelwood for the home and for industrial activities such as tobacco curing or pottery firing. Rural farmers sometimes supply local pulp mills with raw materials.

Trees are an essential building material - both as poles and sawn lumber. They are used in the construction of houses and other buildings. A myriad of other wood products are also used ranging from kitchen utensils to furniture and fishing vessels to beehives.

Fodder for livestock is another important tree product. A wide variety of species provide leaves, pods, fruits, and branches that are indispensable to animal nutrition (FAO 1989b). In some areas up to one-third of animal fodder comes from trees (Gregersen *et al.* 1989).

Aside from their potential contribution to annual crop and livestock production trees play an important direct role in human nutrition (FAO 1989b; Gakou 1992; Hoskins 1990). The leaves, nuts, fruits, bark, and roots of trees are all significant human food sources. Some of these products are harvested from natural forests while others are found in trees planted in farm lands or near the home. While trees are food sources throughout the year they may be particularly important during difficult times such as shortly before the agricultural harvest and during drought (Falconer 1990; FAO 1989b; Hoskins 1990). Further research into potential food products from trees is needed (Zimsky 1990).

Natural forests play a role in providing bush meat for local consumption. Both large and small animals can be important food sources (FAO 1989b). Appropriate forest management techniques may help to increase the availability of this resource (Aisbey and Child 1990).

Non-wood products from trees in addition to food and fodder are collected or harvested for a variety of uses. Dyes, perfumes, insecticides, adhesives, and medicine are a few examples. Much of the traditional knowledge of these uses may be disappearing. The potential for expanding collection of non-wood products for local use and world markets is considerable (Hanover 1988). Research into the uses of selected species and social and biological means to encourage their management and use are needed (Hanover 1988).

Social and economic benefits

Tree growing by rural people can lead to important social and economic benefits. Growing trees for home consumption can increase the amount of time people have available to devote to other activities and decrease the amount of money that might have to be spent to purchase those goods. Surplus tree products - wood, fruit, nuts - can be sold in the marketplace thus increasing local incomes. For some, selling tree products may be their only source of cash income. Trees may serve as savings, being harvested in times of economic need (Chambers and Leach 1990). The harvesting, processing, and sale of tree products can create substantial employment opportunities for rural people (Gregersen *et al.* 1989).

Planting trees in farm fields can help to reduce farmers' risk. The increased farm diversity helps to buffer farmers from changes in crop prices and total crop failure (MacDicken and Vergara 1990b). Tree planting done as part of a community development project can help to organize and motivate people to work together.

Social forestry programs have sometimes inadvertently helped one segment of the population at the expense of another (Gregersen *et al.* 1989). A clear understanding of who the intended beneficiaries are and the most appropriate ways to work with them is essential to assuring equitable social and economic development through forestry activities. For example, one social forestry program in India was intended to increase the availability of trees for fuel and fodder locally. Many landowners established eucalyptus plantations, with over 80 percent of the wood being sold for pulp. Some of the former laborers displaced from these lands and looking for alternative income-generating activities, began selling firewood taken from the natural forest (Shiva *et al.* 1987). The overall impact of the project on the poorer people of the area and the forest resource may be more harmful than helpful. Nevertheless, well thought out and implemented tree planting schemes can provide numerous social and economic benefits to the people concerned (Gregersen *et al.* 1989).

Donor Agency Activities

U.S. Agency for International Development Forestry Assistance

United States Agency for International Development (AID) support for tropical forestry activities has a long history dating back to the 1950's (Chew 1989). Progressively increased involvement in tropical forestry has helped to shape the agency's current initiatives. Present activities under AID's Tropical Forestry and Biological Diversity Programs focus on four main areas of concern to tropical forestry (USAID 1988):

1) protection of biological diversity and tropical forests - includes assisting countries to conserve resources through the establishment and maintenance of parks and other protected areas, to develop plant and animal conservation programs, and to identify and assess species;
2) sustained-use management of existing tropical forests - focuses on designing practices for managing tropical forests;
3) land rehabilitation through reforestation and watershed management - includes activities targeted to bring degraded land back into production and protect watersheds;
4) assisting farmers in improving the productivity of their land through agroforestry practices - focuses on ways to assist resource-poor farmers to maintain and improve their agricultural production while also increasing their production of wood and other associated products.

Private Voluntary and Non-governmental Organization working with USAID in Tropical Forestry and Biological Diversity Efforts

- Adventist Development and Relief Agency
- African Wildlife Foundation
- Africare
- Amaschina (Ghana)
- Asian Wetlands Bureau
- CARE
- Caribbean Conservation Corporation
- Catholic Relief Services
- CATIE (Costa Rica)
- Center for Environmental Education
- Christian Children's Fund
- CODEL
- Conservation Foundation
- Conservation International
- Environmental Problems Foundation of Turkey
- Experiment in International Living
- Food for the Hungry
- Fundacion Natura (Ecuador)
- Global Tomorrow Coalition
- Haribon Foundation (Philippines)
- Holy Land Conservation Fund
- International Council for Bird Preservation
- International Union for Conservation of Nature and Natural Resources
- King Mahendra Trust for Nature Conservation (Nepal)
- LIDEMA (Bolivia)
- Missouri Botanical Garden
- The Nature Conservancy
- New York Botanical Garden
- Nitrogen Fixing Tree Association (NFTA)
- Nitrogen Fixation by Tropical Agricultural Legumes (NIFTAL)
- Pan American Development Foundation
- Royal Society for the Conservation of Nature (Jordan)
- Save the Children
- SHARE
- SKEPI (Indonesia)
- Technoserve
- VITA
- WALHI (Indonesia)
- Wildlife Conservation International, New York Zoological Society
- Wildlife Fund (Thailand)
- Winrock International
- World Resources Institute (WRI)
- World Vision
- World Wide Fund for Nature (WWF - International)
- World Wildlife Fund (Pakistan)
- World Wildlife Fund (United States)

Source: USAID n.d.: 14

AID funds country-specific projects as well as regional initiatives and projects to provide assistance worldwide. Total agency forestry obligations for 1991 are nearly US$72 million, including over $US27 million for Latin America and the Caribbean, $US22.5 million for Asia and the Near East, $US10.5 million for Africa, and over $US11 million for projects centrally funded from Washington (I.C.T. n.d.). AID takes a variety of approaches to natural resources management, building on past experiences and testing new ways to conserve and manage resources (USAID n.d.).

AID works in partnership with other U.S. government agencies, private voluntary organizations (PVOs) and non-governmental organizations (NGOs) (USAID 1988; n.d., refer to box). The U.S. Department of Agriculture, Peace Corps, Fish and Wildlife Service, National Park Service, and Environmental Protection Agency all collaborate with AID, providing expertise and personnel to increase assistance to tropical countries. AID partnerships with U.S.-based, international, and indigenous PVOs and NGOs are an important part of the agency's program. Working with these organizations may increase total funding available to projects through matching grants. Indigenous NGOs are particularly effective in increasing grass roots participation in development efforts.

AID support for tropical forestry is increasing. In addition to their other benefits, these initiatives directly deal with global warming by helping to decrease deforestation and expand tropical tree planting. Continuing and new climate-related initiatives include (USAID 1990:xii):

- "Collaborative efforts to strengthen international tropical forest research and the institutional mechanisms to carry it out;
- Expanded technical service in forest management, agroforestry, buffer zone development, conservation, and nature tourism;
- Research and analysis looking toward development and implementation of policy packages to identify and address important, root causes of tropical deforestation and degradation, including market failures and policy distortions; and
- Strengthening the institutional and human resource capabilities to conduct research and implement appropriate policies and programs."

Major Tropical Forestry Initiatives

In addition to the United States many other countries carry out bilateral programs with tropical countries that address tropical tree planting and forestry concerns (see box). International and local PVOs and NGOs play a major role in forestry activities in the tropics. Many of these organizations are involved in raising funds and carrying out tree planting and natural forest protection initiatives. They may help to coordinate research activities and facilitate local involvement in forestry programs. Local NGOs have been particularly effective in raising awareness about environmental issues and searching for grass-roots solutions to problems.

Multilateral donor organizations play a role in tropical forestry activities by sponsoring projects and research through grants and loans. The United Nations through the United Nations Development Programme (UNDP), the Food and Agricultural Organization (FAO), the United Nations Environment Programme (UNEP), and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) is involved in forestry initiatives throughout the tropics. Major international development banks involved in tropical forestry include: the World Bank, African Development Bank, Asian Development Bank, and Inter-American Development Bank.

International organizations that address tropical forestry through on-the-ground initiatives include the World Wide Fund for Nature (WWF), the World Wildlife Fund (WWF-US), and The World Conservation Union (IUCN) (formerly the International Union for the Conservation of Nature and Natural Resources).

Nations Involved in Aid and Investment in Tropical Forestry

Australia
Austria
Belgium
Canada
Denmark
Finland
France
Germany
Ireland
Italy
Japan
Netherlands
New Zealand
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdom
United States
East European Communities

Source: Laarman and Contreras 1991

Many small and large organizations carry out research on tropical forestry activities throughout the world. Some of the major organizations involved in extensive programs and located in tropical countries are: CATIE (Centro Agronomico Tropical de Investigacion y Ensenanza) in Costa Rica, ICRAF (International Council for Research in Agroforestry) headquartered in Kenya, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics based in India, and IITA (International Institute of Tropical Agriculture) in Nigeria. The Consultative Group on International Agricultural Research (CGIAR) is in the process of establishing the International Forestry Research Institute. The Institute is expected to be operating by the end of 1992 with regional offices in Africa, Asia, and Latin America. It is intended that the Institute will be addressing problems requiring "strategic research" as opposed to location-specific research (ACIAR 1991).

Major international initiatives that concentrate on the conservation and wise use of tropical forest resources and imaginative financing arrangements have helped to focus interest and channel resources to tropical forestry programs. Some of these are briefly described below.

Tropical Forest Action Plan

The Tropical Forest Action Plan (TFAP) was launched in 1985 by FAO, UNDP, the World Bank, and the World Resources Institute (WRI) to help reduce the destruction and degradation of tropical forests. The plan provides a strategy that is flexible and can respond to carefully determined needs (FAO staff 1990). National experts working with international specialists put together national plans to address country-specific problems and concerns. The

TFAP outlines strategies and actions for five interrelated components or priority areas for tropical forestry activities: forestry in land use; forest-based industrial development; fuelwood and energy; conservation of tropical forest ecosystems; and institutions (FAO *et al.* n.d.).

1) *Forestry in land-use* deals with improving the integration of forestry with agriculture and livestock production. Proposed actions under this component include increasing agroforestry initiatives, integrated watershed management, and expanded arid forestry programs.

2) Strategies to promote appropriate *forest-based industrial development* include generating employment and satisfying wood demand through involving local populations in natural forest management, increased research on appropriate harvesting techniques and forest industries, and improving marketing capabilities for forest products.

3) *Fuelwood and energy* priorities include decreasing the demand for fuelwood and increasing supply. Improved fuelwood efficiency, better management of existing fuelwood resources, and creation of new fuelwood sources are important actions to address this component.

4) *Conservation of tropical forest ecosystems* involves improving and expanding forest management for sustainable production, protecting areas of special value, and developing partnerships with local people, through increased research into sustainable natural forest management and policy and planning initiatives to insure protection of some areas and sustainable management of others.

5) In order to realize goals in tropical forestry activities *institutions* need to be supported and improved through increased training and support for forestry personnel and better integration of forestry into national development strategies. Private sector and local institutions are an important part of the institution strengthening strategy.

While acknowledging that TFAP has helped to raise awareness about the plight of tropical forests, recent criticisms of the plan have recommended ways to strengthen and improve the plan. These include a multi-sector approach that better coordinates forestry actions with other government sectors, increased attention to the policy reforms that are essential to success of the plan, more meaningful participation by indigenous NGOs, a better internal institutional and management structure, improved operating guidelines and more rigorous monitoring of activities, and increased funding (see FSP 1990a). Efforts to reform and improve the TFAP are underway (FSP 1990b, 1991). It remains one of the most promising approaches to address tropical forestry issues (Miller and Tangley 1991).

Man and the Biosphere Programme

The Man and the Biosphere Programme (MAB) was launched by UNESCO in 1971. The principle aim of the program is "to develop the basis, within the natural and social sciences, for the rational use and conservation of the resources of the biosphere" (Batisse 1980:180). MAB activities focus on research, training, and education activities that examine human interactions with specific environments and processes occurring within those environments (Batisse 1980). A global network of "Biosphere Reserves" has been set up under the program. Governments join the program through setting up national coordinating committees and nominating areas for inclusion within the reserve system (Miller and Tangley 1991). While research and other activities are not confined to biosphere reserves (Batisse 1980), 276 biosphere reserves have been established in 68 countries (WRI 1990).

Biosphere reserves are one of the ten categories of protected areas proposed by IUCN. They are intended to conserve the diversity and integrity of biological communities and natural ecosystems (MacKinnon *et al.* 1986). Biosphere reserves are composed of a core protected area surrounded by a buffer zone where different, appropriate activities, are carried out (Batisse 1980). Buffer zone activities might include research, nature tourism, traditional uses, and agroforestry. The MAB program provided the initial model for buffer zones that has been refined and adapted to a number of areas by different governments and international organizations (Van Orsdol 1987).

Debt-for-Nature Swaps

Debt-for-nature swaps are an innovative approach to funding conservation and forestry activities in tropical countries. International non-governmental organizations buy part of a country's debt from a lending institution for a discounted price, the NGO then "sells" the debt back to the country's central bank which invests the face value of the debt in local currency in conservation programs (Miller and Tangley 1991). These arrangements are beneficial to the commercial banks, debtor countries, and international and local NGOs, while increasing conservation activities (WRI 1989). Debt-for-nature swaps have taken place in Bolivia, Costa Rica, Ecuador, the Philippines, and Madagascar (WRI 1989). They have helped to finance management and protection of reserves, environmental education, park buffer zone management, sustainable development activities, and other conservation activities (USAID n.d.; Miller and Tangley 1991; WRI 1989).

Multinational corporations have made debt-for-equity swaps, in which they exchange commercial debt for an equity investment in the debtor country. These for-profit swaps have been used to expand forest-sector investments (Prestemon and Lampman 1990).

While debt-for-equity swaps transfer assets to foreign owners this is not the case with debt-for-nature swaps (WRI 1989). Debt-for-nature swaps have provided significant funds for conservation activities but have done little to reduce overall debt burdens (WRI 1989). Nonetheless they are an attractive way for debtor countries to reduce external debt and they provide a novel way to increase financing for conservation directed activities.

Food Aid for Forestry

Food aid is an important resource used in forestry projects in the tropics. Over half of the trees planted in Africa during a ten-year period were as a result of food-aided projects (Kramer and Tapp 1986). Yet there are widely differing views on the appropriateness and efficacy of food as a development resource (see Nembot 1990). The World Food Programme (WFP) of the United Nations and the United States through its PL-480 program (Public Law 480) are two of the largest suppliers of food for development activities. WFP food is composed of donations from a number of countries. The United States, in addition to its contributions to the WFP, uses U.S. agricultural products for development activities usually carried out with private voluntary organizations (PVO).

Some of the food made available through PL-480 is monetized (sold) by recipient countries for use in development projects, particularly those activities related to increasing a country's own production and distribution of agricultural products and improving rural health and nutrition (USDA 1983). Forestry research operations are funded this way in some countries (Kramer 1987). The use of the money generated from the sale of food is comparable to cash grants (Kramer and Tapp 1986).

Other PL-480 food (Title II) and WFP food is contributed to a wide variety of development projects, including forestry, and it is primarily that food aid which is discussed below. French (1986) and Kramer and Tapp (1986) outline how food aid, often referred to as food-for-work (FFW), is used in forestry and natural resources projects:

Food for Wages. Food is used as a wage either alone or with a cash supplement for people working on large-scale conservation or reforestation works. This might include labor on a government tree plantation or carrying out gully control work. Food as wages may also be paid to people who will not receive direct benefit from the activities, such as tree planting in towns or along roads. Employees on a project, including extension agents and nursery laborers, may be paid with food. Generally this type of wage is for short-term employees, though it may also be used to further encourage low-paid government staff to work with a project.

Food as an Incentive. Food is used as an incentive or subsidy to encourage farmers to carry out forestry or conservation measures on their own farms or on communal lands. The food is essentially used to help reduce a participant's risk in undertaking an activity. Examples might include building terraces or contour bunds, planting trees (with compensation in subsequent years based on the number of trees surviving after a certain period), or community woodlot establishment.

Food as Subsistence. Farmers who attend training courses may be provided food rations as subsistence during the course. The food may also serve as compensation for lost productive time in a farmer's own field.

Food as Compensation. Some forestry and conservation measures may take several years to become established. Immediately following certain practices farmers may experience reduced agricultural productivity, food rations may help to tide farmers over until productivity increases. In some cases this has been suggested as a use of food if agroforestry practices reduce overall crop production.

Food as Cash. In both WFP and PL-480 food for development projects a small percentage of the food may be monetized to pay for other costs directly related to the project.

Estimates of the actual value of food aid contributions to forestry activities are difficult to unravel. Many projects are classified as "forestry" while other "non-forestry" projects may have forestry components. In 1986 the World Food Programme was spending between US$130 and US$140 million per year on forestry activities in 55 countries (French 1986). The United States donated over US$11 million worth of food for forestry projects in fiscal year 1987, not including food used in monetization programs (USAID 1988).

The number of beneficiaries of food aid varies by the country and type of project, and little information is available. In one in-depth study of a food-for-work project in Guatemala it was estimated that over a ten-year period over 136,000 people received food for participation in soil conservation, tree planting, training, and other activities (Nations *et al.* 1987).

Methods to evaluate the effectiveness of food-aided projects are not well developed (Nembot 1990), though guidelines for designing and monitoring projects may help in the future (see for example Bryson *et al.* 1989; CARE 1985). Nevertheless some general observations on the benefits and shortcomings of food-aided projects may help in understanding their role in tree planting programs and other forestry activities in tropical countries.

In many instances food aid is a link between disaster relief aid and long-term development activities (Kramer and Tapp 1986), though the distinction between relief and development objec-

Uses of Food for Forestry

Food for Employment
Public lands forestation
Road building
Direct seeding
Weeding
Soil conservation measures
Public areas planting

Food for Products
Tree seedlings
Tree seeds
Shading and fencing material
Gully fill
Dune stabilization materials

Food for Fallow
Tree establishment
Resettlement plantings
Tree survival

Food for Training
Extension worker salary
Participant meals
Participant salary

Food for Protection
Fire control squads
Grazing controls
Tree and plantation protection
Forest guards

Food for Incentives
Meals for volunteers
Salary augmentation

Food for Local Currency
All forestry activities

Source: FSP 1987

tives is sometimes arbitrary (Nembot 1990). CARE (1985:1) points out some of the advantages of food aid:

- As food aid is "self-targeting" it is a means of improving income distribution aimed at the most disadvantaged.
- Food can be a net additional resource to an area with beneficial consequences.
- The rural poor play a broader role in economic life and community development through labor-intensive technologies promoted by food.
- Food aid is a direct and effective way to relieve acute malnutrition and food shortages.
- Food can be used in a variety of ways to promote and support development objectives.

At a food aid and natural resources programming workshop for African countries participants felt that food aid, both directly and through monetization schemes, could play an important role in complementing other resources to increase the impact of forestry and other natural resource development activities (AID/PC 1987). In the Guatemala project mentioned above food-for-work has had several positive impacts on participants (Nations *et al.* 1987). By receiving food farmers are able to devote time to conservation measures on their own and others' land; in the absence of food many farmers would be inclined to migrate, at least seasonally, in search of work. In the eastern part of the country food serves as an incentive to tenant farmers as they get an immediate return for their labor.

Some of the problems noted in food-aided projects are specific to forestry programs while others are present in all food-aid projects. Food-for-work and monetized food could potentially depress prices and production and marketing incentives for local commodities, though there are safeguards in the U.S. legislation in an attempt to protect against this (Ferguson 1988).

Food aid is more difficult to program than cash (Kramer 1987). The logistic arrangements for requesting, shipping from the source country, transporting within a country, storing, and distributing a bulky and perishable commodity such as food can be difficult, particularly when food is only a small portion of a project (Kramer 1987).

The costs of administering food aid can be high. Many PVOs feel that new avenues for providing funds to administer food projects are needed (GAO 1990). CARE Mali found that while one person-year of food was valued at approximately US$120, in-country transport, storage, and administrative costs for that person-year were over US$300 (Kramer 1987; Kramer and Tapp 1986). The cash needs of food-aided projects can be several times the value of the food. For example, in Sudan CARE found that non-labor expenses for one-person year of work on block plantations were as much as $1,500. On a self-help forestry project in Kenya the costs were US$1,200 per person-year of labor (Kramer 1987; Kramer and Tapp 1986).

Just like other development programs, food-for-work programs may foster dependency in communities. Several examples from Africa illustrate this point (Joyce and Burwell 1985). In Lesotho people are reluctant to carry out self-help projects without food aid, while in Niger people previously compensated with food for windbreak construction initially resisted attempts to remove the food component. In Ghana people growing cassava to raise money for community projects are paid for their "volunteer" work with food rations. While the project is successful in raising money it is dependent on food to do so. The problem may be more one of inappropriate uses of food-for-work than using food-for-work *per se* (Joyce and Burwell 1985).

Poor labor productivity and poor seedling survival rates are problems associated with forestry food-aided projects (Joyce and Burwell 1985; Kramer and Tapp 1986). The location of a project, the choice of workers, and the rotation of FFW-paid laborers all contribute to poor productivity and low survival rates (Joyce and Burwell 1985).

Some of these projects may be designed more with their FFW potential in mind than resource objectives (Kramer and Tapp 1986). Food-incentive backed tree planting projects on private lands also experience difficulties. Farmers may be planting trees primarily to receive food (Kramer and Tapp 1986). Stories of farmers pulling up trees after they have received their food rations, and planting new ones the next year to receive more food are not uncommon and is rational behavior on the part of the farmer. Policies that provide food in subsequent years based on tree survival could achieve much more reforestation and might help farmers to realize some of the potential benefits of tree planting in addition to the food incentive being offered.

Food aid will continue to play an important role in forestry and other natural resources projects in tropical countries. Evaluation of the food component of present projects can help to better illuminate problems and their potential solutions while highlighting beneficial aspects of food aid. Sound design of forestry projects using food could help to alleviate many of the problems. In the initial analysis of potential food projects designers must evaluate the food security situation in a country, the location and nature of any deficit regions, and the development priorities of that country (Bryson *et al.* 1989). By asking key questions throughout the design process planners can better target food to appropriate areas and appropriate uses (see Bryson *et al.* 1989 for such guidelines).

Lessons Learned from Tropical Forestry Activities

Much valuable experience has been collected from past and on-going forestry activities in tropical countries. Lessons learned from successful initiatives are just as important as those learned from failures. Success and failure are relative terms, and projects which are successful in one realm, such as producing more trees, may be unsuccessful in others, such as increasing the economic standing of the poorest. The more successful initiatives are due to a combination of social, economic, political, and technical factors (Shaikh *et al.* 1988a). A better understanding of these factors can help to shed light on future directions to improve tropical forestry activities. Some of the key lessons, all interrelated, that have been learned in tropical tree planting projects are elaborated on below.

Understanding local culture and local environmental conditions is necessary for the success of forestry activities.

Forestry projects that are based on local conditions - cultural and environmental - can better respond to people's needs, increase their participation, and lead to increased chances of successful tree planting and management. Identifying the unique aspects of local culture, particularly with respect to the forest and tree planting, and capitalizing on them is crucial, for ignoring them can lead to problems not easily resolved (Shaikh *et al.* 1988a). Religion may play an important role in local customs, and religious leaders may be instrumental in promoting natural resource activities (Wechakit 1990). Social groupings and local experiences working in different groups may affect people's willingness to undertake specific actions (Cernea 1989; Sen and Das 1987; Wake 1990; Wilson and Connelly 1990). The culture and practices of different groups of people in the same area may influence how they interact in resource use and what practices one or another group may be willing to try (Shaikh *et al.* 1988a).

Local farmer knowledge about resources and techniques for sustainable practices under local conditions is invaluable (Reid 1989). Farmers possess knowledge about the best time to carry out certain practices and ideas about the most important species or types of trees to meet their needs (Ponce *et al.* 1991). They are not only knowledgeable about what may potentially work but can adapt technical solutions to their own economic and environmental constraints (Glowacki and Cleaves 1990; Kerkhof 1990). What works in one area is not always appropriate to other areas; an understanding of local conditions is central to effectively working with people.

Techniques such as Rapid Rural Appraisal (RRA), Diagnosis and Design (D&D), Farming Systems Research (FSR), and Agroecosystem Analysis and Development (AAD) provide semi-structured ways and tested tools for including local people in project design, monitoring, and evaluation (Marcucci 1990). Their use provides a starting point for learning about local social and environmental conditions. But learning does not end with their use. Project extension agents and other staff should be constantly learning more about local priorities and local conditions and how they change. Projects have to be flexible enough to respond to increased knowledge and changing conditions in an "adaptive, experimental" manner (Reid 1989).

The participation of local people in all aspects of project design, implementation, and evaluation is crucial.

Participatory approaches to rural development have met with far more success than authoritarian top-down techniques (Fortmann 1988a; Shaikh *et al.* 1988a; see Korten 1987 for examples). By including local people as central actors in decision making, activities and goals can be designed to coincide with their needs and their approach to meeting those needs. Projects which have attempted to introduce one type of technical or social approach to developing forestry in an area have sometimes found that local people can create their own structures and mechanisms for dealing with a problem better. For example, intended community forestry approaches may be discarded for farm forestry, while rigid technical guidelines that meet forest department standards may be altered to more adequately reflect local resources and local needs (Kerkhof 1990; Wilson and Connelly 1990). Time spent trying to impose predefined structures on people may be time wasted.

Preparing wood for construction, Sudan Photo: T. Tear and D. Forester

Developing participatory forestry programs is not always easy. It requires important interpersonal skills on the part of extension agents and a willingness on the part of governments and donors to exchange short-term visible results for long-term sustainable results. The process of developing local capacity for resource management and establishing working relationships between agencies and local people is just as important as physical accomplishments (Shaikh *et al.* 1988a). Social forestry programs are more successful if people feel it is their program and that the products of their organization and work belong to them (Shepherd 1985; Wake 1990). Participation can help to develop local capacities for solving a variety of rural development problems (Fortmann 1988a).

Because of the central role women often play in forestry activities, attention to their needs and encouragement of their participation is essential for long-term benefits.

Women's roles in agriculture, livestock, and forestry practices have often been pointed out and calls made to include them more directly in natural resources projects (Fortmann and Rocheleau 1985; Hoskins 1979; Molnar and Schreiber 1989; Reid 1989). Men and women often have preferences for different trees and different uses for those trees (Fortmann and Rocheleau 1985; Gakou 1992), certain species may be considered "men's" while other species are "women's" (Kerkhof 1990). Women's rights to own trees and land may be restricted in some regions (Fortmann 1988b). Men's activities, including tree planting, can impact the activities of women.

Gender differences are important considerations during project planning (Chew 1989; Kerkhof 1990). New initiatives to increase women's participation, that take into account their busy schedules and diverse responsibilities need to be attempted. In some areas female extension agents and other staff may be better able to communicate with women than men (Nations *et al.* 1987), yet many tropical country forest department staffs are composed mostly or entirely of men. Women's groups have played important roles in tree planting initiatives and forest protection in India, Kenya, Tanzania,and elsewhere (Fortmann and Rocheleau 1985; Shanks 1990). Women have taken initiatives to improve their environmental conditions and enhance their lives. A greater recognition of the role they play and how their participation can be facilitated is needed in all forestry initiatives.

Extension services staffed by agents who communicate well with local people and follow through on initiatives is important.

Extension services are the backbone of many topical tree growing programs. Extension agents working with government agriculture or forestry departments and local NGOs are the link between research activities, national goals, and local people. Traditionally trained foresters who are now working as extension agents often lack training and skills in effective communication techniques (Casey and Muir 1986; Shepherd 1985). Conflict and distrust between forest department staff and local people due to the policing role of foresters can be difficult conditions to reverse (Shepherd 1986; Stewart 1990).

Training for extension agents to help them acquire the necessary skills, knowledge, and attitudes to work with social approaches to forestry are needed (Foley and Barnard 1984; Mahony 1987). Communication skills that promote effective dialogues between extension agents and local people and encourage meaningful participation are necessary. Technical training emphasizing the role of trees in agricultural land and small woodlots is also important.

Extension techniques used in different areas will vary based on local culture, available resources, and extension agent capabilities. Experimenting with different techniques can help in finding the best approach or combination of approaches. The impact of natural resource activities and the success of skills and knowledge transfer have been found to be proportional to the number of years of extension follow-up of activities (Shaikh *et al.* 1988a).

Woman carrying firewood, Uganda Photo: F. Tear and D. Forester

The perceived potential economic and financial returns from tree planting and other forestry activities are key concerns to farmers considering the adoption of new practices.

The economic and financial returns from tree growing programs can be many and varied. Farmers are more likely to undertake activities that offer them reasonable financial returns (Shaikh *et al.* 1988b). Appropriate technologies that can lead to increased land productivity need not be costly (Reid 1989), and farmers in some areas appear eager to experiment with techniques that require little capital (Shaikh *et al.* 1988a). Many social forestry projects have provided reasonable rates of return to farmers (Gregersen *et al.* 1989).

The availability of local markets can influence whether or not a farmer plants trees, what species are planted, and how many (Shaikh *et al.* 1988a). Agroforestry projects that have failed to consider the availability of markets have often met with failure, while those in which marketing possibilities were well researched and markets available have been more successful (Chew 1989). The potential for flooding markets and reducing prices in some areas has to be considered, as does the possibility that the market may not be as strong as anticipated (Fortmann 1988a).

One of the many reasons given for the traditional and growing contemporary adoption of agroforestry practices is that they may diversify risk (MacDicken and Vergara 1990b). While agricultural crops may fail either partially or totally in any one year, trees are usually more reliable producers and can provide important food and income during difficult times (Chambers and Leach 1990; Hoskins 1990). This could be a positive economic incentive for tree planting in some areas.

A thorough understanding of land and tree tenure and the changes they are undergoing is essential for devising strategies for working with local people.

Land and tree tenure issues constantly emerge as some of the most important constraints to tree planting. Farmers with insecure tenure to the land they farm may be unwilling to plant trees. Communal lands may actually be *de facto* private land, removing community incentives to reforest or manage them (Cernea 1989). Tenure of trees planted on private land by community efforts and that benefit more than just the land owner, as may be the case in windbreaks, may be difficult to decide (Shaikh *et al.* 1988a). Tree tenure may vary based on government regulations, such as restrictions on rights to cut trees on private land, or gender differences that assign rights in certain species to men and other species to women (Fortmann 1988b; Fortmann and Rocheleau 1985).

Removing tenure restrictions can be a positive incentive for tree growing activities. Farmers with secure tenure to the trees they plant, including the right to harvest them, are more likely to undertake social forestry activities (Shepherd 1986). Potential land and tree tenure constraints to tree planting should be identified during project design and methods to overcome them addressed (Chew 1989). Land tenure in some areas may be changing, understanding the dynamics of those changes is important (Cernea 1989). A thorough understanding of a local situation can help in devising strategies to overcome tenure constraints. For example, a project in Kenya discovered that women could plant certain species for fuelwood and not others, a tree that women could plant was promoted as part of the project to increase women's participation (Skutsch 1986 in Falconer 1987).

Incentives used in forestry projects have both positive and negative effects and should be used with care.

Incentives are often used to encourage people to undertake tree planting initiatives. In many cases these are subsidies which may include cash or food for work on government, communal, or private lands, and free seedlings or other inputs (Chew 1989; Gregersen *et al.* 1989). While these incentives do encourage tree planting, dependency relations may be created, particularly with cash and food incentives (Shaikh *et al.* 1988a), they may do little to encourage people to manage trees and undertake sustainable activities (Chew 1989; Reid 1989). Economic distortions caused by subsidies may also be significant (Reid 1989).

The use and value of incentives should depend on what is appropriate under local conditions (Gregersen *et al.* 1989). Food-for-work programs have been effective in areas with few resources, they have been useful in promoting participation in the absence of trust between farmers and officials, and are useful for large-scale public works and infrastructure development (Shaikh *et al.* 1988a). Incentives can also help to encourage people unaccustomed to tree planting to experiment with project proposals (Gregersen *et al.* 1989). Grants to local communities for tree planting programs may make the difference between thinking tree planting might be a good idea and actually doing it (Camser 1987).

Incentives that do not involve subsidies such as policy reforms, market development, tenure security, training, and tax advantages may be more effective in encouraging long-term tree planting and management (Chew 1989; Gregersen *et al.* 1989; Shaikh *et al.* 1988a).

Policy reforms which remove disincentives to tree planting and serve as a stimulus for action are needed.

Many different aspects of policy influence natural resource activities (Reid 1989). Policy reforms in many sectors of tropical countries can lead to a better climate for tree growing initiatives (Shepherd 1986). This includes policies in the agricultural, livestock, development, tax and land-use realm as well as in the forestry sector. Policies that may allow people to plant trees but require government permission to cut trees, even on private land, are disincentives to forestry investment (Chew 1989; Fortmann 1988a). Policies that grant tenure to land only after it has been cleared of forest cover encourage deforestation (Repetto 1988). Higher *ad valorem* taxes on land that has trees, while recognizing the value of trees, may be a disincentive to poor farmers who cannot afford the higher taxes.

Policies that recognize the importance of forestry in national development goals are needed (Chew 1990). Policy reforms that respond to people's needs can be a catalyst for increased tree growing initiatives. These reforms need to ensure local people have access to the benefits of their activities (de Montalembert 1991). Such reforms that have worked in the past include transferring land and tree tenure rights to local groups and allowing special organizations to function outside of state organizations (Shaikh *et al.* 1988a). Government policies need to make forest conservation and tree planting more attractive than destructive activities (de Montalembert 1991). Policies that grant land tenure to people after tree planting (Bruce *et al.* 1985; James and Fimbo 1988) are a positive approach to tying land rights to tenure. Forest policies should complement agriculture and livestock policies in recognition of the interrelatedness of activities and to achieve better overall land use (de Montalembert 1991). Tax incentives for tree planting and maintenance could increase participation in tree planting programs by reducing the costs and risks associated with it (Gregersen *et al.* 1989).

Forest product prices should reflect their true cost.

A recurring theme is that prices that do not reflect the true value of forests and forest products encourage their destruction. Government pricing policies that essentially supply short-term incentives to timber organizations lead to rapid depletion of the forest resource with little or no investment in reforestation (Johnson *et al.* 1991; Repetto 1990). By increasing the royalties and taxes on timber harvesting operations governments can begin to capture the true cost of the forest resource, which will increase government revenues while encouraging reforestation as a commercially viable activity (Johnson *et al.* 1991; Repetto 1990; Tingsabadh and Phutaraporn 1989). Undervaluing wood through government policies including subsidies, permit fees, and stumpage prices may be a disincentive to tree growing for farmers as well as industrial concerns (Chew 1989).

Equity issues must be addressed if tropical forestry programs are to succeed.

The best intentioned development projects can create more problems than they solve if adequate attention is not paid to issues of equity. Some farm forestry initiatives have been criticized for benefitting the wealthier segments of society and doing little to provide the rural poor access to fuelwood, building materials, livestock fodder, and other forest products. The costs of some social forestry projects may be disproportionaly borne by the poorest people. They are especially threatened through being displaced from land, losing access to income generating opportunities and traditional land rights, and new land uses that negatively impact adjacent areas, such as trees shading agricultural crops (Fortmann 1988a). A farm forestry project in India did far more to increase the income of wealthier land owners than to meet the wood needs of local people (Shiva *et al.* 1987).

Community forestry initiatives may only promise uncertain access to the products produced (Sen and Das 1987). Private interests may usurp community efforts and a "tragedy of the commons" may ensue (Gregersen *et al.* 1989; Hardin 1968). Tree planting activities may increase the value of common land, creating incentives for its privatization. Concerted attention to the social costs and benefits of social forestry projects is essential from the time the project is conceived. Land or access to land, social and economic impacts on participants and non-participant residents, and security of benefits are only a few of the factors that need to be considered before introducing social forestry endeavors to a region (Fortmann 1988a; Gregersen *et al.* 1989).

Pilot projects or the phasing-in of projects are important means of using limited resources to learn of potential appropriate interventions.

Pilot projects or the phasing-in of project activities has proved useful in a number of situations. By concentrating resources on one area local people and technicians can devise appropriate techniques and approaches to meet local needs and fit in with local culture. Trial and error may be necessary to develop techniques that are cost effective and have the potential to meet local socio-economic and environmental goals.

It is more advantageous to focus limited resources on a few sites and develop sound practices that may be adoptable elsewhere than to attempt to widely disseminate unproven approaches (Gallegos *et al.* 1987). In agroforestry projects this may be particularly true. Through pilot programs promising techniques can be developed with local people before efforts are made to extend them to a larger audience (Chew 1989). In recognition of the importance of testing new approaches and adapting them to local situations before encouraging people to adopt them some new projects are including planning periods of a year or more as part of the project cycle. Even longer periods are needed for many initiatives. A new project in Ethiopia intends to try several different models for social forestry initiatives before determining the most appropriate approaches (Adams 1990).

Success in forestry projects may take a long time to become evident.

Tree growing by its very nature is a long term enterprise. The effects of tree growing on local farming conditions, local markets, and local economies may take several years or more to become evident. Participatory approaches to tree planting may take longer to show tangible results than authoritarian approaches that impose tree planting on people. Yet chances of long-term positive effects are better with participation.

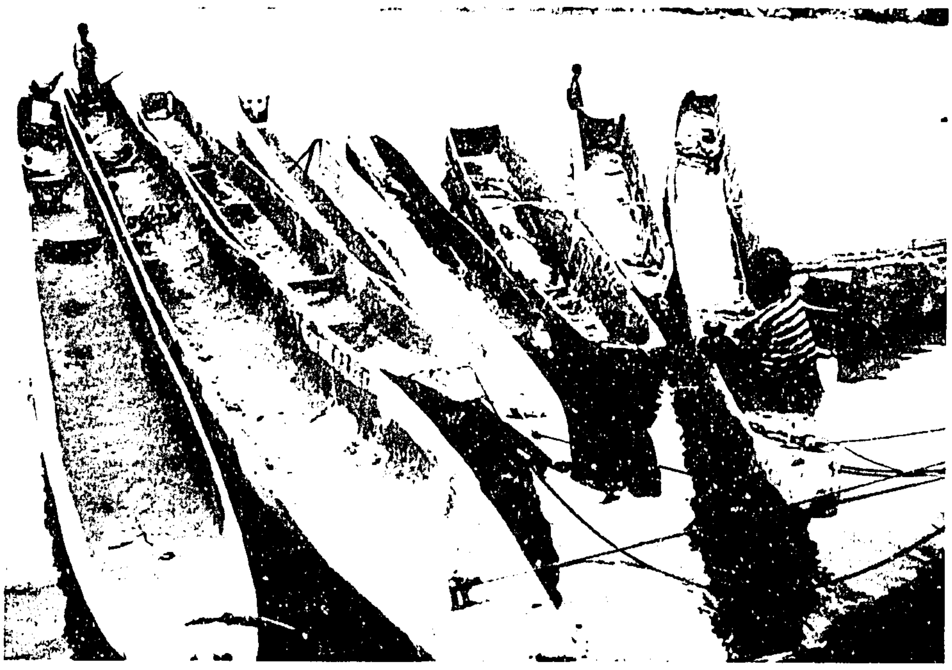
Shaikh *et al.* (1988a:45) found that the time needed to achieve visible benefits in natural resource projects appeared to "increase with the novelty of the techniques [being used], competition for resources, and inexperience of technical assistance." Market incentives, favorable political conditions, and supportive local values and social structures were found to decrease the time to tangible benefits. A minimum ten-year commitment to natural resource projects on the part of donors and governments is not unreasonable (Gallegos *et al.* 1987; Shaikh *et al.* 1988a). Monitoring and evaluation activities throughout a project's life can help to reinforce positive efforts and suggest approaches to overcoming problems.

Integration of forestry activities with national goals and local institutions (public or private) is important to assure continuity and reach long-term conservation and development goals.

Forestry activities conducted by outside donors may face an uncertain future once external funding disappears. Local priorities, particularly for things like agroforestry or community managed forestry, need to be better integrated into forest department and other local institution's programs (Shaikh *et al.* 1988a; Shepherd 1985). Initially, institutional arrangements for implementing new initiatives may need to be developed (Chew 1989). By integrating activities into government and local initiatives they become a component of local and national agendas, and experience gained by trained local personnel can continue to contribute to future endeavors (Gallegos *et al.* 1987). While the goal of many development projects may be that they become self-sustaining (Karinge 1990), this may only be possible after a long period. Appropriate government policies and continuing technical and institutional support can help to strengthen and support self-sustaining endeavors.

People's survival is tied to the availability of local resources.

Increasingly it is being recognized that rural people's livelihoods are directly linked to the availability of natural resources in their area and their access to those resources. The findings of a study of rural communities in Sri Lanka stressed the point that greater land resources and access to forests and trees led to better living conditions (Wickramasinghe 1990). In a study of natural resource management initiatives in the Sahel it was found that where biological diversity was threatened, so too were people's food sustenance and/or their income generating capabilities (Shaikh *et al.* 1988a).



Dugout canoes, Papua New Guinea — Photo: T. Tear and D. Forester

Local people can play an important, positive role in natural forest management and should be included in initiatives whenever appropriate.

Increasingly governments and donor organizations are coming to realize that local people have a vital role to play in the management of natural forests and other natural areas. Too often they have been shut off from the resources they depend on. Government actions to exclude local people from managing local resources have sometimes proved inappropriate. Governments often lack the manpower and the knowledge to effectively manage natural forests, while local people may have devised traditional means. The Nepalese government's nationalization of forests contributed to their increased destruction as traditional communal protection systems disappeared. New initiatives to return control of forest resources to local people may prove promising, though villager distrust of forest rangers and government commitment to the new arrangement, as well as problems in reestablishing local control need to be overcome (Stewart 1990).

Local people who have lived in forested areas for generations (as opposed to colonists) may have a great knowledge of the forest and potential ways to manage it sustainably (Anderson 1990; Gómez-Pompa and Kaus 1990). Including local people as full participants in natural forest management can help to conserve the resource, as they have a direct stake in the protection and production of the forest area (Allegretti 1990; Johnson *et al.* 1991). The potential for increased participation by rural people in forest management is great (WRI 1991). Their efforts can contribute to national economies and national environmental goals while sustaining their livelihoods and the forest environment.

The use of inappropriate species and practices threatens the success of forestry projects.

Technical packages that work in one area are not necessarily appropriate in another. Insufficient attention to things such as species choice, planting configurations, and tree and farm management techniques can lead to failure or less than desirable results from activities. The constraints associated with particular species or techniques need to be considered right along with the potential benefits. For example, while windbreaks may help to conserve soil and water resources they may also harbor birds and other pests that eat grains (Shaikh *et al.* 1988a). Some tree species have the potential to become weedy, which could cause considerable ecological problems (NAS 1980, 1983). Certain tree species, such as eucalyptus, are sometimes believed to reduce groundwater levels.

Sustainable practices should be identified for a particular region and potentially unsustainable practices avoided. "Modification of the environment to fit the needs of a production system is much less likely to be sustainable than modification of the production system to fit the environment"

Guatemala Agroforestry and Carbon Sequestration Project

July 1989 marked the beginning of a new approach to tropical forestry activities, one with direct relevance to mitigating global warming. Applied Energy Services (AES), a U.S. independent power producer joined with the government of Guatemala, the private voluntary organization CARE, USAID, and the Peace Corps to fund a ten-year tree planting and forest protection program.

AES sought a tree growing project that would offset the approximately 15.5 million tons of carbon to be emitted during the 40 year life of its new coal-fired power plant. With the assistance of the World Resources Institute (WRI), AES chose to contribute $2 million to an extension and expansion of ongoing efforts by the other four groups in Guatemala. Guatemala has an average annual deforestation rate of 90,000 hectares, or about 2% of its forest cover, and an annual average population growth rate of 2.88%. Tree planting and soil conservation measures are an important part of rural development efforts.

Over 40,000 farm families will be involved in planting 52 million trees during the ten year life of the project. Many more trees are expected to be planted in subsequent years as activities become self-sustaining. Project activities will include:

- creation of 30,000 acres (12,000 hectares) of woodlots
- implementation of agroforestry practices on 150,000 acres (60,000 hectares)
- planting of 1,800 miles (2,880 kms.) of living fences
- terracing for soil conservation on 5,000 acres (2,000 hectares)
- forming forest fire brigades to protect natural forests and new plantings
- formation of local forestry committees to coordinate local activities
- training and extension activities to support and foster other activities.

The project will cost about $14 million for goods and services, including food aid, which will be phased out after the first five years.

It is difficult to accurately determine the long-term carbon sequestration of a project of this type. WRI conservatively estimates that 18.1 million tons (16.3 million metric tons) of carbon will be sequestered over 40 years due to project activities, more than will be emitted by the power plant. The carbon will be sequestered through woodlots and agroforestry practices that displace demand on the natural forest as well as add to standing biomass, fire protection activities and soil rehabilitation measures.

While there are still uncertainties and risks in an undertaking such as this to offset carbon emissions, this project represents a first attempt to combine tropical forestry activities, economic development and mitigation of global warming.

Sources: Trexler et al. 1989; USAID n.d.; WRI 1990

(Reid 1989:29). A wide body of literature exists on technical approaches to tree planting and resource conservation that can help to guide planning. Local people remain an invaluable resource for determining the most appropriate course of action.

Increased information about natural resources and their use should contribute to land-use planning activities at the national level.

Increased information of environmental and natural resources conditions could contribute greatly to land-use planning initiatives (Gallegos *et al.* 1987). Land-use planning initiatives aimed at improving agricultural practices, finding alternative ways to meet fuelwood demand, and avoiding road construction and other practices that lead directly or indirectly to forest destruction would help in conserving tropical forests (Johnson *et al.* 1991). Allocating land uses to those areas where they have the greatest possibility of being productive results in more efficient land use (Dasmann *et al.* 1973). Agroforestry and other approaches to social forestry can be an important part of regional land-use plans (Chew 1989).

Industrial organizations can play an important role in improving the forestry situation in a country.

While there are many examples of industrial concerns being responsible for the destruction and degradation of forests and other natural resources in tropical countries, there are opportunities for industry to play a more positive role in the conservation and use of forests and forests products. In the Philippines, the Paper Industries Corporation of the Philippines plays an important role in encouraging farmers to plant trees and displacing demand from the natural forest (Gregersen *et al.* 1989). The Forest Industries Organization in Thailand has been attempting to increase forest cover and decrease shifting cultivation pressure on the natural forest by setting up villages to settle shifting cultivators and employing them in reforestation activities while giving them access to land for agriculture (Boonkird *et al.* 1984).

Opportunities also exist for collaboration between industries in the more developed countries and tropical countries. A United States utility company funding a tree planting program in Guatemala (see box) is experimenting with a new way to mitigate the carbon released by their coal-fired power plant while contributing to development and conservation in a tropical country (Trexler *et al.* 1989). This initiative might encourage other utility companies to set up similar arrangements. Multinational companies involved in wood processing in tropical countries could supply funds for local reforestation efforts (Prestemon and Lampman 1990). A number of developed country businesses are now promoting and encouraging rain forest conservation through their products. For example, Ben and Jerry's Homemade Ice Cream, Inc. is using tropical forest nuts and fruits in their ice cream, while The Body Shop produces cosmetics from rain forest products (Miller and Tangley 1991).

Tropical Forestry Activities to Reduce and Mitigate Global Warming

Tropical forestry activities can play an important role in reducing and mitigating global climate change. Social approaches and technical methods to encourage tropical forestry have been practiced and refined over the years. Difficulties have been identified and attempts made to overcome them. These efforts represent a start towards addressing the forestry needs of tropical countries and increasing activities that will benefit both the local people and the global population. Expanded tropical forestry activities, backed by sound policies and adequate funding and research, are needed.

Tropical forestry initiatives to mitigate global climate change have been studied by different organizations including the Intergovernmental Panel on Climate Change, the U.S. Agency for International Development, and the Congress of the United States, Office of Technology Assessment (WMO/UNEP 1991; USAID 1990; OTA 1991). Many of the recommendations which follow echo their findings.

RECOMMENDATION:

Implement Policies that Support Increased Forestry Initiatives

Actions:

- Conduct policy analyses to determine the appropriateness of the various policies that impact, directly or indirectly, forestry activities.
- Adopt policies that provide secure land and tree tenure to rural farmer.
- Encourage initiatives to set up local markets for wood products.
- Adopt prices for forest products that reflect their true value.
- Strengthen support for forestry and agriculture ministries and improve coordination between ministries.
- Increase land-use planning initiatives.

Policy changes may be one of the most important and potentially effective means to decrease and mitigate global warming. These changes would create paths for increased participation by rural people in forestry initiatives. Policies that provide incentives to rural people to plant and manage trees on their own land, including secure land and tree tenure and access to markets, combined with increased support for forestry departments could possibly encourage more tree planting than any other government action.

Forest product prices that reflect their true value will help to promote conservation and regeneration of the forest as well as increase government revenues. Sustainable natural forest management techniques are not likely to be carried out in the absence of government policies that encourage or require it.

Land-use planning can help to assure that activities are being carried out on the land for which they are best suited and that sustainable forestry activities play a more prominent role in government planning. Much information remains to be collected for land-use planning activities, nonetheless with available information and local knowledge, much has and can continue to be done.

RECOMMENDATION:

Improve and Protect Existing Forests

Actions:

- Improve the management of natural tropical forests that produce timber.
- Encourage the management of secondary forests.
- Increase the number of forests designated as extractive reserves and protected areas.
- Improve the effectiveness of protection given to already designated protected areas and natural forests.

Introducing sustainable forest management practices and encouraging the management of secondary forests will play several roles in mitigating global warming. It can decrease the area needed to produce wood products and insure that forests will continue to produce products within a reasonable time frame. It will help to insure that forests remain highly productive after logging operations and thus continue to perform carbon fixation as well as carbon storage functions. If accompanied by policy reforms, sustainable forest management could potentially increase government revenues that are directed towards a number of social and technical concerns that may encourage sustainable agriculture, population control, energy efficiency, and other issues that impact directly and indirectly on resource conservation, improved standards of living, and global warming mitigation.

Forest areas designated as extractive reserves and protected areas and afforded adequate protection are likely to remain forested far into the future, thus continuing to perform their important functions. Extractive reserves inhabited by traditional residents may be more cost-effective to establish and maintain than protected areas that need government-paid staff and other funding over an extended period of time. Both systems have the potential to increase economic activity and contribute to improved standards of living for rural populations through income generation from the sale of forest products and tourism. Assuring that natural areas have adequate and effective protection is necessary to insure their existence in the future.

RECOMMENDATION:

Reduce Deforestation

Actions:

- Increase sustainable agricultural practices including agroforestry.
- Increase small-scale woodlot production through community forestry and farm forestry activities.

- Increase peri-urban and bioenergy plantations to produce firewood and charcoal.
- Increase the use of fuel-efficient stoves for firewood and charcoal.
- Develop and promote sustainable economic activity in and around natural forests.
- Decrease land clearing for cattle ranching and forest conversion to other uses.

Reducing the deforestation rate in the tropics is potentially the single greatest contribution tropical forestry initiatives can make to reducing global warming (Trexler *et al.* 1991). It has been estimated that halting deforestation globally would reduce carbon emission by 0.9 to 2.7 billion metric tons (Woodwell 1989).

An important step in decreasing deforestation is to provide rural populations with technologies, and the opportunities to use them, that increase agricultural production and provide sufficient quantities of wood and tree products to help them meet their daily needs and improve their economic standing. Through secure access to land and other resources the subsistence need to clear forest land can be reduced. Agroforestry practices represent a carbon storage advantage in addition to their role in reducing deforestation. It is estimated they have the potential to store up to 4.3 metric tons of carbon per hectare per year (USAID 1990).

Providing wood products, including fuelwood, to ever-expanding urban populations in tropical countries will continue to be an important use of tree resources. Establishing plantations to meet this need in a cost-effective manner is essential if natural forest stands are to be maintained. Plantations are estimated to fix between two and ten metric tons of carbon per hectare per year (OTA 1991). The use of fuel efficient stoves in both rural and urban areas can play an important part in decreasing the demand for both fuelwood and charcoal while at the same time reducing carbon emissions from burning.

Promoting sustainable economic activities in and adjacent to protected areas and other natural areas will help to encourage protection of those areas. If local people have the secure means to earn a livelihood through activities such as nature tourism or sustainable harvesting of timber or non-timber forest products, they will have a vested interest in protecting the natural resources. The equitable participation of local people in managing and profiting from natural areas may be one of the surest ways to ensure that the resource exists in the future.

In some areas, particularly Amazonia, unsustainable cattle ranching ventures play a large role in deforestation. It has been estimated that if the rate of conversion of tropical forest to ranch land were halved over a 25-year period it would reduce carbon releases due to deforestation by two to seven percent (USAID 1990). Halting the conversion of forest land to other uses, such as reservoirs for hydroelectric dams or industrial sites, would also help to assure the perpetuation of the forest resource.

RECOMMENDATION:

Increase Existing Forest Area

Action:

- Increase reforestation and afforestation of appropriate areas.

Increasing the area under forest cover in the tropics is often proposed as a method to increase carbon fixation and carbon storage at least in the short term. When trees are converted into durable products or left to grow for up to 60 or 70 years longer-term carbon storage is effected.

Sedjo and Solomon (1989 in Grainger 1990) estimate that a forest area of 465 million hectares with an annual growth rate of 15 cubic meters is necessary to absorb current annual net carbon increases in the atmosphere. Grainger (1990) has estimated that over 620 million hectares of degraded land in the tropics are suitable and potentially available for plantations (over 172 million hectares in Africa, over 225 million hectares in Asia, and over 222 million hectares in Latin America). The cost to reforest 600 million hectares is estimated at US$240 billion (Grainger 1990). At a planting rate of 20 million hectares per year by the year 2020 the reforested area would compensate for the present net annual increase in carbon dioxide (Grainger 1990). The potential costs and quantity of carbon offset by different planting scenarios is given in Grainger (1990). Trexler et al. (1991:7-8) point out that "our knowledge of land use in the tropics is not sufficiently good to specify what land might actually be "surplus," and satellite technology has not yet provided an answer." Much of the land assumed to be available for reforestation may actually be in use and any reforestation plan would have to take that into account.

Nevertheless, plantation establishment in the tropics could play an important and powerful role in mitigating global warming. The social, political, and economic factors which affect plantation establishment and management would, however, have to be given due consideration if this approach were to be pursued in earnest.

RECOMMENDATION:

Increase Responsible Funding for Tropical Forestry

Actions:

- Increase bilateral and multilateral funding of tropical forestry activities.
- Ensure that funded projects will have a positive impact on the local environment.
- Explore alternative funding sources.
- Increase support for the Tropical Forestry Action Plan.

In order to increase forestry activities to mitigate global warming as well as to meet legitimate national and local

Conclusion

conservation and economic goals increased international support for tropical country forestry and environmental activities is needed. Funds to support public and private initiatives and policy review can help to assure that other needed actions are implemented. Externally-funded development projects have sometimes caused environmental damage or created increased opportunities for environmental destruction (Reid 1989). Environmental and social impact assessments before project initiation can help donors to avoid funding projects with potentially negative environmental and social effects. Many donors and tropical country governments are making a concerted effort to avoid initiating potentially destructive activities; ways to assure that this continues to happen need to be institutionalized.

Unique arrangements for funding forestry and conservation activities can increase available funds. Debt-for-nature swaps are promising methods for reducing external debt while supporting conservation activities. Their use should be further explored and ways to increase their use investigated. Increasing concern about carbon emissions on the part of industry in developed countries has led to another innovative approach to funding tropical forestry activities: industry funding of tree planting programs in the tropics. Policies in highly industrialized countries could encourage this type of initiative.

The Tropical Forestry Action Plan (TFAP) process should be reformed. Greater participation by local communities, indigenous peoples, and NGO's should be stressed. Balanced programs of conservation, reforestation, and forest protection should be advocated as cost effective approaches on such concerns as global climate change, destruction of tropical forests, and loss of biodiversity. Once the reform of TFAP has been completed and a satisfactory governing structure established, the donor community should consider providing increased support for TFAP.

RECOMMENDATION:
Increase Research

Actions:

- Increase research in sustainable forestry including natural forest management for timber and non-wood products.
- Increase research in sustainable agriculture including agroforestry practices.
- Increase research into social and economic considerations in forestry activities.
- Increase research in culturally acceptable, low-cost energy efficient stoves.

While much is already known about forestry technologies in the tropics, much more remains to be learned. Additional funding for applied research activities can improve the effectiveness and increase the potential impact of forestry activities to mitigate global climate change. Practical social and technical approaches to sustainable forestry and sustainable agriculture practices need to be developed and further refined. A thorough understanding of the socioeconomic situation in a given area, and the role of forestry activities in that area, can help to increase the chances of success of any forestry initiatives. The use of social science tools such as Rapid Rural Appraisal, Agroecosystems Analysis, Farming Systems Research, and ICRAF's Diagnosis and Design needs to be expanded and encouraged (Marcucci 1990).

Fuel efficient stoves that meet the needs of women have been developed in many countries. Women in different countries and different regions within countries have varying needs based on their fuel source (wood or charcoal) and traditional cooking practices. Efforts to expand wood stove research to include those areas in which appropriate technologies have not been developed or adopted is necessary.

Tropical forestry activities to mitigate global climate change are receiving international attention. This report has explored social approaches and technical considerations for increasing natural forest management and tree planting activities. The potential for tropical forestry activities to contribute to international efforts to mitigate and reduce global warming are substantial. Forestry initiatives to address global warming can produce a myriad of benefits at the local, regional, national, and global level. Sound programs established by national governments and supported by the international community are needed in tropical countries.

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