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ECONOMICS AND ORGANIZATIONAL ASPECTS OF PRIVATE TREE FARMING TO INCREASE FUELWOOD PRODUCTION IN DEVELOPING COUNTRIES

A Report Submitted To:

The United States Agency for International Development
per AID Grant No. LAC-5728-G-SS-4075-00

By:

Energy/Development International
1015 - 18th Street, N.W., Suite 802
Washington, D.C. 20036

April 30, 1986

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ENERGY / DEVELOPMENT INTERNATIONAL

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ECONOMICS AND ORGANIZATIONAL ASPECTS OF PRIVATE TREE FARMING TO INCREASE FUELWOOD PRODUCTION IN DEVELOPING COUNTRIES

SUMMARY

Farmers in numerous developing countries are beginning to harvest wood from trees planted as a consequence of government's, development assistance agency's, and non-government organization's farm forestry promotions. Organizations promoting tree planting have developed optimistic projections of benefits for the farmers, but few actual farm forestry experiences that included profits have been documented.

Recognizing that lack of information on economic and organizational experience of farm forestry is a constraint on further development of woodfuels and other production from farm-grown trees, the Agency for International Development issued Grant No. LAC-5728-G-SS-4075-00 to fund a study by Energy/Development International (E/DI). The purpose was to describe farm forestry activities in several countries, so as to discern opportunities to improve future tree farming projects.

E/DI recruited expert cooperators in the Philippines, Gujarat, Haiti, Java, Bangladesh, Kashmir, Thailand, and Maharashtra. The cooperators used standard schedules to interview farmers who had planted trees as crops. These structured interviews supported less formal discussions with the farmers, tree crop middlemen, and various government and NGO farm forestry experts.

This report describes the background, tree farming practices, costs incurred, marketing, and income gained for typical farm forestry operations in each of 10 regions. From these descriptions several common patterns are observed, and inferences are drawn for consideration by designers of future farm forestry projects. The findings include:

- Farmers, even those who consume much more of the tree products than they sell, base planting and management decisions mainly on their understanding of potential profits from cash sales of wood.

- Organizations promoting farm forestry have seldom included market development as part of their projects.

- Where tree farming is a new enterprise, the first generation of growers are usually relatively wealthy farmers. Frequently they stand to make a good profit on their first crop of poles.

- Farmers with small landholdings may risk tree growing when good profits have been demonstrated, but independent small farmers usually cannot get the same high prices they heard about.

- Where tree farming is a more mature, stable enterprise, farmers usually have several tree species and produce several products. These farmers also base decisions on expectations for cash profits.

INTRODUCTION

USAID and other development assistance agencies have actively promoted trees as farm crops since about 1979. In India, Indonesia and a few other developing countries, government agencies started effective programs to encourage tree planting by farmers several years earlier. By 1985, some farmers who had been motivated by these efforts had begun to harvest their planted trees. In some cases substantial benefits have been demonstrated so that neighboring farmers have begun to plant trees.

The tree farming components of development projects are expected to have direct near-term benefits, such as producing a cash crop of wood for fuel. Longer-term benefits are also intended, such as improving regional energy balances, controlling soil erosion, enhancing microclimates for crop production, and reducing excessive cutting of natural woodlands. Farmers are often aware of the long-term benefits, but can afford to risk limited capital, land, and labor only if substantial profits seem very likely.

Where farmers have traditionally planted trees, agencies seeking to increase tree farming have often had only to make more planting materials available. But in many other cases, farmers -- especially those without large land holdings -- have been reluctant to invest in trees until they are convinced by demonstrations of rapid tree growth and reports of real profits. In a few cases, government agencies or development banks have made tree farming investments possible with subsidies or loans that allow farmers to invest in spite of the delayed returns inherent in tree crops.

Many potential investors in tree farming remain unconvinced regarding both profitability and risks. Neither farmers with small land holdings, nor entrepreneurs with access to larger sites, nor banks and other agencies that could finance tree farm development are easily convinced by projections of profits based on various production and marketing assumptions. Until extensive documentation is available on the actual economic experience of the pioneering farms using rapid-growing trees as commercial crops, investments in farm forestry are likely to increase slowly at best.

Tree farming has been a common focus for development projects for only a few years, but various farming and marketing patterns already exist. Description of these should help project planners know what to expect. Recently, government and non-government agencies have begun to experiment with innovative organizational models, particularly in India.

Recognizing that the information needs enumerated above constrain further development of fuelwood resources and other tree products, the United States Agency for International Development (USAID) sponsored a modest investigation of micro-economics and organizational aspects of tree farming enterprises in several countries. This report presents the results of that investigation.

The method of investigation was to cooperate with experts in each of several developing countries where tree farming has been established long enough to estimate actual cost experiences and incomes from the first harvests of the trees. The countries included are India, Thailand, Indonesia, the Philippines, Bangladesh, and Haiti.

To select and describe tree farm enterprises typical of particular regions, the cooperating experts consulted with forestry and agriculture officials and with non-government personnel experienced in tree farming projects. The cooperators used a standard questionnaire to interview several tree farmers at each site. They elaborated on the questionnaire as appropriate for the particular site.

Thus we have data for cross-comparisons. However, although the data are in similar format, the case studies are anecdotal. This was not intended to be a statistically valid survey, but rather an investigation to indicate commonalities and differences in the economic and organizational experience of several cases that can be instructive for planning future promotion of tree farming enterprises.

THE SEVERAL CASES

The tree farming enterprises investigated range from the rather well-known and highly organized dendrothermal energy project in the Philippines to unstructured planting of trees for on-farm use by small farmers in Bangladesh and Haiti. The tree farming techniques covered include block plantations where only trees are grown, planting lines of trees around fields and along roads and canals, and planting scattered trees in fields used for pasture or annual crops.

In three of the regions investigated, growing trees for purposes other than fruit production, is a recent innovation largely stimulated by government and non-government organization programs. These include the Philippines, Gujarat, and Haiti. In three other regions, where trees have traditionally been planted as farm crops to produce not only fruit but also wood for fuel and construction, government programs have affected the choice of species and the extent of investment in trees. These cases are Java, Bangladesh, and Kashmir. In two of the cases, Thailand and Maharashtra, relatively wealthy farmers are beginning to harvest substantial plantations established with minimal government assistance.

Common experiences were more frequent than expected among this wide range of cases. Before addressing those, each enterprise is briefly described.

BOLINAO, PHILIPPINES

Background:

Nine wood-fired power plants have been constructed in a program to reduce the Philippines' dependence on imported oil, increase rural employment and income, reforest denuded hillsides, and stabilize rural electricity rates. Equipment to build another eight plants has been received from foreign suppliers. The project is designed to use rapid-growing trees grown on small farms to produce the entire fuelwood requirements for these generators. For this purpose, a minimum of 1,100 hectares of tree farms are to be established at each of the project sites, mostly on upland areas leased from the government. The tree farms are generally on degraded forest land hardly suitable for other agriculture.

Of the dendrothermal projects implemented so far, the PANELCO I Bolinao Tree Farm is most successful in terms of area planted and trees surviving. It is the only dendrothermal project tree farm where significant harvesting has been done. The PANELCO I power plant produces a maximum of 3.4 megawatts of electricity to supply power for about 20,000 rural households.

The municipality of Bolinao is located some 250 kilometers north of Manila in the Province of Pangasinan. The area is flat to rolling with elevation from 10 to 100 meters above sea level. The clay loam soil has pH of 6.2 to 7.5. Annual rainfall averages 2,550 millimeters, with a four to five month dry season.

Tree Culture:

Tree planting began in 1980. Virtually the only tree planted for fuelwood in the program at Bolinao is a "giant" variety of the legume tree Leucaena leucocephala. Some of the farmers also plant fruit trees for household use.

Sites were prepared by cutting and burning all competing vegetation. Seeds were then sown directly in the soil on a one by one meter spacing at the beginning of the rain season. The plantations are densely stocked with as many as 15,000 stems per hectare, as farmers often drop several seeds in each planting hole. As the plantations develop, mortality occurs, reducing the density.

During the first half year, weeds are suppressed by hoeing two to three times. When the trees reach about 1.5 meters, this is no longer necessary. Thinning is not practiced, except on a small-scale where farmers take some wood for household use. Thus from 6 months after planting, little labor has been needed until the first harvesting four years later.

By March 1986, the plantations had became heavily infested with psyllid insects (Heteropsylla spp.). No protection or control measures were being undertaken by farmers, as the insect threat was not yet considered serious.

Silvicultural practices which have been suggested but not implemented include thinning, fertilization, and removing all but the most vigorous coppice shoots from stumps a few weeks after harvest.

Good stands may be harvested after only 3 years and slower growing stands may not be harvested until 5 or 6 years of age. The time of harvest is determined mainly by the size of the stems. When the stems are 6 to 12 cm. diameter at breast height (DBH), the stands are clearcut with machetes, leaving stumps 15 to 25 cm high to coppice (sprout new stems). Tops and small branches are trimmed from the stems and left in the field.

The coppice growth on Leucaena is often faster than growth of the initial crop, so the second harvest may begin after only three years. How many rotations can be taken from the coppice is not known.

Relationship to Other Crops and Livestock:

Trees are the major crop for the 100 households who are formal members of the project. Food crops -- corn, mongo beans, and root crops -- are interplanted with the Leucaena, but farmers get only one crop before the tree canopy closes. The interaction in that first year is apparently positive, since weed control benefits both the trees and the interplanted crop.

Many of the farmers have fruit trees and annual crops -- coconut, mango, cashew, banana, avocado, rice -- on small farms near their Leucaena plantation. A few have livestock to which they feed Leucaena leaves during dry season when other forage is scarce, but livestock in the area are few and do not enter the plantations.

Organization:

Ten tree farmer associations of 10 households each are formally organized to grow fuel for the power plant on land owned by PANELCO I and on land leased by PANELCO I from the Bureau of Forest Development. The associations often work cooperatively, but on average each farm family plants and maintains about 10 hectares of Leucaena plantation.

The Philippine Dendrothermal Power Program began in 1979. PANELCO I, one of the first rural electric cooperatives selected to manage a dendrothermal plant, actively recruited the farmers. Most who joined were poor and had not had legal access to land. The project promised loans and technical assistance to help establish tree farms, a guaranteed market for the wood, legal access (but not ownership) to land, health and medical services, and improvements in area infrastructure.

The 100 families began land preparation in late 1979, and large-scale planting started in May, 1980. The project's credibility with the initially skeptical farmers improved when the first plantation loans were disbursed and when construction of the power plant began.

Production:

Between 1980 and the end of 1985, some 822 hectares of plantation had been successfully established by the PANELCO I cooperators. In addition, individuals and groups who are not members of the project have planted some 1,500 hectares of Leucaena elsewhere in the municipality of Bolinao.

Foresters of the Philippine National Electrification Administration (NEA) inventoried the PANELCO I project tree farms in mid 1985. (See Table 1.) The growth rate indicated is 60 stacked cubic meters per hectare per year, equal to about 25 green tons/ha/yr. Thus the project's 822 hectares of plantations are growing about 20,000 green tons each year.

Marketing:

At present, virtually all the wood used by the PANELCO I power plant comes from the projects' tree farms. However, the power plant is not yet generating electricity on a continuous basis. When the planned operation schedule is attained, the plant will need about 36,000 tons of wood per year, or about 180 percent of the quantity being grown on the existing project tree farms. Much of the additional wood is expected to come from the Leucaena planted by other farmers in the region. Some may also be supplied from natural forests in the Bolinao area.

More than 95 percent of the wood harvested from members' tree farms is purchased directly by PANELCO I, which is recognized as having legitimate first rights of refusal on project-produced wood. The few outside sales are small volumes of firewood or charcoal.

Farmers cut the tree stems into 1 meter lengths, deliver and stack the wood at pickup points within the plantations. Then wood buyers scale the stacked wood and issue vouchers to the farmers. These are later redeemed for cash at the power plant office. The farmers have the option of delivering the wood to the power plant, in which case they are paid a premium, but most lack equipment to do so.

Costs:

Currency Value: Because of the high rates of monetary inflation and fluctuating exchange rates in the Philippines during the past three years, costs and income data are given in this report in dollar equivalents. Since most costs for plantation establishment were incurred early in the project, the 1980 exchange rate of $1.00 = 7.50 Peso is used for those cost data. Another series of costs and the income occurred at harvest time. For these an exchange rate of $1.00 = 18.50 pesos is used.

Land: Land used for the PANELCO I Bolinao tree farms is extremely rocky. Before establishment of the Leucaena it was mainly covered by slow-growing brush, small trees, and grass of poor nutritional quality. Less than 10 percent of the area was being farmed or grazed. Trees and brush on the area were a source of some firewood and charcoal. Thus opportunity costs for this land were low. PANELCO I and the tree farmers lease the area from the federal government for $0.07 per hectare per year (calculated at 1980 exchange rate). This is a concessionary rate, but it underscores the relatively low value of the land used for the tree farms.

Plantation establishment: Prior to planting, farmers cut all brush and burned the area. This required and average of 20 worker-days per hectare. At $2 per day, this is a cost of $40 per hectare. Planting was done by making shallow holes with a sharpened stake and dropping 2 to 3 seeds per hole, 10,000 seeds per hectare. This required 10 worker days per hectare or less, at a cost of $20 per hectare for labor and about $10 per hectare for seed.

Maintenance: During the 6 months following planting, farm families work nearly full time to protect and maintain the trees. Weeding requires 25 worker-days per hectare each time the plantations are cleaned. The trees are protected during the first year by an individual (often a youngster) stationed at the plantation to chase off wandering animals and watch for fires. Only a few farmers build firebreaks. The protection time averages about 15 to 20 worker days per hectare in the first year and 10 worker-days per hectare in later years.

Thus maintenance and protection labor costs about $185/ha in the first year and $20/ha in subsequent years.

Harvesting: Activities at harvest time include felling, removing branches and tops, dragging logs to pickup points, cutting wood into 1 meter lengths, and stacking. A wood cutter with a machete can cut, trim, and stack 1.5 to 2.5 cubic meters (0.6 to 1.4 green tons) per day. When farmers hire laborers to harvest, the wage is usually $1.11 per stacked cubic meter. Thus the laborer may earn $1.67 to $2.78 per day.

One hectare of trees yielding 240 stacked cubic meters of wood requires 100 to 160 worker-days to harvest. With hired labor, the harvesting cost is about $267 per hectare.

Capital and Subsidies: Investment in tools and supplies is minimal. Seed cost is about $10 per hectare; the cost for machetes is another $10 per hectare. Labor is the major cost, either opportunity cost for the farm family or the wages paid hired laborers. The extent to which farmers hire outside labor varies greatly from family to family. Since the opportunity costs for family labor are usually less than the wage paid laborers, the use of hired labor has a large impact on profitability of the tree farm.

To provide income to the farmers until their trees are ready for harvest, NEA and PANELCO I loaned farmers up to $467 per hectare during the plantation development phase. The farmers pay 12 percent annual interest and must repay the principal within 12 years. They are allowed a four year grace period, so do not have to begin repayment until the first harvest is begun.

Table 2 summarizes the costs of the tree farms, with family labor valued at the rates paid hired laborers.

Income and Profits:

Income: The PANELCO I Bolinao power plant has been operating only intermittently, so fuelwood demand has hot been consistent. Also, the cooperative has been delinquent in paying farmers for wood they have supplied. When the plant operations become consistent and cash flow problems are worked out, each tree farm household with 10 hectares of Leucaena plantation on a four year rotation should be able to sell about 600 stacked cubic meters of wood per year.

PANELCO I buyers purchase wood directly from the farmers, paying $2.34 per stacked cubic meter at the roadside or cableway assembly point. (If wood is delivered to the power plant, the price is $3.36.) Thus when farmers are able to sell 600 cubic meters per year, they should receive about $1,405/yr.

The actual sales so far have varied substantially among farmers. In the last quarter of 1985, gross sales per farm ranged from $270 to $973, that is 125 to 400 stacked cubic meters of wood.

Profits: The difference between costs and income summarized above does reflect real profit, since very little production from the trees is used on the farm or sold to buyers other than PANELCO I. The rate of return on the farmers' investment will depend on the rate at which the farmers pay off the development loans and whether the farmers are allowed to repay with low-value currency.

Role of Government and Law:

The Dendro Thermal Development Office, part of the National Energy Authority, was created in response to a Presidential Decree in 1979. It has helped tree farmers by:

a. Coordinating with the Forest Department to allow farmers accesss to government land at virtually no cost.

b. Providing loans to tree farmers to cover costs of plantation and to sustain farm families until trees are ready to harvest and sell.

c. Seeking foreign loans and grants to help support the program.

d. Providing technical experts to advise PANELCO I and the tree farmers on establishment, management, protection, wood harvesting, and wood transport.

e. Helping farmers to procure tools, seeds, and materials.

Table 1

Financial costs incurred by farmers to develop, maintain, and harvest the tree farms at Bolinao

Cost Item	$/ha
Land	negligibl
Supplies and Tools	20
Seeds	10
Site Preparation	40
Planting	20
Weeding	150
Protection	70
Harvesting	267
Miscellaneous	50
TOTAL	627

Table 2

Farm Gate Prices for Eucalyptus Logs (Gujarat Forestry Department Information)

Mean Length (M)	Mean Girth (CM)	Mean Price (Rs.)
2.5	30	20
3.5	30	30
4.5	30	45
5.5	30	54
6.5	30	60
7.5	30	75

f. Providing stability and credibility to the program and rallying nation-wide support for alternative energy incentives.

The government has also encouraged the tree farming enterprise by avoiding enforcement of some existing laws that could be disincentives. These include the requirement for tree cutting permits and the collection of severance taxes on harvested trees.

Role of Non-government Organizations:

PANELCO I, an electrical cooperative corporation:

a. administers the loans to farmers for plantation development,

b. employs a full-time agroforester and five technicians to provide technical advice to the farmers,

c. develops roads and other infrastructure to support the power plant operation. The infrastructure also serves the farmers everyday needs, and

d. provides a market for the fuelwood.

The ten-family tree farmer associations are the legal recipients of the plantation development loans. The members of each association collectively decide how the loan funds are distributed and how tree farming operations are to proceed within their 100 hectare plantation module.

Each association elects officers who represent it at meetings and in negotiations with the National Energy Administration. This structure facilitates quick airing of grievances and speedy dissemination of information.

Direct and indirect assistance has also been provided by consultants hired by the National Energy Administration and by foreign aid agencies (mainly USAID and the Asian Development Bank). The consultants have advised on soil and nutrient requirements of the trees (fertilizers are not used), management techniques, protection, inventory procedures, harvest operations, and wood transport.

Problems and Other Observations:

The future of the dendrothermal energy program is uncertain. The new political administration of the Philippines will eventually review energy policy and may well set new priorities. Similarly the priorities of development assistance agencies that have been helping to support dendrothermal energy may change. Japan, the United States, and the Asian Development Bank may decide to increase overall assistance to the Philippines, but the strategies for assistance under the new political structure have yet to be developed.

Unstable oil prices are another source of uncertainty. Feasibility studies for the dendrothermal energy program were based on assumptions of $30 per barrel oil, and sensitivity analyses tested the effects of prices as low as $25 per barrel. But no one foresaw oil prices dropping as low as $15 per barrel.

A third area of uncertainty is the high level of monetary inflation. For the past 3 years, inflation has averaged about 40 percent per year. Farmers benefit if they repay loans with inflated pesos, but suffer from uncertainty of the real price they will receive for their wood. The farmers must trust PANELCO I to offer reasonable payment for their production. So far prices have been fair, although PANELCO I has reportedly been delinquent in payment.

Thus the viability of tree farming for dendrothermal power plants in the Philippines depends political decisions, world oil prices, and the overall Philippine economy -- all factors outside the control of the tree farmers, PANELCO I, or the National Energy Administration.

More locally, the PANELCO I needs to improve wood transport abilities and power plant operations to make wood consumption more consistent. If the power plant operates at full capacity, then the demand for fuel will increase substantially and the prospects for increased tree planting will be good. Whether those increases would occur within the tree farmer association structure or in a less formal structure will depend largely on whether more land can be leased from the Forestry Department.

Until the political situation, oil prices, and the national economy begin to stabilize, substantial expansion seems unlikely. Meanwhile, however, internal problems including payment schedules to farmers and resolutions of disputes over land tenure may be worked out.

On the technical side, the psyllid infestation must be monitored. Investments in plant protection measures may be necessary to protect the mono-crop tree farms. The decision to use only one tree species now appears to have been an error.

The PANELCO I Bolinao Tree Farm Project is the most advanced and so far the most successful of the nine dendrothermal plants established. Some of the other sites are also making good progress,but some are also reporting very poor results.

Several components have been identified as necessary for project success. Problems have troubled the project at Bolinao only when one or more of these have been neglected.

a. Acquisition of land suitable for growing trees.

b. Early establishment of project credibility.

c. Ability to convince farmers that a market will exist for their product.

d. Strong leadership in the local rural electric cooperativ sponsoring the project.

e. Timely disbursement of loans to farmers.

f. Timely provision of tools and seeds.

g. Sound technical advice offered in a manner acceptable to farmers.

h. Development of a strong management and protection program.

i. Development of adequate infrastructure to assist farmers in skidding and transport of wood.

j. Prompt payment to farmers for all wood purchased.

GUJARAT, INDIA

Background:

The small and poorly distributed forest in Gujarat produces only 0.3 million tons of fuel and 0.2 million cubic feet of timber, while demand in the state is 4.46 million tons for fuelwood and 1 million cubic meters for timber. As a result tree and shrub growth is heavily cut in both the forest and the "wasteland" areas.

The State Government of Gujarat began a Community Forestry Programme in 1969 with tree plantations along roadsides and canal banks. Some farmers with relatively large holdings began to plant Eucalyptus for poles as a cash crop. One of these tree farms, that of Shri Kalidas Patel, became quite famous and inspired many other farmers to plant Eucalyptus cash crops.

State sponsored community forestry was expanded in 1974 to promote woodlots in the rural grazing areas and to encourage farmers to plant trees on their own land by providing free seedlings and extension service.

By 1979-80 farmers with small holdings also began tree planting. In that year, the State distributed some 40 million seedings. Following the lead of the richer farmers, small farmers have planted mainly Eucalyptus for harvest on a 4 to 5 year rotation. By the year 1983-84, annual seedling distribution numbered 200 million.

The seedlings are raised for 6 to 8 months in plastic bags at a cost of Rs. 0.20 to 0.25 each. In addition to its own nurseries, the Forest Department purchases seedlings. These are grown on contract by farmers who receive training in simple nursery techniques from Forestry personnel. Seedlings are also raised by private nurseries, which sell them to farmers for Rs. 0.25 to 0.35 apiece.

The Gujarat government foresaw that its lengthy and cumbersome procedure for permitting cutting and transport of forest products from private land would constrain tree farming. So the rules have been relaxed for Eucalyptus, Casuarina, and Subabul.

The farmers with land holdings over 4 hectares have been profiting from tree farming and have needed little assistance beyond subsidized or free seedlings and a some technical advice. Therefore in recent years the government programs have concentrated on farmers with 4 or less hectares. This latter group have begun tree farming, motivated both by their own need for fuel and small timber and by the opportunity for a cash crop. They view the trees as a sort of savings program to be cashed in when necessary.

By early 1986, farmers with Eucalyptus plantations on 5 to 6 year rotations for production of poles had become quite worried about their market. Local markets for this size wood were apparently saturated. Farmers with trees ready to harvest were waiting for buyers willing to

offer a good price, but prices had apparently slipped considerably. Table 2 is a list for farm gate prices for Eucalyptus stems of the size attained by trees of farmers interviewed for this study. But the few who were selling were getting prices significantly below these.

Numerous informants observed that good markets for pole-sized wood still exist in nearby states, where less Eucalyptus planting has occurred, but that the infrastructure to move wood from Gujarat to those markets does not yet exist. Nor was there any report of businessmen or others trying to develop those market linkages.

Forestry personnel commented that the market for charcoal in Gujarat is strong and experiments are underway to develop techniques for converting Eucalyptus wood to salable charcoal. Similarly, a strong market for wood for paper pulp is thought to exist but farmers in the regions we studied have not yet found how to sell to either charcoal or pulpwood buyers. No data on what prices they could expect to get for charcoal or pulp production were available.

Considerable optimism still exists regarding tree farming in Gujarat, in spite of the recent doubts about the market for poles. The unusually high profits gained by tree farmers with large landholdings continue to inspire enthusiastic projections that trees will pay farmers as much as or more than other agricultural crops.

Tree Farms in the Central Region of Gujarat

Background: The densely cultivated central region of the Indian state of Gujarat comprises about 33,000 square kilometers. Of this area, 10 percent is forest land, 50 percent is cultivated. The remaining 40 percent is grazing area, some "cultivable waste land," and land which apparently has no economic potential.

Normal farms in Central Gujarat, which are 2 to 2.5 hectares, are a profitable enterprise in spite of frequent drought. Three major rivers and numerous tubewells feed a network of irrigation channels to supplement rainfall, which averages 750 mm. per year. Temperature in Central Gujarat varies through the year from a minimum of 5 to a maximum of 40 degrees Celsius.

Tree Farming Practices and Costs: The village named Zaroli of Nadiad Taluka of Kheda District comprises some 135 farm households, of these 69 planted trees under the leadership of a local primary school Headmaster. A school nursery was begun in 1982 to provide free seedlings, mainly Eucalyptus, to farmers. The school received materials and a subsidy (0.15 Rupees per seedling) from the State government.

Shri Kabhi Mangalbhai Solanki is typical of tree farmers who own relatively small crop areas in the village. During the rains of 1982 he planted a line of 120 Eucalyptus seedlings, spaced 1.5 meters apart, around the edges and through the middle of his square-shaped 0.4 hectare crop field. Shri Solanki has received no subsidies other than the free

seedlings. He continues to plant rice in monsoon and wheat in winter, but notes that the grain production is now substantially reduced (perhaps by as much as 50%).

Land preparation for the tree planting included a hired tractor plowing the area three times for Rs. 90 and the farm family digging 120 pits. The cost of ploughing can be mostly charged against that year's grain crops. During the first year the seedlings were weeded each 15 days. The farmer estimates that this time totaled about 15 days. Weeding was less frequent in subsequent years and the labor requirement was reduced by about half. Fence is necessary and expensive, but already existed to protect the grain crops, so is not charged against the trees. One year after planting and occasionally since then, the lower branches are pruned away to reduce shading of the crops.

Tree Farming Income: Shri Solanki's reason for planting the trees was to gain a cash crop and to have wood for fuel, construction and implements used in his own household. By early 1986, 115 trees had survived and grown to an average girth of 30 cm with a clear bole some 6 meters long. He had planted in only one year, as he had no land for further tree planting. He did not expect to cut his Eucalyptus until 1988, by which time they should be the size needed locally for house construction.

Some farmers with larger land holdings in this village had planted earlier and some of these have begun cutting trees for their own use and for sale. When farmers cut for their own use, two men can cut 6 trees per day. One farmer present at the interview of Shri Solanki had harvested ten 4.5 year old Eucalyptus to use as poles for his own house. These poles purchased in the nearest market would have cost Rs. 1000 plus the cost of transport.

Farmers with 1000 or more trees 5 to 6 years old have sold them for Rs. 20 to 40 each with the buyer paying for cutting and grading in some cases and the farmer paying in others. The price has reportedly been slipping in the past year, and farmers with relatively few trees (e.g. 100 rather than 1000) have difficulty in finding buyers who will come to their farms. Markets to which farmers could take poles or other wood products are not sufficiently organized. Still, most farmers interviewed believed they could get at least Rs. 20 per 5 to 6 year old tree.

For the region as a whole, using costs incurred and prices received by the larger tree farmers, a simple financial analysis of Eucalyptus farming is indicated in Table 3. The cost of labor for site preparation, planting, maintenance is the local cost for farm labor. This is probably a slightly high estimate of the opportunity cost for labor of a small farm household such as that of Shri Solanki. The figures are presented on a per tree basis rather than per per hectare, because line-plantings are common:

Farmers with relatively large land holdings do plant in blocks, 2000 trees per hectare are typically planted and with a 15% average mortality, about 1700 are harvested. Expenses per hectare (excluding the cost of land) are about Rs. 9,200 for 5.5 years. With a price of Rs. 20 per tree, the income is about Rs. 34,000 per hectare.

Table 3

Expenses and income, expressed as Rupees per tree per rotation for Eucalyptus in Central Gujarat. Costs of land not included.

Item	Cost	Income
Raising stock for planting	0.23	
Site prep, planting, watering	0.86	
Maintenance for 5 years	0.29	
Regular irrigation	0.92	
Harvesting	2.65	
Grading	0.47	
Farm gate price		20.00
Sum	5.42	20.00
Net, Rupees per tree:		14.58

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Economics of Tree Farming: To calculate the real benefit of tree farming it would be necessary to know the opportunity cost of the cropland used for block plantings, or the profit lost from raising grain or other crops because of yield reductions caused by line plantings of trees. Also, the branchwood used by the farmer households as fuel should be valued. (The Eucalyptus do not produce fodder.) Unfortunately we do not have those data, except for a general estimate that cropland on which these farmers are planting trees sells for about Rs. 2,500 per hectare. (Rs. is the abbreviation for Rupees.)

The apparent profit, or "land rent" gained by farmers who have harvested relatively large plantations of Eucalyptus is reportedly over Rs. 25,000 per hectare for a 5 to 6 year rotation. This is considered such an uncommonly high return for a farming enterprise, that some farmers with very small holdings, who can scarcely afford to sacrifice current production, are responding to the reports of high profits by planting a significant portion of their land with Eucalyptus.

However, in early 1986 many farmers in Zaroli and adjoining villages who had trees they considered ready for harvest were not cutting because they were not able to get the price they had expected. This was especially a problem for those with smaller holdings. The farmers with thousands of trees were still able to find buyers.

Even for larger farmers, prices have softened. At least two explanations are possible. The local supply of poles may have caught up with demand. And too few entrepreneurs may have organized to move the poles into neighboring regions that still have substantial unsatisfied demand. The other possibility is that local wholesalers are cooperating to reduce the farm gate prices. Most informants give more weight to the first explanation.

Farmers with large holdings who were waiting for higher prices were apparently wealthy enough to afford the wait. It is not clear that the price will rise for 6 year old Eucalyptus, but while they wait their trees continue to grow. The farmers seem not yet concerned about whether the the tree growth is being limited by the relatively close spacing between trees. Thinning is not a common practice in the region.

Many of the smallest tree farmers, like Shri Solanki, were motivated to plant trees at least partly by the need for wood to use on the farm. Thus even though those farmers with small holdings are likely to be hardest hit by price reductions, the farmers generally plan to continue for a second rotation of trees. They are aware of the slipping prices for Eucalyptus poles and many of the smaller land holders plan to use fewer Eucalyptus and more multi-purpose trees on their next rotation. *Acacia nilotica* and *Zizyphus jujuba* (ber fruit) are mentioned often. While fuelwood seems important to analysts of the wood deficit, the farmers talk more about the need for wood to make implements and construct houses.

Constraints on Tree Farming: Problems perceived by the farmers included:

- Difficulty in procuring seedlings at the right time and difficulty in transporting seedlings to the farm.

- Lack of marketing infrastructure organized to benefit farmers.
- Lack of an extension service, a central place to go for technical information, or other mechanisms to transfer know-how.
- Lack of credit facilities.

The Arid and Semiarid Region of Gujarat

Background: The dry region of Gujarat comprises 30,000 square kilometers, of which about 10 percent is classified as forest, 45 percent is agricultural land, and 54 percent is grazing land plus cultivable wasteland plus land without economic potential. Average annual rainfall is 500 mm, but this is very erratic and droughts are common. A few farmers with 15 or more hectares have irrigation from shallow wells and tube wells, but most farmland and all the land in small holdings of 4 hectares and less is unirrigated. Thus farming is not a very profitable enterprise in the dry region of Gujarat. In spite of this, the reported cost of cropland is the same as in the central region of the state, Rs. 2,500 per hectare.

Tree Farming Practices and Costs: In the village of Kherva in Mehasana Taluka some 20 farmers with holdings of 4 hectares or less have planted trees. Their land is of poor quality and food crop yields are meager. They received seedlings and technical advice from the Forestry Department as well as a subsistence allowance of Rs. 250 per hectare per year for five years where tree survival is over 70%.

Most of the plantings are Eucalyptus. The variety provided by the Forestry Department grows rapidly, cattle do now browse it, many people are aware of the substantial profits made from Eucalyptus by larger farmers in Gujarat, and the Forestry Department has promoted Eucalyptus vigorously.

Some farmers with small holdings have also planted fruit trees, most commonly a grafted ber fruit variety of *Zizyphus jujuba*. This tree grows well in the dry, degraded soils and once established requires no watering or other support. Within in one year after grafting the tree begins to bear fruit. In two years the yield is about 10 kilograms per tree of fruit which sells for Rs.3 per kilogram.

One of the informants for our study was Mr. Somabhai Ishwarbhai Patel who owns 4.25 hectares spread out in some 9 locations. About 3 hectares are planted with various subsistence food crops. For cash income he keeps 2 dairy buffalos and 2 dairy cows. Also, he has planted 1 hectare with Eucalyptus mainly as a cash crop but also to get wood for on-farm use. The trees are on land formerly used for food crops.

During the rain season of 1982, Forest Department extension officials provided 2222 seedlings to Mr. Patel and planted them for him in a block with trees spaced 3 meters by 1.5 meters. The Forest Department had paid him for land preparation, which included ploughing twice by hired tractor and digging pits by hand. By early 1986, some 1,561 of the trees had survived and grown to an average girth of 45 centimeters with an average clear bole of 5 meters.

Maintenance in the first two years included 20 irrigations with hand-carried water, 4 cultivations for weed control, and eight applications of insecticide (aldrin liquid and aldrex) for control of termites. Also, the trees were fertilized with castor cake (residual from castor oil production) and with urea. The field is protected with a hedge-fence of thorny Euphorbia.

The expenses and labor for maintenance were provided by Mr. Patel, who received a subsidy of Rs. 250/yr. for his hectare of Eucalyptus plantation. In the first year he intercropped the block with cotton, which offset some of the labor costs for tree maintenance. Thereafter the land has been used only for the trees. Mr. Patel estimates that the labor requirement was about 365 man-days per year for the first two years. In the third and fourth years not much labor was necessary -- 150 man days per year or less.

Mr. Patel's trees will be ready for cutting as poles in about one more year. From the experience of other farmers, he has some expectations regarding the harvest. He and his family will do the cutting, two persons can cut 20 to 25 trees per day. The trees will be sold at the farm if a buyer comes, but if not Mr. Patel would be willing to take them to market (about 4 kilometers) at his own expense.

Tree Farming Income: The most recent sale in the village was by a farmer who cut 500 trees in late 1985 that had been planted in 1980. He received Rs. 12 to 15 per tree. Other farmers are ready to cut but are "waiting for customers." Most of them are "nervous" about whether they will be able to sell their trees. They say they need help with marketing.

Table 4 summarizes the expenses and income incurred by farmers in this dry region village of Gujarat if the farm gate price is about Rs. 14 per 5 year old tree.

Constraints on Tree Farming: Mr. Patel is concerned about the market and says that he will not expand his Eucalyptus plantation because it is "not paying". However, he is not giving up on tree farming. He plans to leave the roots of his Eucalyptus after cutting to get a coppice crop, and says that he wants to plant *Prosopis cineria* and *Zizyphus jujuba*, around the edges of his crop fields.

Problems perceived by Mr. Patel and other tree farmers in this village in the dry region include:

- No marketing to sell their trees.
- A shortage of water for irrigation.
- Termites are the major threat to survival of Eucalyptus, Pesticides for termite control are expensive.
- No credit is available for expenses.
- Technical guidance is lacking for selection and culture of species other than Eucalyptus.

Table 4

Expenses and income expressed as Rupees per hectare for a 2000 tree/ha plantation of Eucalyptus on a 5 year rotation in the dry region of Gujarat. Cost of land not included.

Item	Cost	Income
Raising stock for planting	390	
Site prep, planting, watering	1,500	
Maintenance for 5 years	500	
Harvesting	4,500	
Grading	800	
Farm gate price		20,000
Sum	7,690	20,000
Net for 5 years:		12,310

Note: This assumes survival of about 1,440 trees. Labor is priced at the local farm wage rate. If regular irrigation were used, the additional cost would be about Rs. 4,000. The trees would grow larger, perhaps to sell for as much as Rs. 28,800. Such irrigation is seldom available to farmers with small holdings. Some farmers receive a Rs. 1,250 subsidy not accounted here.

Most of the farmers interviewed in this region say that because of the lack of market development for their Eucalyptus, they will not plant more of this tree. Some expect to encourage a coppice crop, others plan to take out the roots. The farmers talk about planting other species instead, including Acacia nilotica, Prosopis cineria, and other legume species. They speak of a ready local market for fuelwood from these species which does not seem to exist for Eucalyptus wood.

Southern Gujarat

Background: The South Gujarat Plains area has deep clay and loamy clay soil and the highest annual rainfall in the state -- 700 mm to 1800 mm. Temperatures are tropical, ranging from 8 to 42 degrees Celsius. Agriculture is practiced year around in many locations. The principal crops are paddy, wheat, cotton, jowar, groundnut, and sugarcane.

Because of adequate rainfall and good soil, the returns per hectare from farming are highest in this region of Gujarat. Higher land prices and smaller land holdings reflect the difference. Cropland costs Rs. 5,000 to 6,000 per hectare, over twice the cost of land in the central region and the dry region.

The average farm size is 3 hectares, but this includes a few very large holdings, so that a farmer with more than 2 hectares is classified in this region as "large", while farmers with 1 to 2 hectares are "small", those with less than 1 hectare are "marginal", and those with only the compound on which their hut is located are "landless".

Being the moist region of the State, this is the most heavily forested area and a substantial portion of the population are tribal people, who are traditionally associated with forestry in Gujarat. Most of the tribals are either landless or have marginal holdings and are considered "below the poverty line" by local standards.

The case study for this region was in Fadvel, a village in the Valsad district. It is a tribal village of 3300 households, of whom 548 are landless. It is considered an uncommonly progressive village, largely due to an active Village Panchayat and the leadership of Panchayat President Shri Parvezbhai Italia.

While the landless tribal people do not have cropland, some 307 of them are reported to have planted about 100 trees each on their homesteads. At the same time, many of the small and marginal farmers have planted trees on their cropland. The "Fadvel Tree Growers' Cooperative Society" comprises mainly small and marginal farmers and the agricultural laborers. This new organization was formed to expedite the distribution of subsidized credit and other inputs available from the government. It may also prove useful for marketing the wood.

Tree farming practices and costs: Mr. Nishalihar Silalabhai Patel is a tribal man who, with a family of 6 and a farm of 2 hectares is just between the large farmer and small farmer categories. He owns his land, most of which is used for a subsistence crop of paddy rice. He reports that his rice crop does not suffice for his family's consumption. For a cash crop he plants some sugar cane and keeps 2 bullocks to turn a crusher to make cane juice, from which his profit is about Rs. 5,500 per year. He also has 3 cows for milk for his own use and 2 extra bullocks.

This farmer began tree planting in 1980 with 500 Eucalyptus and 500 Casuarina seedlings received free of charge at the Forestry Department nursery. He planted another 1000 Casuarina in 1983 and again 1000 Casuarina in 1985. Some of the trees are in a block (woodlot), others are around his house. Some of the trees have been intercropped with ginger, eggplant and tomatoes. He does not expect to plant more as the remaining land is barely enough for his rice and sugar crops.

Mr. Patel, his family, and hired laborers planted the trees at the beginning of the rains in June, though labor is in great demand for agriculture at that time. The common rate for farm labor is Rs. 10 per day. Site preparation for planting 3000 trees takes about Rs. 1,200 worth of labor. The planting was done at the rate of 75 seedlings per day per laborer, and thus costed about Rs. 400 .

Weeding is done 3 to 4 times in the first year and once in the second year. Mr. Patel has applied insecticides occasionally but has not fertilized or irrigated. The trees are protected by a thorn fence that already existed around the fields. He estimates that maintenance takes about 40 man-days in the first year, 15 days in the second, and 8 to 10 in the third year. After the third year, no maintenance operations are necessary. Thus, the farmer estimates his total maintenance cost for the trees at Rs. 640 .

Only 56 of 500 Eucalyptus survived, but 2,177 of the 2,500 Casuarina have survived. The farmer believes Casuarina has done better because his soil is slightly saline. Thus by early 1986, Mr. Patel had successfully established 2,233 trees, and he reports that his costs were about one rupee per planted tree. This excludes the opportunity cost for the land, the costs borne by the Forest Department in providing free seedlings and advice, and the costs for subsidized interest and for administration of the loans provided by the government.

The government provided loans to Mr. Patel and other tree farmers. Through a special program for tribal people, they were to receive Rs. 1.50 per plant in the first year, 1.10 in the second year, and 0.40 in the third year. (Actual disbursements may have varied somewhat from these planned rates because of constraints on the bureaucracies handling of funds.) The intended loan was thus Rs. 3 per tree. This is provided at 4% interest per year, and would be sufficient to offset Mr. Patel's expenses on labor, insecticides and tools, with some left to offset the opportunity costs for the land.

Expected tree farming income: The trees are to be grown on a 10-year rotation. Thus Mr. Patel does not expect to begin cutting until 1990. He mentioned that the trees are a form of savings that can be "cashed in" early if money is badly needed, but that the price would not be good if he were to sell only a few of the trees at one time. Thus he expects to wait the full ten years. He has heard that some trees have been sold by farmers for as much as Rs. 100, and expects that 10-year old Casuarina will sell for Rs. 50 to 60 each. Harvesting and handling the trees is expected to cost about Rs. 3 per tree. Loan repayment would be another Rs. 4.50, leaving a net of about Rs. 47 per tree.

At that rate he would eventually sell his trees for a gross return of about Rs. 100,000. The investment would have been Rs. 2,240 plus opportunity costs for the land and less subsidies received. He considers the Rs. 100,000 will be a "quick and very good financial return." Of course it remains to be seen whether the market will be ready when the trees are.

Another significant benefit from the tree farm is grass that is cut between the trees and carried to livestock. Farmers who do not have their own source for fodder expect to buy about 1 rupee per cow per day for grass.

Farmers in this village noted that while those with large holdings can sell many trees at once and command a good price, those with only a few trees are likely to be exploited by the buyers. Mr. Patel, for example, expects to sell about 400 trees in 1990. This will not be enough for a strong selling position. Officers of the Panchayat and Forest Department officials note that in addition to the coop, the farmers need to have tree marketing regulated as is the marketing of grain, cotton and other crops.

Constraints on tree farming: Mr. Patel and most of the other tribal people interviewed at Fadvel will not expand their tree farming further because their land holdings are small and land is expensive. The loans provided have been important to their decision to take up tree farming, but delays in payment of the loans were a hardship for Mr. Patel, who had to sell household articles to get money in time for planting the trees. Other farmers may have decided against tree farming or failed to plant and maintain trees on time because of the funding delays.

The major technical constraint cited by the tribal farmers is the lack of irrigation facilities to enhance seedling survival and tree growth rates. Forestry officials estimated that where irrigation facilities are available, regular irrigation of trees would cost about 1 rupee per tree during the entire 10-year rotation. However, land with irrigation facilities would have a much higher price or opportunity cost than the unirrigated land used for tree farming now.

Generally, farmers with larger land holdings feel constrained mainly by lack of technical advice and by inaccessibility of some needed inputs (such as insecticides) on a timely basis.

Farmers with smaller holdings are more constrained by the inadequate infrastructure for delivery of seedlings and other inputs. The delivery of inputs to tribal people in Gujarat is reported to be liberal but cumbersome, confusing, and slow. Transport of seedlings from the Forestry Department nurseries is a major factor determining which villages can undertake tree farming. The Forest Department lacks information that could help it to match the scale of its operations in various regions and the choice of species at its nurseries to the farmers' felt needs. Some farmers interviewed complained that technical advice regarding plantation, maintenance, harvesting, and marketing is seldom available when it is needed. The coop has no expertise in these matters.

While farmers in Fadvel were not so "nervous" about the market for their trees as farmers in other regions of the state who were ready to sell now, they were concerned about the lack of a marketing system that could protect them from exploitation by middlemen.

NORTHERN HAITI

Background

In Northern Haiti, farmers have been encouraged and helped to plant trees since the late 1960s by three missionary organizations: the Mennonites at Grand Riviere, the Oriential Missionary Society at Vaudreil, and the Hopital le Bon Samaritain at Limbe. The three missions developed tree nurseries, producing seedlings in plastic bags for distribution free of charge to farmers. The main species promoted were mahogany (*Swietenia macrophylla*, and *S. mahogoni*), which were intended to be a cash crop.

One of the missions developed a tree-planting cooperative in which members purchased shares, worked together in cooperative nurseries, and planted trees on land owned privately by the coop members. This system was able to successfully plant and maintain about 75 hectares of land over a ten year period. However, the coop never reached a self-sustaining level of organization. It continues to need active care from the foreigners at the mission.

The trees, planted on a 2.5 meter spacing, are now in need of thinning. Mahogany grows straight and tall and was supposed to be sold as poles. However, Haitians have since learned that mahogany wood is easily attacked by borers, so the trees now have little commercial value. Thus the owners are reluctant to do the needed thinning, and growth of the trees has stagnated.

The other two missions worked directly with private farmers rather than though a cooperative structure, but their experiences and scale of operation were similar. A number of farmers would take a two to six trees, but the missions could not expand these tree planting programs substantially. This was partly because the farmers could carry only a few of the bulky seedlings over the rough terrain to their mountain-side gardens. Also, the farmers felt they had too little land to use much of it for trees which repaid their investment so slowly. Now most of the farmers face the prospect of making fuelwood from the mahogany they had expected to have substantial commercial value.

The missions began to use a wider variety of species, and rootrainers (containers smaller than the plastic bags) were introduced to produce smaller seedlings so that farmers could carry more per trip to their farms. With the fuel shortages of the mid 1970s, fast-growing hardwoods began to appear more attractive. Because the area has high rainfall, it appeared that Leucaena and a few other species could give profits quickly enough to motivate farmers to plant more trees.

Experience of farmers assisted by Hopital le Bon Samaritain

It soon became apparent that grazing animals destroy unprotected seedlings, but fences seemed too costly. One of the missions therefore

developed a system of interplanting Leucaena and Cassia siamea in the existing gardens, which were being protected from livestock. The missions' extension agents explained to farmers that the trees could be cut on a two to three year rotation for charcoal and poles, and would re-sprout to give successive cuttings. At the request of the farmers, high-value hardwoods were added at wide spacing within the plantations.

A team working for the mission plants the trees with the assistance of the farmer/owner. In most cases, garden crops such as manioc and sweet potatoes are planted in the same fields. Follow-up visits after six months by the extension agents find both completely failed plantations and some with high survival rates. The average survival is about 50%. Farmers participating in this program were interviewed for the present study. The experiences of three farmers are summarized in Table 5.

All the farms visited were located within 100 meters of sea level in an area with about 1,800 mm/yr rainfall and daily average temperatures that vary from 80 to 95 degrees F. Night temperatures are generally between 65 and 70 degrees. Soils are of volcanic origin and have a neutral pH.

The three cases illustrated in Table 5 suggest the range of experiences. Further comment on them will be more informative than additional data from the other interviews.

Jean Aristile is both a farmer and owner/operator of a small bakery located in his home. Besides trees he grows manioc, patate, and maize. He is a man of some means -- he owns a house in Port-au-Prince which he rents out for $2,000 per year. He harvested his 5-year old plantation of fast-growing hardwoods to produce wood for his bakery that he would otherwise have had to purchase for the price indicated in Table 5.

Unlike most Haitian farmers, M. Aristile is enthusiastic about the value of firewood trees as a farm crop. He intends to replant firewood, but wants to mix in high-value (timber) trees this time.

Joseph Alexandre is a seasonal worker at the tree nursery of Hopital le Bon Samaritain. He is a progressive farmer. Rabbits were introduced to Limbe only 8 years ago, and he already has over a hundred head. When pigs were reintroduced to Haiti, he was among the first to try the new breed.

The main products of M. Alexandre's small mountain-side farm are yams, tarro, and plantain. All are cash crops. He has purchased and planted more trees than most people in Limbe. In addition to the 100 mahogany planted in 1971, he has since planted 500 Catalpa, as well as some neem, Simaruba, Leucaena, Kapab, Oak, and mango.

During the 12 years the mahogany trees were growing, M. Alexandre pruned them and grew annual crops under them. About 25% of his mahogany resprouted after cutting and the new stems were about 20 cm. diameter by March, 1986.

Table 5

Experience of typical farmers planting trees
in Limbe, Haiti
(Costs and incomes in U.S. Dollars)

Name:	J. Aristile	J. Alexandre	J. Abel
Habitation:	Saut-d'eau	Mazamba	Paris
Hectares in total farm:	0.97	0.32	0.42
Tree type:	Leucaena, Cassia, Calophyllum, Kapab	Mahogany	Leucaena, Cassia
Number planted:	630	100	425
Hectare planted:	0.32	n.a.	0.21
Year planted:	1980	1971	1983
Survival:	90%	80%	82%
Year cut:	1985	1983	1985
Portion cut:	100%	85%	100%
Purpose:	Fuel for own bakery	Wood & charcoal to sell	Charcoal
Quantity produced:	420 donkey loads	$500 craftwood 40 sacks charcoal $30 firewood	5 sacks
COST ITEMS			
Site prep:	$ 50	$90	$30
Seedlings:	47	10	32
Planting:	15	1	2
Maintenance:	12	120	8
Fence:	9		
Cutting:	50	10	2
Hauling:	139	20	1
Subtotal:	322	261	75
Less gifts from mission:	- 62		32
Farmer's costs:	$260	261	43
INCOME			
Value:	$840	664	7
Net (profit) in 1 rotation:	$580	$403	$ (36)

Note: These figures underestimate the profit (overestimate the loss to some extent because the site preparation was also for the interplanted crops (manioc, etc.).

The main problem encountered by M. Alexandre is that he received a poor price for his trees. Our cooperator calculated that the trees yielded about 90 board feet of useful craftwood per tree. The wholesale price for such wood is $0.40 per board foot. Had he had the wood hand-sawn into craftwood pieces at a cost of $12 per log, he would have had a net of about $24 per log. He received $6.25 per stem. A fair price would have been about $1000 to $1500 for the wood. In spite of this calculation by third party, when M. Alexandre was able to sell his mahogany trees to a company in Port-au-Prince for $500, he was so pleased that he began immediately to plant trees on all the rest of his land.

Josue Abel was a willing tree planter in 1983 when he asked the Hopital le Bon Samaritain project to plant for him. Besides the 425 fast-growing Leucaena and Cassia for charcoal, some 100 mahogany and Simuraba were planted for timber. However, M. Abel decided the trees for charcoal were not valuable enough for land that could be used for annual crops or for cocoa and coffee. So he cut the Leucaena and Cassia before they had grown much and produced only 5 sacks of charcoal, which were used at home. (The charcoal could have been sold at the price indicated in Table 5.)

The accounting in Table 5 shows that M. Abel incurred a substantial loss because the trees were cut so soon. But this does not include the value of the high-value trees that are still protected and growing on his land, spaced about 6 meters apart. These he is likely to prune and keep in his garden until he needs funds very desperately.

Comparing the three cases, one is an enterprising baker/farmer who made more profit from a 5 year rotation of trees planted for fuel than another farmer made from a 15 year rotation on a similar area of "high-value" timber trees. But the farmer who decided to take out his fuelwood trees is probably most typical of farmers in Haiti, who generally feel that only lumber trees have value.

JAVA, INDONESIA

Background

Farmers on Java have historically included multipurpose trees in their cropping systems. During the past two decades, the farmers choices of which kind of trees and how many to plant have begun to change in response to the Forestry Department's Regreening Program. This government soil conservation program provides seedlings and information concerning the culture of trees to farmers in the region.

The Regreening Program has had a strong influence in the village of Desa Kepoharjo since 1972. In that year a group of students from Gadja Mada University worked with the villagers to build an artesian well and gravity flow water system to bring water to each household.

Previous to 1972, the village was a semi-arid area where the farmers had water enough for only one crop of corn and yams per year. The location is on a rough but usually passable road just 27 kilometers from the provincial capital, Daerah Istimewa Jogyakarta. It is between 900 and 1000 meters up on the slope of volcano Mt. Merapi. There is no naturally level land, but terraces have been built and the volcanic soil is fertile and well drained.

Since addition of the water system, the villagers have planted much former grassland and have both intensified and diversified their agriculture, including their use of tree crops. The students went on to form a non-government organization, Yayasan Dian Desa (Indonesian Appropriate Technology Group), that is still actively bringing innovations to this and neighboring villages.

The 700 farms of this village are remarkably even in size with hardly any under 0.5 hectare and few over 1 hectare. Most of the farms have 0.5 hectare of cropland and 0.5 hectare of woodlot. Crops include corn, cassava, bananas, coconut, oranges, vegetables, papaya, and grass for livestock that is usually confined. Highest value fruit trees are planted on the homestead, trees for shade and fodder are planted at very wide intervals on the cropland, and trees for fuelwood are planted more densely on the woodlots. Clumps of bamboo are planted to delineate boundaries.

A typical farm

Most farms have several kinds of trees. Typical is the 1 hectare farm of Mr. Parmoreto in the hamlet called Duku Kaliaddem. Ten kinds of trees take up about half of his farmland. They include:

Acacia, 1000 plants grown for firewood for home use and sale.

Albizia, 15 plants used for fodder and construction wood.

Jackfruit, 25 plants for fruit and wood for construction.

Leucaena, 15 plants to shade a coffee and clove trial.

Bamboo, 25 clumps for construction material for home use and sale.

Mindi, 25 plants for firewood, shade, and construction material.

Lenglesh, 50 plants for wood and fodder.

Kepi, 25 plants.

Jeruk, 20 plants.

The other half hectare has crops including corn, cassava, vegetables, papaya, oranges, bananas, and grass. The farm's confined livestock, to which fodder is carried, includes 3 cows, 2 rabbits, 2 geese, and 1 chicken. Assisted by the NGO, Mr. Parmoreto is one of several farmers trying small plots of coffee and cloves.

Since before Mr. Parmoreto was born, trees have been cut as needed through the year and replanted at the beginning of rain season. For some species, seedlings are started in the farm's own small nursery, while other species are direct seeded. Tree planting was increased on this farm in the late 1960s, when the Acacia woodlot was planted.

Site preparation and planting involves tillage, digging pits and placing the trees. It takes about 1 man-day for each 100 trees planted. Survival is typically 75 to 90 percent; trees that die are replaced. Weeding is done by hoeing two to three times in the first year. That takes about 2 man-days per year per 100 trees. No other maintenance is necessary. After the first year, no maintenance operations are done.

Mr. Parmoreto carries substantial quantities of fodder from his trees to his livestock while the trees continue to grow. He could not estimate the quantity collected in a year, but noted that it is worth Rs. 12 per kilogram and, with grass produced on the farm, is all he needs for his livestock.

He estimates that he cuts 50 Acacia trees per year. From this he gets about 500 kg/yr charcoal which he sells for about Rs. 30,000. He sells some 25 poles per year for Rs. 6,500, 2 cubic meters of construction wood for Rs. 12,000, 100 bamboo stems for about Rs. 25,000, and an unspecified quantity of firewood. (The firewood sells at the farm gate for Rs. Rs. 375 for 40 kg of wood.) We could not get a confident estimate of the time spent harvesting fodder and wood. Charcoal production takes about 4 man-days.

Thus the interview suggests that this farm's trees take half an hectare of land and 10 man-days per year (plus more time for seedling production, harvesting and marketing). The farm wage rate is Rs. 1,000 rupees per day. The yearly income from this tree farming includes Rs.

67,000 plus firewood, fodder, construction wood used on the farm and some modest cash income from firewood sales. The expenses and income for which we could get cash values suggest a net income worth about Rs. 57,000, or 50 U.S. dollars.

It seems likely that the fodder and fuelwood consumed on the farm is worth more than Rs. 57,000 per year, but Mr. Parmoreto and most of the other farmers interviewed indicated that cash profits were a major reason for the choice of trees over other crops for part of their land. The other major reason is that labor is in short supply during critical periods. Thus the farmers prefer trees to other crops that would take more labor than is available. The farmers plant trees on land that is similar in quality to that used for annual crops.

General observations on farm forestry in Desa Kepoharjo

Choice of species: The most popular kinds of trees here include Acacia, Albizia, Jackfruit, Leucaena, Gliricidia, Calliandra, Mahogany, and Mindi. Of these, farmers seem most enthusiastic about Albizia. They say it produces excellent fodder, enriches the soil, and provides valuable construction wood. Only Acacia is commonly grown in the half-hectare woodlots which are mainly used to produce fuelwood and charcoal. The Acacia are planted on a 2 x 2 meter spacing. Calliandra is not considered a good crop because it does not get very large. Gliricidia would be cultivated more but is difficult to propagate.

Farmers say their first consideration in choosing species is how fast cash returns can be expected. They say they also consider the affect of the tree on the soil and especially on grass which they grow beneath the trees as cattle fodder. Thus mahogany is being planted less than formerly because it grows slowly and is perceived to deplete the soil and spoil the grass.

Trees to be interplanted with food crops are chosen especially carefully. Jackfruit used to be a favorite for this purpose because of its fruit and the high value of its wood as a construction material. It was planted with a 20-year rotation in mind. However, it is being replaced now by the more recently introduced Albizia, which is perceived to have a better effect on the soil and which is planted for a 10 year rotation to produce construction material that is not so valuable as Jackfruit wood. Both give interim products -- fodder from the Albizia and fruit from the Jackfruit. Both yield some firewood at the time they are cut for construction wood.

Regarding rotation periods for the various species, there was widespread agreement on ideal periods but all the farmers noted that only the Acacia and Leucaena grown for fuel are cut on a regular schedule. Others species are cut when there is a particular need for cash or wood to use on the farm. Acacia fuelwood is cut on a 5 to 7 year rotation and Leucaena on a 5 year rotation.

Marketing the tree products: Most of the charcoal, fuelwood, and construction wood are sold at the farm gate to wood traders who are also farmers in the village. Desa Kepoharjo has 3 such traders. The grower leaves wood at the side of the road. When the trader estimates that the amount is sufficient, he contacts several buyers from the nearest market towns who pick up the wood or charcoal and transport it to town. It is then sold to one or more other businesses before passing to the final consumers.

Exceptions to this pattern include charcoal that is sometimes carried by the farmer to the town on foot for sale there, and single large trees that may be sold to buyers either from within the village or outside. In this case the buyers cut and remove the tree. Also, a small amount of Acacia bark is sold to traders who resell it to the batik industry in Jogya.

Scale of the tree farming enterprise: Virtually all the households in the village and most in nearby villages grow trees as described here. In this village most have a half hectare woodlot with a grass floor, as well as trees around their houses and in their cropland planted at wide spaces to provide shade and fertilizer. The fertilizer effect comes not only from natural leaf-fall but also from manure and leaves that are composted.

All the tree products used in the village are produced on the farms, including all the fertilizer and fuel except for kerosene used for lighting and kerosene used by a small segment of the villagers for cooking. The kerosene price in Java is subsidized by the government.

Planting stock and extension services: Farmers get most seedlings either from those sprouting in their fields or from small on-farm nurseries. Mahogany seedlings must be got from a Forest Department nursery 60 kilometers away and are seldom available. Albizia seedlings are distributed by the government's agricultural extension service and are also produced in nurseries run by village farmer groups. Leucaena seeds and seedlings are being distributed by the NGO, Yasan Dian Desa, as a package with coffee and clove plants. The Leucaena is intended to be a shade or "nurse" tree.

The Forestry Department motivated increased tree farming through initial provision of seedlings and advice. Now the farmers get advice on trees and all other crops from the Agricultural Extension service, and on the coffee and cloves from the NGO.

Costs and income from tree farming: The value of land on which trees are planted varies from Rs. 1,000 to 1,500 per square meter. This is cheap compared to land values in other areas of Java. A half-hectare Acacia woodlot thus occupies land worth about Rs. 6.25 million. (That is 5,530 dollars at the exchange rate of January, 1986.) However, there is not much buying and selling of land in Desa Kepoharjo. The village headman does not allow outsiders to purchase land in the villages, and most farmers acquired their land long ago when its value was much less.

The farmers reported that preparation, planting, and maintenance of a half-hectare woodlot takes about 18 days of labor in the first year and almost no labor thereafter. Acacia in woodlots are usually spaced 2 x 2 meters, so a half-hectare would have about 1,200 trees. The woodlots are managed for a 5 to 7 year rotation with cutting and replanting occurring every year. Thus the annual planting and first-year maintenance is probably done with about 200 trees yearly, which takes about 3 days of labor.

The farmers interviewed could not estimate time spent harvesting the trees. A guess based on experience elsewhere is that that ten man-days per year might be used to cut 200 Acacia trees. Farmers did report that each farm spends about 4 man-days per year are spent on charcoal making. Thus the total labor for the half hectare of Acacia is about 25 days per year. This would be valued at about Rs. 25.000.

The average charcoal yield from a half-hectare Acacia woodlot is said to be 500 kilograms, which the farmers can sell for about Rs. 37,500. They also report selling about Rs. 67,500 worth of poles and other construction wood.

The farmers could not estimate the average quantity or value of firewood sold per year, rather they discussed the number of days (which varied from 2 to 12) that it takes them to accumulate a 40 kilogram load for the trader and the prices paid for 40 kg. by the traders (varied from Rs. 375 to 1,000). This does not provide a basis for even crude financial analysis, except to note that the lower limit derived from these numbers would be one load sold every 12 days for Rs. 375, or Rs. 11,000 per year.

Fodder from grass in the Acacia woodlot and from Albizia and other trees in other parts of the farm is used on farm not sold, but the farmers did estimate the value to be Rs. 12.5 per kilogram. A typical estimate of production was 15 kilograms per day. Thus the estimated value of fodder from the tree farm would be Rs. 68,000 per year.

The total of the above estimates of typical income is Rs. 184,000 per year. This suggests a profit of at least Rs. 119,000 per year, or about 105 dollars. (Less than 2 percent of the reported value of the land used for the woodlot.) That net income probably underestimates the value of the firewood sold and does not value the firewood consumed, or the occasional sales of large Jackfruit, Albizia and other trees, or sales of minor products, such as Acacia bark.

Problems and apparent trend in tree farming: Tree farming activity has been increasing in the village for over a decade, but farmers feel no further increase is likely. To plant more trees on private land would crowd the needed food crops. They feel they might be able to increase the density of planting but are not sure that would increase yields. They recognize that fertilizer applications would increase tree yields, but say fertilizer produced on the farm is all needed for the food crops and manufactured fertilizer is too expensive to be used on the trees.

The farmers suggested that tree farming could be increase by planting communal lands now in grass cover, with the participating farmer taking half the income and paying half to the village. However, they feel that shortages of labor at planting time, which comes at the same time for trees and food crops, prevents planting of communal property.

Role of a dynamic leader: This village is considered more progressive than most in the region with respect to both tree culture and other innovations. Our informants say credit for this is mainly due to the village head, who has been in his position since 1937. He has insisted on villagers taking an active part in the design of government and NGO projects carried out in the village, and has maintained social and economic stability with rules such as his ban on sales of land to outsiders.

BANGLADESH

Eastern Bangladesh, comprising the Sylhet, Comilla, Noakhali, and Chittagong areas, region covers about 20% of the country's area and 25% of its population. Thus use of trees on farms is similar throughout this region.

Typical farm holdings are very small, 76% of the farms have less than 2 acres (0.83 ha). All the cropland on these small farms is used for grain and other food crops, so that the only available sites for tree planting are around the houses. Still, the number of trees planted on these sites is substantial.

Tea estates in this region have in recent years begun to establish energy plantations of up to 100 acres, as the natural forests that used to supply firewood for tea drying are severely depleted now. In hilly areas unsuitable for food crop agriculture, bay leaf and fruit orchards, usually sized below 20 hectares, have been established.

Over half the requirements for fuelwood, timber, poles and other wood products are believed to come from within the villages. Fodder also comes mainly from within the villages. The balance comes from forest areas and other government land. These villages do not have community land. (For the country as a whole, an estimated 75% of the tree products come from private sources, most of this from trees planted around the houses.)

In spite of the crowded land resources, tree planting seems to be increasing. Trees have traditionally been planted for fruit and for minor products, and only in recent years has planting of timber and firewood trees begun to be more popular. This is partly because of increasing prices of these tree products and partly because seedlings for fuelwood and timber species have become easily available at many locations.

Tree farming practices and costs:

A large variety of tees are popular with farmers in this region. The main types and their uses are:

Jackfruit:	fruit, timber, fuelwood, fodder.
Mango:	fruit, fuelwood, match and packing boxes.
Jam:	fruit, timber, fuelwood.
Coconut:	fruit.
Betelnut:	nuts.
Citrus trees:	fruit.
Teak:	timber.
Mahogany:	timber.
Albizia:	fuelwood, timber, fodder.
Champa:	timber, fuelwood.
Simul:	match boxes, fiber from fruits.
Eucalyptus:	fuelwood, timber.

Jarul:	timber, fuelwood.
Raintree:	timber, fuelwood.
Bay leaf tree:	leaves (only in Sylhet).
Chapalish:	timber, fuelwood.
Kadam:	match boxes, packing boxes.
Maddar:	live fences, fuelwood.
Minjiri:	fuelwood.
Neem:	medicinal, fuelwood.
Krishnachura:	ornamental, fuelwood.
Satian:	match boxes, packing boxes.
Tamarind:	fruit, fuelwood.
Bamboo:	construction poles, tools, crafts, etc.

Except on the tea estates' fuel plantations and the fruit and bay leaf orchards mentioned above, the tree planting is around houses. Assigning the cost of this land as a cost of tree growing is difficult. It is the most expensive land in the region, selling for 20 to 40% more than good cropland. But an economic return from the trees that is in normal proportion to the cost of the and is not expected by the farmers.

Labor is also difficult to price, since each farmer plants only a few trees per year and this during "spare time" These units of time so short and scattered that they have little identifiable opportunity cost. Similarly, farmers could not give a useful estimate of time spent maintaining homestead trees.

For an Albizia plantation used for energy on a larger tea farm, site preparation on already cleared land takes about 20 man-days per hectare, and planting 2 x 2 meters takes another 25 days of labor per hectare. A common farm wage rate is Tk. 25 per day. Thus labor for establishment of the plantation would cost about 1125 Tk. per hectare. Where the land has never been cleared, costs are higher. One tea plantation reported site preparation and planting costs of Tk 5,800 per hectare.

Trees on small farms are protected by fences, at least while they are small. These are usually constructed with materials gathered on the farm, bamboo, thorn branches, etc., and the cost could not be estimated. The tea estates' energy plantations are usually not fenced.

Trees grown on homestead land have no fixed rotation. Once the reach usable size, they are cut as needed for on-farm use or for sale to get cash for special needs. A common age for cutting of trees to be used or sold for construction material is 15 to 20 years. Cutting branches for fuel and fodder is started on many species 6 to 10 years after planting.

Income from tree farming:

Fruits are usually sold to traders who contract for the production while the fruit is still unripe on the trees. Bay leaves are also sold directly to traders. Timber and fuelwood are less significant as cash crops. They may be sold directly to a consumer from the same or a

neighboring village or they may be sold to a trader. Such sales usually involve only one or a few trees. The wood may then be sold to local consumers or aggregated for shipment to another level of traders.

Farmers rarely have regular yearly or periodic income from their trees, except for fruit sales. Even fuelwood used on-farm is irregular, since it supplements (or is supplemented by) substantial quantities of fuels (wood, crop residues, manure) collected off the farm. As a result, the farmers do not seem to have a conceptual accounting of the annual benefits vs. costs of tree growing. There is a widespread attitude that tree growing on the homestead is the best use of this land, and that all land is scarce and must be but to its best use.

Quantitative income data were also not obtained by our study from the tea estate energy plantations. Many of these are recently established and have not yet begun to harvest. One tree farming operation owned by a tea estate reported producing, from a long-established 900 acres of tree plantations, about 30 cubic meters of timber and 280,000 cubic meters of firewood yearly. They could not assign a value to the firewood, since the alternative is to have estate laborers collect it from naturally regenerated trees on government land.

Constraints and apparent trends:

The major constraint for most farmers is the paucity of land. Planting trees for timber and fuelwood to be used on the farms is apparently becoming more popular, presumably because these products are becoming more scarce from off-farm sources. But with land so scarce, the only opportunities to increase production significantly appear improvements in tree genetics and tree culture techniques.

The tea estate managers interviewed for this study reported the major problem they had with tree farming was extensive theft of both timber and firewood. During the first year after planting, both droughts and flooding from heavy rainfall are significant causes of seedling mortality. Shortage of water during dry season for the first years caused significant mortality, they said.

A constraint on tree-planting, a long term investment, that was cited by both small farmers and estate managers was a shortage of credit to finance tree farming.

KASHMIR, INDIA

Background:

The Valley of Kashmir has a Himalayan temperate climate and an elevation of 1800 meters. Seventy-five percent of its 4 million population are farmers. Most of the farms have less than 2 hectares of land. An estimated three-quarters of the farms include trees among their crops.

The tradition of tree planting by farmers is centuries old, but the current practices for use of trees date to the late 1950s and early 1960s, when average land holdings began to get smaller and the value of farm-grown fuelwood began to increase. Now an increasing number of households are planting trees and the plantation area is increasing.

Although Kashmir is rich in natural forest resources and its forest industry is substantial, tree on farms do contribute a large portion of the wood products used in the province. Most of the fuelwood consumed in Kashmir's cities and towns is supplied by the Forest Department from government owned forests and other government lands, but another 20,000 cubic meters per year comes from private sources.

In rural areas, 41% of annual fuel needs are met from twigs and branches of farm-grown trees. Another 10% comes from private willow plantations, while the remaining half of the fuel need is met by collection of wood from government forests and wastelands and by use of cow dung and agricultural wastes.

Farmers also produce about 15% of the construction timber used in Kashmir, i.e. about 15,000 cubic meters per year. Another major use of wood is manufacture of fruit packing cases, and 95% of this comes from farms. Thus private farms are a major contributor to the region's wood and fuel balance.

Tree farming practices:

The Kashmiri farmer's economic strategy seems concerned at least as much with survival (risk reduction) as with profit. Thus the crop and tree planting practices include numerous species even on small land holdings. The tree species mix on a typical farm would include the following types. The indicated percent in the mix is an estimate for an average small farm. Of course the species and percentages vary greatly among farms.

1. Fruit trees -- 30%. These trees, such as apples and almonds, are planted mainly for cash crops. Fruit is a major industry for Kashmir. Wood pruned from these trees is used for both fuelwood and charcoal.

2. Willow -- 28%. These are very popular and versatile species, used for fuelwood and as winter fodder for sheep. The timber is used in manufacture of cricket bats, an important cottage industry in Kashmir. The wood is also exported to other parts of the country to make artificial limbs.

3. Poplars (Populus deltoides, P. nigra, P. ciliata) -- 14%. These are used for wood to make packing cases for the fruit industry and as a substitute the expensive conifer construction timber. Leaves of some varieties are used for fodder, and poplars are used to delineate farm boundaries.

4. Robinia (R. pseudoacacia) -- 6%. This highly adaptable tree is used for live fences and for wood production on the poorest land. It is considered a very good fuelwood and is increasingly being used in manufacture of furniture.

5. Walnut -- 5%. Grown mainly for its fruit. It has high potential value for sale to furniture and handicraft industries.

6. Others -- 17%.

In recent years, there has been a shift in the proportion of each species in the mixture. For example, less fruit trees and more poplars are being planted. The main reasons are rising costs of fruit orchard establishment and maintenance on one hand and rising prices of fuelwood, construction timber and other wood products on the other. Wood plantations have begun to seem an economically attractive and viable proposition.

The farmers' choice of species depends largely on perceived profitability from sales of wood, yet most tree products are consumed on the farm. Expert informants estimate that farmers use about 70 percent of their tree products, and sell the rest. The balance for any particular farm depends on the farm size, distance from government-owned forests or other public land with trees, opportunities to use land for various crops, and other factors.

Another strong influence has been the policy of the government to encourage the rural population to produce their own fuel. This policy led gave rise to several planting programs and a social forestry project. Through these programs, seedlings for both fuelwood and timber species have become readily available to many farmers at almost no cost.

Trees are planted both in woodlots and elsewhere on the farm. An estimate of the typical tree distribution on the farm is as follows:

Woodlots on fallow land:	50% of farm trees
On boundaries and bunds:	40% of farm trees
Around homesteads:	4 to 6%
On land previously cropped for food:	4 to 5%

The interactions between trees and other crops are considered by the farmers, but not with benefit of science. Rather they rely on tradition and personal experience. Species with large crowns are avoided to minimize shading of crops. Populus nigra is a popular tree for fences and avenue planting because of is very narrow crown. One of the most widely recognized interactions is that trees near paddy fields result in increased damage to the rice crop from birds.

The most common intercrop is grass used for fodder. Grazing among the trees is usually permitted when the trees are three years old, and grass from woodlots is often cut and carried to confined animals when the trees are younger.

Rotation times and other management decisions vary greatly from farm to farm, depending both on the farmer's needs for wood and cash and on his ideas of how to maximize tree growth rates. Robinia can be felled for firewood when it reaches a 10.5 cm diameter in about 11 years. Poplars can be sold for packing case wood when they reach a 30 cm diameter in about 12 years, but are substantially more valuable if allowed to grow further. Poplars rotations are planned for up to 21 years, but may be interrupted to raise money for special needs, such as marriages.

Collection of leaves for fodder from poplars and willows begins 3 to 5 years after planting and lopping branches for fuelwood begins in the 6th or 7th year.

Marketing firewood and charcoal:

Pruning materials and lops are used to make charcoal. Some of this is used on the farm, any surplus is sold though a local collector. The collector is often another farmer who has made necessary contacts in the nearest town. Pruning, lopping and thinning material is also sold directly to confectionaries and to small brick kiln businesses or to middlemen who purchase for large brick kilns.

Other surplus firewood is sold in towns or cities. Often a farm household member takes the wood to town on foot, by horse, or by purchasing transport on a passing truck or bus, and then sells directly to consumers. Where the farmers can accumulate larger loads of wood, they sell through middlemen who arrange the transport and retail sale.

When the entire tree is harvested at the end of its rotation, it is usually not for firewood or charcoal but for timber. Such trees are most often sold standing with the buyer, who is a middleman, taking responsibility for cutting, transport, and resale.

Tree farming costs and income:

The cost of farmland used for trees in Kashmir varies from 1,200 to Rs. 20,000 per hectare. In most cases, the trees are planted on the least productive land within the farmer's holding.

The following are estimated costs per tree for a typical Kashmir Valley farm with about 1,250 trees. The figures are derived from farmer interview done for this study as well as an earlier study done by our cooperator in Kashmir, Mr. Javid Hussain. The costs of labor for charcoal production and the cost of planting material are not included in this list. Only fruit tree seedlings are commonly purchased, other material is produced on the farm from cuttings (e.g. willow), or received free from the Forestry Department (e.g. walnut).:

Item	Rupees/tree/12 yrs
Site preparation, pit digging, and planting 1250 trees:	0.7
Initial fencing cost:	1.0
Weeding, protection, irrigation, fence repair, etc:	1.0
Harvesting:	2.5
Total:	5.2

Farmers have difficulty estimating income from their trees. The main product is firewood for on-farm consumption. According to Forestry Department records, rural households use an average of 7.2 kilograms of firewood per day. If this were purchased it would cost Rs. 7.2 per day, thus about Rs. 2,600 per year. This figure happens to be three quarters of the average cash income of farm households with small to modest land holdings in Kashmir. It is likely that even farmers who grow trees get some of their firewood from wastelands or forests off the farm.

The price farmers receive for whole trees sold as packing cases depends on the size of the tree and the species. Larger trees get a higher price per unit of wood. Willow is more valuable per wood unit than is poplar. When the demand was less, some 10 to 20 years ago, farmers often grew trees on a long rotation and sizes were quite large when the tree was cut. Now poplars are often sold as soon as they reach a 10 to 12 inch diameter, i.e. 10 to 12 years after planting.
A 12 year old poplar typically has 0.5 cubic meter of wood and can be sold standing for Rp 50.

The trees are usually not evenly spaced in blocks but rather are scattered over the farm on boundaries and other sites not suitable for food crops. And they are not cut all together, but rather one is cut now and then. If farmers can, they keep the tree another year for the marginal growth and the marginal increase in price per unit of wood. If they must have cash, they sell as many trees as necessary.

Farmers are paid Rp. 50 per kilogram for charcoal. One of the farmers interviewed for this study estimated that the loppings from 1,200 trees on his farm produced about 60 kilograms of charcoal per year. He used some of

this at home and sold some at Rs. 50 per kilogram. Had he sold it all, the income would have been Rs. 3,000, or 2.5 rupees per tree. Because this household had charcoal, it presumably did not use Rs. 2,600 worth of firewood.

Farmers are paid 1 rupee per kilogram for firewood. Those who have about 1,200 to 2,000 trees use about 3/4 of the firewood they produce and sell about 1/4. Thus the typical cash sales of firewood would be about Rs. 870 per year, or 0.5 Rupees per tree per year.

The income from 1,250 planted trees can thus be roughly estimated according to the following list. These figures include both the value of the wood products consumed and the estimated income from sales.

Item	Rupees/unit	Rupees/tree/yr.
Firewood consumed and sold	1 Rs/Kg	2.0
Charcoal consumed and sold	50 Rs/Kg	2.5
Timber sales	100 Rs/Cu.M.	4.1
Fodder for livestock	unknown	unknown

Estimated costs during 12 years, Rs. 5.2 per tree, compared to the estimate income at the end of 12 years, Rs. 103 per tree, suggests that tree farming is an attractive enterprise for the farmers.

The above calculation probably suggests more income from timber sales than is achieved by typical farmers with less than one hectare of land in Kashmir Valley. However, the fodder from trees is critically important to carry sheep and other livestock through the winter, so this calculation probably does not overstate the importance of farm forestry to small farms in the region.

Constraints on tree farming:

The above estimates of costs and income suggest that farm forestry is a successful enterprise in Kashmir. However, they are very rough calculations, as are other studies that have been done of farmers' use of trees in this region. The lack of adequate information both on technical aspects and economics of tree farming has led farmers to some bad decisions.

Cases of high mortality, apparently caused by poor selection of species and inadequate knowledge of techniques, have been reported frequently. In some places enthusiastic forestry officials are said to have over-stated potential yields and financial returns so that farmers are disappointed in the crop and may loose faith in the foresters' and extension agents' advice.

Very little is known by either farmers or foresters about the most appropriate spacings for trees or the best patterns for integrating trees with food crops so as to optimize the trade-offs between yields and risk reduction.

A major constraint perceived by both farmers and foresters involved in the social forestry programs is the lack of credit for farm forestry. To invest their land and time in establishment, protection, and management of trees, the farmers must take a relatively long term view of profits. But the lack of credit compels all but the relatively wealthy to concentrate on crops and activities that will give short-term returns.

The government is, in principle, anxious to encourage tree farming. However, laws established to protect the government's interest in natural forests can become constraints on farmers. Some local laws prohibit movement of wood products without obtaining permits. This often leads to farmers being exploited by middlemen who have the resources to overcome the administrative hurdles of getting such permits.

Apparent trend of tree farming in Kashmir Valley:

Demand and prices for tree products have been increasing in Kashmir. Meanwhile, food crops are not in short supply. Thus it appears likely that farmers, even those with modest holdings, will at least continue to include tree crops in the patterns that have been established over the past two decades. Some further intensification of tree farming seems likely to occur if the demand for wood products continues to rise.

THAILAND

Chachoengsao province is about 150 kilometers east of Bangkok. The area studied is low lying land just a few meters higher than the alluvial Central Plain. It includes some low, rolling hills, and is typical of much of Eastern Thailand. Soils are of medium to good quality for agriculture and include large areas of recently-cleared forest land. Farming is relatively productive compared to Thailand generally. Cassava is the principal upland crop.

Pathumthani is 50 kilometers north of Bangkok, on the flood plain of the Chao Phraya river. Most areas can be irrigated and flooding is generally a more serious problem than drought. Because the soils are somewhat acid, rice yields tend to be lower than normal for the Central Plain region, and many farmers have diversified into producing oranges and other fruit. Because of the proximity to Bangkok, large areas have been developed for residential use, and other areas are awaiting development.

Tree species and uses:

In both the regions, Casuarina and Eucalyptus are the most commonly used trees for farm forestry. The main use for the trees is as construction poles and posts. The most valuable trees are 15 cm or more in diameter and are used for house posts. Some of the trees have been sold for use in a pulp mill at Khon Kaen, some 400 km. away. Branches are used for firewood on the farm. Occasionally the firewood is sold or given away free to other farmers in the same village.

Farmers seem motivated entirely by the opportunity for profits from these trees. They attach little value to the wood products consumed on farm and seem to have little or no interest in indirect benefits such as shade or soil conservation.

History and trend of tree farming:

Thailand as a whole has experienced rapid reduction in its natural forest area, with the territory under forests declining from 53% in 1961 to 30% in 1982. The forest that is left now is generally that which is economically inaccessible. Consequently Thailand has changed from being an important exporter of wood into a net importer.

Since the mid 1970s, the scarcity of wood for construction has been causing both increased interest in agroforestry and increased use of substitute materials, especially concrete. The academic community has been promoting agroforestry since the mid-1970s, and the Department of Agriculture Extension Service has done some promotional work since 1980. The governor of Chachoengsao province launched a personal campaign, including radio broadcasts, to encourage farmers to plant trees. By about 1980 to 1981 the interest in tree farming was manifest in substantial planting of Eucalyptus and Casuarina.

At first most interest was focussed on Eucalyptus, which was studied, demonstrated, and extensively promoted by the Forestry Department and by private nurserymen. Several publications in Thai language explain practical aspects of growing Eucalyptus. More recently, Casuarina has been gaining in popularity. Farmers report that it survives well, needs little attention, grows straight, and produces good quality wood for construction. Eucalyptus planting seems to be going out of favor. Farmers interviewed for this study said they would prefer Casuarina if they plant trees again.

As is usual in agricultural development in Thailand, the main impetus for tree farming has come from the private sector, urged on by a few enthusiastic politicians and technocrats. Government agencies have played a supporting role: extension agents provide some assistance, but usually only after the farmers have begun to grow trees.

None of the farmers interviewed for this study had an annual cycle of planting and cutting. With one exception they had planted in just one year and had cut or planned to cut all the trees at once, after either 5 or 6 years of growth. The exception was the farmer with the largest tree area, 88 hectares. He had planted in three successive years.

The Bank for Agriculture and Agricultural Cooperatives has stopped lending for Eucalyptus because wood prices received by farmers to date have been less than expected. Nearly all the Eucalyptus and Casuarina trees planted on private farms since the mid-1970s have been intended for sale either as poles and posts or as material for the pulp mill in Khon Kaen. The market for posts and poles has not developed as expected. Increasing popularity of concrete posts may have have led to some decline in the demand for wood. The pulp mill was never intended to use much Eucalyptus, though nurserymen selling Eucalyptus seedlings broadcast optimism about that market several years ago.

Tree farming practices:

Generally, only the farmers with relatively large land holdings are involved. Farms studied ranged from 10 ha. of expensive land in Chachoengsao to 150 ha. of relatively cheap land in Pathumthani.

Planting and management practices seem essentially the same for Eucalyptus and Casuarina. Farmers purchase seedlings at unsubsidized prices ranging from 0.8 to 2.5 baht each. The most common price is 2 baht per seedling. The sites are prepared by tractor ploughing (3 times) and, in Pathumthani, by ditching and/or raising dikes to give protection from flooding. The farmers all know they "should" plant trees at 2 x 2 meter spacing (2,500 trees/ha). In practice the plantings range from 2,300 to 3,100 per hectare.

Maintenance includes tillage for weeds and application of herbicides in the first year, poisoning rodents, clearing firebreaks or making ditches around the fields. Ants (perhaps termites) were the major insect problem, but insecticides were not used. Nor are the trees fertilized.

Mortality was generally low, only 5 to 10 percent. Very little maintenance is necessary after the first year. Protection from livestock is not a problem as both areas studied have almost completely replaced draft animals with machines.

Farmers in Chachoengsao with Casuarina were very concerned about fire, though none had sustained damage yet from fires. One farmer interviewed in Chachoengsao had lost trees in the first year after planting because of drought.

Thinning was not practiced by the interviewed farmers. Because the price is higher for larger trees, selective cutting is practiced by some. That is, only trees over 15 cm diameter are cut in year 5 and the rest in year 6. Other farmers clearcut, either all in the same year or half in that year and half in year 6. Normally the stumps are destroyed (burned) after cutting.

Costs, marketing and income:

The land used for trees seems not to be significantly different in value from land used for annual crops in these areas. The market price for this land ranges from 2,000 Baht per rai for land in the reserve forest areas of Chachoengsao to 30,000 Baht per rai for land with direct road access in Pathumthani.

Details of cash expenditures for establishment, maintenance, and harvest are indicated in Table 6. Labor is paid in several ways. In some cases workers simply plant trees, in others they dig pits and plant as separate operations, and in other cases they are paid to plough and plant as a single operation. Payments can be on a piece-rate or a time-rate basis. Consequently the table has aggregated the data for site preparation and planting.

The farmers normally sell trees as poles and posts in either one or two sales. Firewood may be sold more continuously throughout the fifth and sixth years, but most firewood comes from branches lopped off trees felled for sale as poles/posts.

Except for quantities of firewood that were small relative to their total production, the farmers interviewed did not use any of their tree products on the farm.

The wood is normally sold to a trader, who may either be a middleman or a direct employee of a wood-mill. (In one case the local police act as a middleman for both timber and firewood.) The wood is later sold by the wood-mills to consumers, either construction companies or private individuals. In some cases the farmer pays the costs of cutting and transportation, while in others the buyer cuts and removes the trees.

Table 6

SUMMARY OF COSTS AND INCOMES
FROM TYPICAL FARMER INTERVIEWS
IN TWO PROVINCES OF THAILAND

Case No:	1	3	6
Province:	Pathumtani	Pathumtani	Chachoengsao
Tree type:	Casuarina	Casuarina	Casuarina
Area planted:	4.8 ha.	3.2 ha	88 ha
COST ITEMS			
Site prep:	87,000	20,000	322,500
Seedlings:	50,000	16,000	484,000
Planting:	48,000	included	242,000
Maintenance:	4,000	0	432,000
Harvest & transport:	33,600	11,000	(buyer paid)
Subtotal:	222,600	47,000	1,480,500
INCOME ITEMS			
Timber*:	320,000	225,000	88,000
Firewood:	3,000	0	250,000
Subtotal:	323,000	225,000	338,000
ANTICIPATED COSTS AND INCOME FROM BALANCE OF PLANTATION**			
Harvest & transport:	50,400		0
Other costs:	0		216,000
Subtotal:	50,400		216,000
Timber*:	480,000		4,831,000
Firewood:	4,500		500,000
Subtotal:	484,500		5,331,000
TOTAL COSTS:	273,000	47,000	1,696,500
TOTAL INCOME:	807,000	225,000	5,669,000
NET:	534,000	178,000	3,972,500
TOTAL NO. OF YEARS:	6	6	9

*"Timber" means mainly poles for construction. Case 2 includes some wood sold to a pulp mill.

**Anticipated costs and incomes are farmers' expectations assuming prices and selling arrangements remain the same as in first year of cutting.

Constraints on tree farming:

Tree farming in the areas investigated is done entirely on a free market basis. No artificial incentives or disincentives are directly aimed at tree farming. The main problems are economic: (1) farmers decide whether to plant trees depending on the return they can expect in comparison with returns from other uses of the land, (2) tree farming requires considerable capital, and (3) there is considerable forgone cash-flow from having the land tied up for five years before any sales are possible.

The main technical concern expressed by all the farmers interviewed was the danger of fire, though none of them had actually experienced any fire damage.

Thai farmers seem generally willing to innovate with new crops, but once they have begun with a crop few show interest in improving technology, either to raise the quantity or quality of their output. This characteristic is apparent among the tree farmers interviewed for this study. None had experimented with fertilizer or spacing changes. They had made little effort to get technical advice concerning land preparation, maintenance, or cutting and marketing cycles.

Generally, tree farmers have large land holdings. Most of them use only a relatively small portion of their farms for trees. The high investment costs and long wait for income are important disincentives for small-scale farmers.

The market for tree products seems uncertain to the farmers. Most farmers have not been able to get the prices they were led to expect when they made the decision to plant trees. In fact the prices vary substantially by the size of the logs, as indicated in Table 7. Returns would be very good in comparison to other annual or perennial crops if the farmers could be sure of producing logs 6 in. in diameter in diameter within 6 years.

Future for tree farming in this region:

Prospects for tree farming in the regions of Thailand investigated seem to depend on the farmers being convinced that they will make good profits, and this in turn depends on their ability to produce logs of the sizes demanded at the markets. To do this the farmers will probably have to plant, maintain, and harvest their trees on a more systematic basis than most are doing at present.

This implies needs for farmers to get (1) more detailed market information to give them management objectives, and (2) more technical support from the Department of Agricultural Extension. It also implies a need for credit, either from the commercial banks or from the government's Bank for Agriculture and Agricultural Cooperatives. Finally, it depends on reasonably secure markets in the private sector. At present, farmers are

not convinced that any of these three conditions are being met. As a result, there has apparently been less private tree planting in the past three years than occurred in 1980-82.

MAHARASHTRA, INDIA

Background:

Mr. Bonbehari Nimbkar is President of the Nimbkar Agricultural Research Institute in Phaltan, District Satara of Maharashtra state. He is owner/operator of 3 farms on which he has been planting trees since 1980. Cost data on inputs and harvesting are incomplete for this case, but the other data appear quite accurate.

Two of the farms, of 15 hectares each, were cropland before 1980 and are still used in part for sugarcane, cotton, sorghum, corn, sunflowers, onions, and watermelons. The other farm, of 100 hectares, was abandoned cropland used for grazing before 1980. Livestock on the farms now includes 14 head of bullocks, cows, and buffalo. All the animals are confined and fed sorghum, Napier grass, stylo, buffel grass, and one tree product -- Leucaena leaves.

Mr Nimbkar has planted 60,000 trees. He plans a gradual conversion of the three farms to grow only tree crops within five years. Reasons he gave for this change include:

- Trees grow better than other crops on difficult soils.
- Trees are more drought tolerant than the other crops.
- Once the trees are established, there is no labor demand during the peak labor period.
- The value of the wood is increasing faster than the inflation rate.
- The price is steady for wood products.
- The stony, shallow soil on the 100 hectare farm is badly eroded and the trees are helping to reclaim this damaged fan

Tree farming practices:

The Forest Department of Maharashtra has provided 20,000 seedlings to Mr. Nimbkar's farms at subsidized prices, Rs. 0.20 to 0.50 each. He has raised the other 40,000 seedlings in his own nursery. He has concentrated his plantings on three species: Eucalyptus tereticornis, Casuarina equisetifolia, and Leucaena leucocephala. He is also experimenting with a number of others, including teak, neem, Gmelina, Grevillea, Santalum, Thespicia, Cieba, Prosopis, and Acacia.

Mr. Nimbkar notes the following advantages of the three main species on his farms: The Eucalyptus has a good market for large poles and is not browsed by livestock. The Casuarina has the advantages of Eucalyptus and

is also a better firewood, tolerates waterlogging, and can be grown at a higher density. The Leucaena grows better than the others on shallow soils, improves the soil quality, coppices very well, and gives a very quick return on investment.

Trees are planted yearly when monsoon rains begin. The plantations included both woodlots and trees intercropped with stylo and other forage crops. Where the soil is good, site preparation includes deep plowing and ridge formation. Where soils are shallow, individual pits are dug by hand. With sites prepared well six laborers ("two men and four women") plant about 2,000 trees per day. Farm labor wage rates are Rs. 10 per day for men and Rs. 6 for women.

Until the seedlings are 1 meter tall, they are irrigated every 15 days and weeded regularly. For the rest of the first year, they are weeded less frequently and are watered every 30 days. After the first year, water is used only if it is both needed and available in winter. All the trees are fertilized with 300 kg/ha single superphosphate and the Eucalyptus also gets 150 kg/ha of urea. The response to fertilizers is excellent. This maintenance takes about 16 man-hours per month for the irrigation when it is being given, and 80 woman-hours per month for the weeding and fertilizer applications. In addition, watchmen protect the plantations from depredation by livestock. Survival of the seedlings has been 95%.

Income from sales of wood:

A small inventory of poles and firewood is kept and replenished from cutting as buyers take the inventory. The planned cutting schedules is as indicated in Table 8. So far, only Leucaena and Eucalyptus have been cut.

In June 1984, hired laborers cut 415 poles from a block of Leucaena that had been planted on a 1 x 2 spacing in February of 1982. In 1985, another 528 poles were cut. The Leucaena poles were 6 to 7 meters long and ranged from 3 to 10 centimeters in diameter. Prices received at the farm gate varied from 1 rupee for poles 2 to 3 cm in diameter to Rs. 12 for poles 9 to 10 cm in diameter. The total value of 943 poles cut from about 0.15 hectare, was Rs. 3,986.

Records were not kept of the firewood and cattle feed that also came from this harvest.

Mr. Nimbkar reports that the labor cost for planting, maintenance and harvesting the trees in the first Leucaena cutting totaled about Rs. 1,025. Of this about 50% was for irrigation and 5% was for harvesting. Subsequent crops from the coppice should be less costly to produce.

Mr. Nimbkar extrapolates data from his initial Leucaena sales to an expectation that first cuttings should produce 22 tons of dry wood per hectare worth Rs. 500 per ton, or Rs. 11,000 per hectare. He expects labor costs to be about Rs. 2,500. Although these numbers do not seem to correspond exactly to those given earlier, they do suggest the basis of this farmer's decision to convert the entire three farms to tree plantations.

Table 7

1985 Wood Prices in Pathumthani, Thailand
(Farmer pays costs of cutting and transportation)

Diameter (in.)	Length (m.)	Price (Baht)	Cubic meters	Baht/ c.meter
6	6	120	.109	1,100
5	6	90	.076	1,184
5	5	70	.063	1,111
4	5	50	.041	1,220
4	4	30	.032	938
4	3	20	.024	833
3	3	10	.014	730
2	3	5	.006	833

Table 8

Cutting schedule for Nimbkar Tree Farm

Kind of Tree	Seedling Generation	Coppice Generations
Eucalyptus	5 to 7 years	4 to 5 years
Leucaena	3 to 4 years	2 to 3 years
Casuarina	4 to 5 years	none

Eucalyptus poles sell for a higher price than Leucaena poles of the same size at this farm's gate. A block of Eucalyptus cut in 1985 had been planted in 1982 on a 1 x 3 meter spacing. There was great variability in the diameter and length of the poles, but they were generally larger than the Leucaena. In all about 1000 Eucalyptus poles and 9 bullock-carts (about 4.5 tons) of firewood were harvested. Records were kept on 336 of the poles. These ranged in diameter from 114 poles classified as "thin", 95 with diameters 6 to 8 cm., 104 with diameters 8 to 10 centimeters, and 23 with diameters of 10 to 12 centimeters. Again, the larger poles commanded a much higher price. For a 5 meter pole that is 6 cm. diameter, Rs. 18 is paid to the farmer, while a 5 meter pole 11 cm. diameter sells for Rs. 55.

The average price received at the farm gate for 336 Eucalyptus poles was Rs. 23. The farmer does not extrapolate these data to an income per hectare figure, and neither should we, since he does not report that these came from clear-cutting a 336 tree block.

Mr. Nimbkar reports that in his region only farmers with large land holdings are planting sizable numbers of trees, although the Forestry Department is trying to promote more widespread tree planting. He observes that most fuelwood comes from naturally regenerated Prosopis trees growing in wastelands around villages. He says the pole market for house construction is improving, as is the market for furniture wood and for large-sized fuelwood used in cremations. But the waiting period for a tree farm's profits is too long for the poorer farmers with small holdings.

COMMONALITIES

The most striking common finding in the several case studies is the farmers' concern for potential cash returns. Even farmers in Gujarat and in Bangladesh with very small holdings, who will probably use most of their tree products on the farm, were basing their choice of species and management practices on their understanding of potential cash returns.

Farmers who had produced poles for on-farm construction remembered precisely the quantity and value of that product. But few farmers could even guess at the quantity of tree fodder and fuelwood consumed on farm. The only exceptions were farmer businessmen -- the small scale baker in Haiti and the large tea estate in Bangladesh -- who regularly purchased fuelwood as an input to production.

A related common feature of the several cases is trepidation regarding the market for tree products. Except for the dendrothermal project in the Philippines, the organizations that had promoted tree planting -- the government departments, development assistance agencies, and NGOs -- did little to develop market structures or even market information channels that could help farmers to get a fair price for their products.

In Gujarat, early planters of Eucalyptus for poles had made substantial profits. Hearing of this, farmers with small land-holdings began to plant Eucalyptus. But the local markets began to be well enough supplied by poles from the large farms. As a consequence smaller farms without economies of scale for harvest and transport may not be able to realize the hoped-for profit.

Commonly in agriculture some early risk-takers who produce for an unsatisfied market can enjoy high profits. Then more farmers begin to plant the same crop and eventually the price falls to an "equilibrium" that pays a return on the land, labor and capital invested that is similar to the return from other crops. It is too early to judge whether this pattern will occur with tree crops in the areas where they have been recently promoted.

The interaction between market dynamics and farmers' decisions is confounded for tree crops by the time lag between the time of planting and the first harvest. In Gujarat the period of high profits might be stretched out if someone organizes marketing and transport to move the poles to nearby regions where less tree planting has occurred and the demand is still not being satisfied. In Thailand, tree farmers seeing soft prices stopped planting.

The time lag in tree crop cycles seems likely to result in wider oscillations of price than occur with annual crops. This effect can be mitigated for individual farms by planting some and cutting some each year. Indeed this is the practice where tree planting has been long-established in Kashmir, Java, and Bangladesh.

The effect of the time lag can be mitigated at a regional level if individual farms' rotations are not synchronized. In Thailand, most of the Casuarina and Eucalyptus planting for house posts apparently occurred in one two-year period. Then farmers either foresaw soft prices or all those who were likely to be tree planters had finished planting. As a result, a temporary glut of posts seems likely to be followed by another shortage and higher prices seem likely again after the current crop has been cut.

In cases such as Thailand, if a boom-and-bust cycle in tree product prices stretches over several years, then it seems likely that alternative products, such as concrete house posts, will capture a larger share of the market. Thus the long-term future of tree farming may be dim so long as farmers do not plant and cut regularly.

Where tree farming is an innovation, interest seems to be focussed on one or two species and a single product, as in Gujarat and Thailand, and the Philippines. For varying reasons, this narrow base for these enterprises appears to be an error. At the dendrothermal project in the Philippines, the species planted produced well, but now it is threatened by an insect that also specializes in just one species. At the same time the market for the single product, fuelwood for electricity generation, may be threatened by the falling price of a substitute product, oil.

In Gujarat, Haiti, and Thailand farmers having been through the first rotation are expressing the importance of planting a wider variety of species. In the regions of more mature tree farming, Kashmir, Java, Bangladesh, the species and product mixes are much broader and are still changing in response to changing market demands. In all these countries, government agencies have been able to influence the farmers' decisions by providing free or subsidized seedlings. How carefully the agencies are monitoring markets, and how well they are predicting markets 5 to 10 years ahead remains to be seen.

While a broad set of species and several products seems the best strategy for small farms, larger operations, such as the tea estates in Bangladesh, can probably afford to risk continued specialization to get production or marketing efficiencies and thus get higher profits. However, where the product is fuelwood, as in the Philippines, there seems little reason to risk specialization on just one species.

Excepting the tea estate, the baker-farmer, and the dendrothermal project, tree farmers contacted had to depend on middlemen or manufacturers to come to the farm, or to a local market, to buy the tree farm products. The buyers available to any one farmer were few and were usually better able than the farmer to shop for favorable prices.

For longer-established crops, both annuals and perennials, various organizations and systems of government intervention have been developed to protect the farmers from their marketing disadvantage. But such structures do not yet exist for tree products -- it is still a "buyers' market." This could possibly lead to the demise of farm forestry in some of the areas where it has recently begun.

The best-organized structure is in the dendrothermal project in the Philippines. But those farmers deal with only one buyer, who helped to organize the marketing structure to begin with. It is a model that can be instructive where small farms are used to produce an industrial product. For example where leafmeal is produced from trees for a livestock feedmill, or where charcoal is produced for an industry. In Gujarat, various forms of tree farmer societies and cooperatives have been formed to assist with distribution of subsidies and inputs. These may begin to work on marketing as well.

On the other hand, crops of wood give the farmer an important advantage. Unless he needs cash desperately, he does not have to cut when the prices are low. Left standing the trees will become more valuable. For timber and pole species, the value gain not only continues, it accelerates as buyers generally pay more per wood unit if the logs are larger.

The price data for poles, posts, and small logs in Thailand, Gujarat, Maharashtra, Kashmir, and Haiti all indicate that many farmers are cutting at a time when the trees are beginning to appreciate most rapidly. In areas where tree farming is a long-established practice, e.g. Kashmir and Java, early cutting apparently occurs when farmers cannot possibly afford to wait longer. But in Haiti, Thailand, and Gujarat, it appears that the farmers may lack both experience or credible advice regarding wood prices and tree growth rates to achieve the most profitable rotations.

Techniques that can enable a farmer to use longer rotations include: spacing trees widely to allow interplanting with annual crops, thinning, and regular annual planting and cutting schedules. The interplanting technique and annual planting/cutting are common in the regions with long-established tree farming.

In regions where tree farming is a recent innovation, each farmer plants all the land he has for trees in one or two years, and all the harvest is in one or two years. Where cutting is spaced over even two years it is usually because some of the trees were too small for commercial sale at the time cutting started. Thus a common practice is to cut everything that can be sold and leave the smaller trees until the next year -- the opposite of thinning.

The idea that developing country farmers discount future income at a very high rate is a tempting explanation for the early cutting and the lack of thinning and other other practices that might enhance profits. The farmers' frequent expressions of concern for rapid profitability certainly reinforce the idea of a high discount rate. However several of the cases investigated suggest that he concept of discount rate is too simple to explain tree farmers' behavior.

In Haiti, very poor farmers with very small holdings often do cut trees planted for firewood before the planting is profitable. But the same farmers will plant and maintain some slow-growing timber trees and will forgo cutting these for may years until the need for cash is extraordinary. In Kashmir, farmers will cut one or two of several valuable timber trees

when cash is badly needed, forgoing better prices that could be gained by economies of scale if all the trees were cut. They prefer to wait as long as they possibly can for the future higher price per wood unit that will be paid for the larger log.

To be useful in understanding tree farmer behavior, the discount rate concept apparently must recognize that farmers have different rates for different products (e.g. fuelwood vs. lumber) and for different planning periods (e.g. year 1 to 5 vs. year 6 to 10). Unfortunately, this preliminary study could not get the depth of information necessary to understand how farmers think about and place value on future income.

INFERENCES FOR DESIGN OF TREE FARMING PROJECTS

Numerous projects -- sponsored by government departments, development assistance agencies, and non-government organizations -- are being designed to use trees as farm crops in various ways. These include homestead plantings, woodlots, shelterbelts, hedgerows for alley cropping, and widely scattering trees over crop fields and grazing land. In all cases, the farms will be expected to receive both direct and indirect, both short-term and long-term benefits from the trees. However, this investigation of the existing use of trees suggests that farmers' decisions about how (indeed whether) to protect and manage the trees will be based on their understanding of the best way to maximize the more direct, shorter-term benefits.

From this observation and the other findings discussed above, the following inferences are drawn:

Motivation to establish and maintain tree crops

1. Without firm commitments from buyers or compelling evidence of real profits to be made, farmers often will not protect and maintain trees that are intended mainly for fuelwood production, even though they may have agreed to plant them when free seedlings or other subsidies were given. In many places, however, farmers will maintain fruit trees and precious timber trees. Thus interventions to promote fuelwood production for sale in a general market situation may be more successful if the fuelwood is presented as a side benefit from production of another more highly valued product.

2. Plantations intended mainly for fuelwood are most likely to be maintained where the farm is using the wood for production of some other higher-value product and has to buy wood if they do not produce their own (e.g. baking, crop drying).

3. Farmers are keenly interested in the potential to use trees as cash crops. Their decision making seems less influenced by subsistence crops of wood, fodder or other tree products for consumption on-farm.

4. Farmers often respond quickly to credible accounts high profits from new crops, such as trees, even though the farmers may be poor and the profits may accrue more slowly than once per year.

5. Annual crops are commonly interplanted with trees in the first year of woodlot establishment. Thereafter, farmers get little interim benefit other than fodder from woodlot land. As a consequence farmers with small holdings can seldom afford to maintain woodlots long enough to get a profitable cutting without subsidized loans or other assistance to replace forgone income

from the land. Loan programs have enabled poor farmers with small holdings to maintain woodlots. Whether the loans will be repaid remains to be seen.

Marketing constraints on profitability of tree crops

6. Farmers in developing countries have little access information that would let them predict price changes, especially in the poorly developed thin markets typical of new crop situations. As a consequence farmers may make inappropriate planting and harvesting decisions.

7. Individual farmers are in a poor position vis-a-vis tree crop buyers. In regions where tree farming is relatively new, markets are likely to be poorly developed. The price oscillations caused by free market dynamics may to too great to sustain participation by individual farmers.

8. Farmers with small holdings lack economies of scale for cutting, transport, and marketing. The prices they get may be significantly lower than the prices paid to larger operations.

9. If organizations promoting tree crops do not plan adequately for marketing, they may be setting farmers up for disappointing profits and disenchantment with trees as crops. The only farm forestry projects that have demonstrated success with marketing components are those where a single organization commits to pay a fair price for the wood crop when the project is beginning. Innovative projects, such as tree growers cooperatives, are beginning to be promoted in India and should be closely monitored with progress reports available to project designers elsewhere.

10. Tree crop buyers are often businessmen of good will with a real interest in farmers having enough profit to sustain their interest in trees. Such buyers may have ability to expand the markets for tree crop products (e.g. transporting poles to another region), but lack the capital to do so. Thus organizations promoting tree farming may want to consider loans, information assistance, or other development for not only to producers but also to middlemen.

Technical constraints on profitability of farm forestry

11. Farmers growing wood for fuel, poles, craftwood, and other products often cut trees before the optimum age for maximum return on investment. Also, tree farmers often cut the largest trees of an even-aged stand but seldom practice thinning -- i.e. cutting the less valuable trees to accelerate growth of the more valuable. These two common practices are not necessarily an economic response to a high discount rate on future income. They may be occurring because the farmers do not know or have not been convinced about the profitability of longer rotations or thinning.

12. Some projects promoting farm forestry have included fairly intensive follow-up to advise farmers regarding management practices. The effect of those project components has not been well documented but could be. Meanwhile, projects which distribute free trees or other subsidies to encourage farm forestry should also try to provide adequate technical follow-up to assure that farmers' benefits from the trees are substantial enough to sustain their commitment.

Need for understanding farmers' decision making

13. Farmers, especially poor farmers with small land holdings, are widely believed to discount future income at a high rate. That is, they need and prefer short-term returns on their investments of land, labor, and capital. However, the farmers do plant trees and forgo other income from their land for years until the wood or other tree crops are ready. Farmers seem to value future income from some products (e.g. timber) more highly than future income from other products (fuelwood).

14. The choices of tree species, tree farm purposes, and tree management practices promoted to farmers are most likely to be effective if they match the farmers' complex value systems. This implies the need for detailed investigation before decisions are taken regarding technical aspects of project design -- such as species choice and the product to be produced -- are decided upon.