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Paper No. 5

Socioeconomic Impacts of MPTS Biotechnologies on Small Farmers in the Philippines, Nepal, and Thailand

Charit Tingsabadh and Kobkul Phutaraporn
Chulalongkorn University Social Research Institute

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Executive Summary

1. In this study the potential socioeconomic effects of selected MPTS biotechnologies -- micropropagation and the application of mycorrhizae and Rhizobium -- on small farmers are examined, focusing on Thailand, Nepal and the Philippines.

2. In general, small farms can potentially benefit from the applications of the biotechnologies. Micropropagation can benefit the farmers by increasing yields of tree products using specially developed high-yielding tree varieties. Reduction of input costs can be achieved by using mycorrhizae to increase seedling survival rates in areas with poor soil and using Rhizobium to stimulate growth of nitrogen-fixing tree species.

3. A number of constraints to the acceptance of MPTS biotechnologies by small farmers have been identified. These are (1) the poor resource endowment of the farmers, in terms of small landholding, little surplus labor and financial insecurity which leads to risk-avoiding attitudes and behaviour (2) the highly capital- and knowledge-intensive nature of biotechnology as presently practised, which is likely to lead to the farmers being more dependent on external support, and (3) the low level of development of an extension system to transfer the MPTS technology from the research level to the farmers, either in the public sector system or in the private commercial sector.

4. The application of MPTS biotechnology is more likely to succeed in the large scale private reforestation sector, with the emphasis on development of plantations of fast-growing species to provide industrial raw materials.

5. To enable the small farmer to benefit from the application of MPTS technologies, increased attention should be given to such factors as:

   (1) access to land for the small farmers to plant trees,

   (2) design of appropriate agroforestry systems to suit the needs of small resource-poor farms,

   (3) design of extension systems to provide necessary inputs for farming, and

   (4) development of appropriate organizational forms for combining the interests of agribusiness with those of the farmers with reference to the trees being planted by the farmers. Lessons from the field of agribusiness can be useful in setting guidelines for use in the forestry sector.

1. Introduction

1.1. Background and Objective

The objectives of the study were to assess:

- the potential access by small farmers in selected Asian countries to selected biotechnologies for the improvement of multipurpose tree species;
- the potential socioeconomic effects of these technologies on the small/poor farmers;
- to assess the institutional capabilities of existing extension programs and existing market structures to provide the recommended biotechnologies to small farmers;
- the potential availability of the technologies to sectors of the rural economies, namely the medium and large farmers, plantations and sectors other than the small/poor farmers.

In the preparation of the report, the authors visited, in early 1988, selected institutions engaged in research on biotechnologies, projects involving community forestry activities and academic institutions involved in research on community development. Discussion was held with researchers and experts (See Appendix 2, Cruz, 1988). The following report is a synthesis of the findings from the field trips and additional research.

1.2. Organization of Report

Section 2 of the report is a review of the main issues involved in the introduction of multipurpose tree technology to the small farmer, and describes the specific biotechnologies under consideration. Section 3 examines the constraints on small, resource-poor farmer's acceptance of the selected MPTS technologies in more detail. Potential effects of the adoption of the technologies are discussed. The importance of the organizational support system for the introduction of the technologies to the small farmers is stressed in the discussion of the technology delivery system. Effects on large and medium farmers of the technologies are outlined. Section 4 considers the prospects of integrating the MPTS technology in the small farmer's cropping systems and offers recommendations for future research on MPTS technology.

2. An Overview of Issues

2.1. Small Farmers and MPTS Technology

In order to discuss the potential role of MPTS technology for the small farmer, it is essential to appreciate the relationships between the small farmer and trees, and the problems facing the farmer in accepting new technologies for his livelihood.

2.1.1. Trees and the Small Farmer

Trees satisfy many needs of small farmers. Studies in Thailand and Nepal show that farmers obtain essential products and services from trees – fuelwood, fodder, poles and construction timber, to name but a few obvious examples. In addition, trees serve as a source of food, and in some cases, of additional income (Subhadhira, et al, 1987; Nield, 1985; Grandstaff, et al.,1986). The farmer's supply of trees can be located in either the natural forests or on his own farm land. The trees can be naturally grown or planted, depending on the farmer's needs and resource availability.

However, the farmer typically faces many constraints in the allocation of his resources, and in some cases, trees are not able to compete with other crops in the farmer's allocation of his scarce land. Hence there is the tendency to do away with trees on farms, leaving only public and forest lands as the sources of tree products that the farmer requires.

As the demand for these products grows with increasing population, and as the pressure to convert forest land to farm land increases with the prospect of earning income from cash cropping, the farmer faces a dwindling supply of trees to meet his needs.

Multipurpose tree species (MPTS) grown on farm and in common village lands are seen as a potential way to satisfy these needs, in lieu of obtaining tree products solely from the natural forests. The broad question is the extent to which these needs can be met by MPTS. The specific question, which is the focus of this paper, is the role of biotechnology on MPTS in contributing to the satisfaction of these needs.

2.1.2. The Small Farmer and Technology Acceptance

There is a lot of experience about introducing new technologies to farmers with regard to field crops which can provide valuable insights for research into and the implementation of programs to introduce forestry technology to small farmers. The Northeast Rainfed Agricultural Development (NERAD) Project summarizes an approach which is likely to find broad acceptance.

"...(due to) the extreme variability of agro-ecological and economic conditions over both time and space in the Northeast, it is unlikely that cropping systems can be developed which will give optimal returns every year or will be suitable for the entire region..." (Craig,1985).

If we include trees within the definition of the cropping system, we have a statement which has general application well beyond Northeast Thailand. The author elaborates on the characteristics of the required cropping system:

"...the approach should attempt to identify for each specific location a series of low-risk, "robust" technologies which give at least adequate returns (in) all years. These technologies will have to be low-cost and purchased-input levels should be adjusted toward risk minimization rather than yield maximization."

In this formulation, we have a possible specification for the MPTS technology which can be developed to reach small farmers. It should be low-cost with minimal risk to the farmers.

2.2. Features of Selected Biotechnologies

Three specific biotechnologies are considered:

(1) micropropagation through tissue culture

(2) mycorrhiza

(3) Rhizobium spp. In this section, we review briefly the status of each biotechnology with reference to MPTS.

2.2.1. Micropropagation

There appears to be little work focused on tissue culture of MPTS (Gavinlertvatana, 1987; Dhawan and Bhojwani, 1986). Of the three countries visited, only the tissue culture laboratory in Nepal was involved in research with *Eucalyptus* spp. in connection with a community forestry program (Gurung and Raj Bhandary, 1987). In Thailand, work on tissue culture is mostly entered on high value, single purpose species, such as orchids, teak, and ornamental plants. However, some work on multipurpose forest tree species has been undertaken, in addition to teak, on *Melia azadirachta, Acacia mangium*, and there is continuing work on bamboo, rattan, *Acacia auriculaeformis* and *Azadirachta indica* (Bhumibhamon, S., et al., 1987).

In the short term, the question with regard to the use of tissue culture is whether is it the most economical way to produce seedlings, compared with traditional methods of nursery establishment. The advantages of tissue culture are that, given a quality root stock, the method can be used to multiply the seedlings to any quantity required. In contrast, the traditional method may have problems of seed supplies, and variation in quality, etc., as a result of breeding which are not the problem in vegetative propagation.

On the minus side, the cost of tissue culture laboratories and the technical expertise required may be too high, or the trained manpower unavailable. There is also the problem of whether the improved trees can maintain the desired characteristics over their lifetime.

2.2.2. Mycorrhiza Research

The fungi/root association or mycorrhiza is a factor in stimulating plant growth. Mycorrhizae are specific to tree species and soil types. The absence of mycorrhizae may inhibit plant growth entirely, which is an important factor when trees are planted on poor soils. In practice, land designated for reforestation often are of this type, since the land is usually of low natural fertility, has been poorly cropped over with little regard to conservation of soil fertility, and is subject to severe erosion after being abandoned after producing low yields for agricultural crops. Yantasath (1985) reports that mycorrhizae found in evergreen and dry dipterocarp forests in Thailand are absent from agricultural land. As a result, there may be a need to introduce mycorrhizae to assist in plant growth when a tree plantation is established on this type of land, such as in degraded forest which has been used for slash-and-burn agriculture.

The question is how to introduce the mycorrhizae to the plant or the soil. As done in the Philippines, this can be a commercial enterprise producing a tablet "mycogroe" containing mycorrhiza for inclusion in the planting soil when the seedlings of pine and eucalyptus are planted out in a nursery (de la Cruz, 1987). Goldstein(1989) reports that work on the same line is currently carried out, but involving other forest tree species, by the Agency for Forest Research and Development and Tropenbos, a Dutch forestry research organization in East Kalimantan, Indonesia.

Yantasath(1985) suggests a number of approaches for further work in mycorrhiza development. One line of action would be to conduct research into the basic knowledge about the mycorrhiza relationship for selected plants under different soil conditions, choosing the economically valuable crop as a first step and focusing on a specific area. In addition, the development of commercial scale production of mycorrhiza may be undertaken by a tree seedling company, producing seedlings in large quantities, of valuable species which have a low survival rate in nature. Kovit considers that greenhouse production of high quality seedlings of forest tree species has a high potential.

2.2.3. Rhizobium Research

Rhizobium is specific to nitrogen fixing trees, which form an important part of MPTS. The application of Rhizobium to the soil helps stimulate the nitrogen fixing activities of the plant. In Thailand, there is a laboratory producing Rhizobium for soy beans, and this is sold commercially in small plastic bags easily transported to the farmers in the growing area. But so far no work is available on MPTS (Boonkerd, 1986).

3. Biotechnology and The Small Farmers

3.1. Acceptability and Accessibility

In order to be of use to small, resource-poor farmers, the product of any technology has to be in a form that fits in with the limited resources that he or she can control. Typically, this means the following: small land holding, little surplus labor, little or no cash reserve, low credit standing. The resource limitations in turn lead to the farmer having a short term planning horizon and a high degree of risk aversion. The low level of access to technical information and knowledge also limits the farmer's ability to assess the options available to him. These factors affect the farmer's decision making and his choice of technology, and hence his readiness to adopt innovations such as the biotechnologies offered.

3.1.1. Small Size of Land Holding

The size of the farmer's land holding is a major factor determining his interest in innovation, because he has to allocate the land to the highest priority use, which in most cases means food crops and cash crops yielding quick returns. Trees on agricultural land reduce crop yields through shading effects and compete with these crops for soil nutrients, and so are often not tolerated on plots where the farmer plants intensively, notwithstanding results of some studies of the role of trees on farm (Grandstaff, et al. 1986). Where the farm plot is already without trees, the small plot size is therefore an immediate obstacle to introducing trees into the small farmer's cropping system.

3.1.2. Little Surplus Labor

The small farmer often has a limited supply of family labor to work on his farm. Again, he will choose to allocate labor to activities that will provide the highest return to the use of the family labor. Trees generally require little labor for tending, so they should be accepted more easily as a labor saving innovation, if the labor required for planting and tending operations can be accommodated within the farmer's slack period. However, if the biotechnologically improved trees require greater care and attention, for instance by needing more pruning and spraying with pesticides, this is a factor in making the farmer more reluctant to accept the trees.

3.1.3. Financial Insecurity

Financial insecurity can be considered in two dimensions - lack of a cash reserve and low credit standing - though there are many other aspects of which are also related.

Little Cash Reserve. The low cash reserve that the small farmer holds means that he is likely to attach a high marginal value to it. Hence to induce him to pay in cash for inputs such as seedlings and fertilizer and pesticides, the

benefits of these have be clearly demonstrated to be more than other alternative uses, such as the purchase of medicine and social expenditure.

Low Credit Standing. While credit can be a substitute for cash, in the case of the small farmer, his low credit standing prevents him from taking advantage of available credit facilities. However, there are many attempts to work out some organizational arrangements to make credit available to small farmers, such as the group guaranteed loan scheme run by the Bank of Agriculture and Agricultural Cooperatives in Thailand and the Small Farmer's Development Fund in Nepal. These can circumvent the usual strict requirement for loan collateral given by commercial financial institutions. Otherwise, farmers have to resort to lenders in the informal money market or to a dependent relationship with his buyer, who usually provide credit at high interest rates.

3.1.4. Short Planning Horizon and Attitude to Risk

Short-term Planning Horizon. On account of the problems described above, the small farmer usually prefers to look for activities which will provide a quick return, the sooner the better. The implication of this preference is that discount rates appropriate for assessing the farmer's investment are likely to be high.

High Risk Aversion. Because of the limited resources at his disposal, the farmer will be generally reluctant to take risks, since he has little "cushion" to fall back on. In practice, this is a significant factor at the stage of introducing the innovation to the farmer. The best way to convince a farmer is to let him see how someone similar to him has tried and succeeded with the innovation.

3.1.5. Lack of Information and Technical Knowledge

The lack of information and technical knowledge is a limiting factor which makes accepting an innovation a high-risk undertaking for a farmer. He may not understand the innovation and if something goes wrong, he will not be able to solve problems on his own. This means he becomes dependent on the external agent who introduces the innovation to him, and who may not be available at the time he is needed to solve problems unexpected at the time of the innovation introduction.

To summarize, the technology to be presented to the farmer should be: cheap, simple to use, durable, yielding quick benefit, and robust.

3.1.6. Accessibility

Given that the farmer is ready to adopt the technology, the next question is how can the farmer get access to the biotechnology that meets his needs. The question of access relates primarily to the cost of the product to the farmer. The cost should be low enough and the product should be available easily, i.e.

the marketing and transportation costs should be low. If a farmer has to spend a lot of time in order to obtain the low cost product, the cost to him will still be high. This means that it should be available to him at the village, rather than the town or district center, for example.

With regard to the supply characteristics of the selected bio-technologies, it may be noted that, in general, biotechnology has tended to be technology for the large farmers, who face different kinds of constraints from the small farmers we have discussed above. Biotechnology has tended to be for large scale production, for replacing use of naturally-occurring inputs by technically-derived inputs, and for standardization. These trends go against the small farmer's practice of small-scale production, use of natural inputs, and variety in production, which arises from his limited access to commercial inputs due to cash and other resource constraints. However, it is necessary to examine each biotechnology on its own merit, in order to assess its potential to improve the welfare of the small farmers.

Tissue Culture

In the three countries visited, we found that no seedling supply from tissue culture of the MPTS is as yet available or planned to be. Seedlings for the community forestry programs are all planned to be raised from seeds in the traditional method. We were not able to obtain exact cost figures, but it appears that tissue cultured seedlings would be slightly more expensive than traditionally produced seedlings. Furthermore, facilities engaged in tissue culture propagation are located in central areas, at considerable distances from the sites for planting. This raises the question of transportation which will add significantly to the cost of the seedling at the planting site.

Mycorrhizae

The use of mycorrhiza is in an experimental stage in the Philippines, where a commercial firm has been established to produce mycorrhiza tablets for sale to planting firms. We have not been able to ascertain the extent to which farmers can have access to this product at the local level. However, the cost of the tablet is reasonable, and represents an advantage in creating wider access for the product among the users.

Rhizobium

In Thailand, Rhizobium is produced at a laboratory in Bangkok and packaged in small plastic bags for easy transportation to the farmers. This makes it similar in form to fertilizer and seeds. The cost is also quite low, so that farmers can afford the product easily. However, there may be a problem with the access, since there appears to be no commercial network handling the product on a large scale, so that availability may be limited.

3.2. Effects on the Small Farmer

The effects of the introduction of new technology on the small farmers can be categorised into three types. Firstly, there can be productivity gains either from increasing the yield of the activity undertaken by the farmer, or by reducing the inputs required for production. Secondly, there are the negative effects, which can be summarised in terms of cost increases for the farmer compared to his existing practice. Finally, there are effects of externality which may be caused by the farmer's adoption of the technology.

In terms of the MPTS, the effect of the introduction of the selected biotechnologies will be an increased supply of wood resources and tree products to the farmer at a lower cost. The cost reduction may take the form of greater amount of wood available per unit of effort required to obtain the wood -- for example, a village woodlot located close to a village will reduce the time necessary to collect the fuelwood compared with collection from a far away natural forest. There are also tradeoffs that should be considered when trees are proposed to the villagers. What do they have to give up -- for example, the use of land for other purposes such as grazing or cropping? The question of the distributional impacts of a tree planting scheme needs to be considered also, since the procedures governing the tree planting and management may affect different villagers differently. This will effect which group in the village will benefit and therefore will participate in the project.

3.2.1. Productivity Gains

Tissue culture

The potential effect of tissue culture is to increase the supply of seedling/planting material of standard quality available to the farmer. In this sense, the effects will be similar to the use of commercial seeds for planting. The effect can be expected in terms of improved yield and better plant qualities such as resistance to disease and drought etc. In this respect, it is important that the characteristics that are propagated by means of tissue culture are those that will be of use to the farmers in actual conditions.

On the saving side, the availability of tissue cultured seedlings may reduce the need to have local traditional nurseries to produce seedlings, and thus allows for more land to be used for actual tree planting or for alternative uses. Some employment loss may result, since nursery practice usually is rather labor-intensive. However, for the planting out of the plantlets, the procedures should be similar.

The most significant saving may be in terms of the time that is required to produce an adequate number of seedlings to meet the planting requirement in a large scale reforestation project.

Mycorrhizae

The effect of mycorrhizae is most immediate in ensuring seedling survival and growth. In this respect, it replaces fertilizer in the planting process. The saving will be in terms of the cost differential between using the two alternatives. Where the survival of the plant depends on the presence of mycorrhizae, then the effect of the technology is the value of the trees which would not have been established otherwise. De la Cruz (1987) reports that application of mycorrhiza tablets to seedlings of *Pinus* and *Eucalyptus* species result in increased growth of the inoculated over the uninoculated seedlings in the order of 15 to 72 percent for height and 9 to 67 percent for diameter for *Pinus caribaea* and *P. kesiya* in the nursery, and 45 to 64 percent increase in height and 45 to 95 percent increase in diameter for growth in the field. For *Eucalyptus*, the increases shown by the inoculated seedlings are more modest, 32 to 64 percent for height and 38 to 73 percent for diameter, under field conditions. De la Cruz (1988) calculated that the increased growth would be equivalent to the reduction in the cost of plantation establishment, through the reduction in fertilizer cost, in the order of 60 percent.

Rhizobium

The effects are similar to the case of mycorrhiza, but are more confined to the nitrogen fixing species. Data are not available on the effects of Rhizobium on MPTS, but for soy beans, according to Boonkerd (1986, p.46), yield increases of 23 to 89 percent were achieved over the case wherein no fertiliser was applied, and 19 to 70 percent increases over the case wherein nitrogen fertilizer was added.

3.2.2. Cost Increases

While the gains from the application of the selected biotechnologies are potentially available to the small farmer, the potential increases in cost to him should also be recognised. It will be clear that the farmer will be more reliant on external sources to provide him with the benefits of these technologies. Under the usual market assumptions, he will need to be further engaged in the exchange of goods or services to obtain the benefits. In so far as involvement with the market increases the farmer's risk and liability, this is a cost that will be associated with adoption of the technology.

The extent to which the cost to the farmer will increase depends on the organization of the service delivery system. Under the market economy framework, the farmer will need to have cash to buy the required technology. However, there can be many forms of organizations to reduce the costs, such as contract farming in which the farmer enters into a contract with the supplier to produce the output with his land and labor resources, while the company is under contract to supply him with the necessary inputs and information, and,

most unportantly perhaps, to buy the output from the farmer at a guaranteed price. In this instance the farmer can reduce the cost of uncertainty in case of a price decline, but if the price is rising he will forego the opportunity to obtain higher prices by selling in the market rather than to the contractor. In the final analysis, the outcome is a balance of expectations regarding the future course of prices that the farmer has to decide on.

With regard to planting of MPTS, there is little evidence to suggest how the farmers will react. To take an example of tree farming to supply a paper mill, when prices of fuelwood are higher than the factory purchase price, the farmer is more likely to sell the trees in the market as fuelwood than to sell to the factory for pulping. To avoid such market-induced supply fluctuation, the factory needs to set a purchase price which will respond to signals in the competing markets as well.

For mycorrhizae and Rhizobium technologies, the cost of supplies is likely to be less than that of fertilizer. In this regard, the farmer is more likely to gain from the adoption of these technologies in his farming system.

Another cost, which is common to all three technologies, is the cost of licensing the production of the specific technologies concerned. The issues involving intellectual property rights are beyond the scope of this paper, but they are undoubtedly important in determining the price the farmer will have to pay for the benefits of the proposed technologies.

3.2.3. External Effects

Under this heading, the widespread use of tissue-cultured planting stock is likely to have the most serious negative effect, in terms of reducing the diversity of the genetic pool. This is most likely when small farmers are incorporated into large scale reforestation programs. But at present, this is not yet happening.

The use of mycorrhizae and Rhizobium is more likely to improve soil fertility, even though they may be plant-specific. The increase in biomass on the ground should have more positive effects for other crops grown on the same land. This will be particularly useful when trees are planted with other crops in agro-forestry systems.

3.3. Delivery Systems

The question of how to provide the farmer with the access to the benefits of the innovations may be considered under the heading of delivery systems. What is to be delivered ranges from information, for example about new cropping techniques and market conditions, to physical goods such as fertilizers, seeds and agricultural tools. The organization of the delivery system encompasses many actors and players, ranging from the researchers who generate the technical knowledge, the

manufacturers of inputs used by the farmer, the traders who bring news of markets and new crops, to financial institutions and government agencies involved in the propagation of these information and inputs.

With respect to the MPTS, we may consider three delivery systems, namely the Government forestry programs including government forestry extension programs, the private commercial sector and the private non-commercial sector.

3.3.1. Government Forestry Programs

Reforestation Programs

The implementation of reforestation programs is usually the task of the government, since there is little profit in the long term reforestation enterprise. The reforestation program also has many objectives which may not be commercially oriented, such as conservation of watershed rather than the commercial exploitation of forest products, as well as social forestry. Small farmers can be involved in these different reforestation programs and benefit in different ways.

Usually, the reforestation program with a focus on benefiting the small farmer is set up as a social forestry program. Typically, this is a program to provide some form of tenure rights to the land for farmers who lack the legal ownership rights which the governments are unwilling to give. The usufructuary rights are often given to the land holder, but there are various conditions on the transfer of the land use rights, so that they become less suitable as assets compared with fully owned farm land. The result is that there remains some uncertainty about the security of tenure, and this is a major source of risk when dealing with the long term project to plant tree (Malla, 1987).

Nevertheless, the trend is that the community forestry programs represent the main thrust of the current effort to accommodate the government's interests in reforestation with those of the farmers, through the introduction of various agro-forestry techniques and cropping combinations of trees and annual crops, even including livestock and other forms of farming. In this respect, the forestry concern becomes part of a wider approach of farming systems.

So far, the experience of such enterprises in the forestry sector has not been too promising. A study of the Industrial Tree Farm Scheme in the Philippines concludes that these projects provide negligible benefits to the farmers involved, there was little voluntary participation from the farmers' side, and the farmers who participated loss the control of the land use decisions with regards to their own land (Freese and O'Brien, 1983). In contrast, the "forest village" scheme used by the Forest Industry Organization in Thailand appears to provide the participating farmers with some autonomy on their cropping choices, once the tree planting requirement of the is satisfied. However, it

should be noted that the FIO has had difficulties recruiting local villagers to participate in the schemes and had to bring in migrant farmers from other parts of the country to man their plantations. Studies have shown that members of forest villages do not earn higher incomes than people in ordinary villages, and this is probably the main reason accounting for the difficulties faced by the FIO in setting up their forest villages. Other problems include the fact that the forest villages are established in encroached forest areas where the land is already claimed by the encroachers and the forest village often faces strong opposition from the resident population.

Forestry Extension System

In the three countries, the management of forest resources is the responsibility of government agencies. The role of the private sector has usually been that of the commercial loggers. However, the advent of the social forestry concept has brought out the importance of having the participation of the people who are the traditional users of forests or the intended direct beneficiaries of the reforestation projects. In this sphere, many NGOs have been actively involved with rural communities both in favour of or against social forestry programs. In this section the focus will be on the role of government forestry extension systems in delivering the selected technologies to the small farmers.

The ideal extension system is one that works closely with the farmer, i.e. it is decentralized and available at short notice. So far, the forestry programs are limited in the number of personnel to meet this requirement. In addition, the cost of providing support to the extension workers may be quite high, in terms of the budget allocation.

Existing forestry extension service works mainly in the area of seedling supply, training in nursery management and tree maintenance. Little work is done in tree utilization and marketing.

The policy question is how to organize the delivery system to provide the required service to the small farmer. This answer centers on the extent of cost sharing between the technology supplier and the government, since it can be assumed that the small fanner will be able to bear only the minimum of the fixed costs of the supporting delivery system. In this respect, one would have to balance factors like economies of scale in centralized production with the high costs of centralized distribution. Variations in requirements due to site-specific conditions may also counteract some advantages of the potential economies of scale.

The characteristics of biotechnology as currently understood are, however, a major factor affecting the design of the delivery system. According to Dixon (Dixon, 1986), the major feature of biotechnology today is its dependence on

high level intensive research with highly trained manpower and capital intensive equipment. The commercial viability of a tissue culture laboratory devoted to work on micropropagation of MPTS in the developing countries remains to be tested. In addition, there is a need to have an integrated system to deliver the tree seedlings to the farmer. At present, the seedling distribution system in all the countries visited is highly decentralized, with the nursery in the area for the plantation being the standard practice. We do not have any indication as to whether these nurseries are adequate for the task of reforestation and for meeting the demands for seedlings by farmers. In Thailand, forest tree seedlings, especially of eucalyptus, are produced commercially, but there appears to be a shortage of seedlings to meet the potential demand if tree planting is to be undertaken as a major effort. Hence, the establishment of the seedlings supply industry in areas where extensive forest plantation will take place should be a matter requiring further consideration.

With regards to mycorrhizae and Rhizobium, the production facilities observed in the three countries are still in a pilot plant stage, and there is a long way before supply can be developed to meet all the potential demand. There is also a need to extend the range of the products available to meet the demands for different species and soil types.

3.3.2. Private Commercial Forestry Programs

As an alternative to government-funded community forestry programs, the possibility of establishing a commercially viable system to deliver the necessary inputs to the farmers should not be ruled out. Successful examples have been provided by the large-scale agribusiness systems dealing with cash crops and other products in which small farmers are organized around a core of an international concern (Business International Corporation, no date). The major proviso is that there should an adequate demand for the final product in volume terms so that input supplies can be produced at a low enough cost for the farmer to afford.

A recent trend in Thailand is the growing interest in private plantation of fast-growing trees. Thailand started to export wood chips in 1988. As of now, there are plans to establish plantations on degraded forest under the control of the government, and already there is considerable interest in the establishment of plantations of fast-growing trees, specifically *Eucalyptus spp.* on private land which used to be planted with cassava but has now been turned over to tree farming. The market for these trees is entered in the Southeast region, from where the wood chips are exported to Japan and other Asian countries for processing into pulp. Due to the rising pulp prices, there are also plans to establish pulping mills using fast-growing trees as the main raw materials.

A small industry has sprung up to cater to the need of the tree farmers and the wood processors. On the one hand, the tree planters need the seedlings for establishing his plantation, while the processor needs a continuous supply of wood to operate his factory. At present, the processing plants are all operating at less than full capacity due to the shortage of raw material availability, since the supply is drawn from the area within the radius of about 200km from the factory. Beyond that point, the high cost of transporting the wood makes it uneconomical to sell.

The seedlings for these private plantations come from various sources. From accounts of planters, the preferred source is seeds imported from Australia, which have a higher germination and survival ratio, apart from giving faster-growing and more uniform trees. Otherwise, seedlings are obtained from the Royal Forestry Department or from farmer's own plantations. The latter sources are less reliable as seed supply sources, since uniform quality is not assured.

In this sector, the role of tissue culture propagation may be of some significance, in providing an adequate supply of standard planting materials at "low" costs relative to imports. The obstacle may lie in the sphere of patent and copyright protection of genetic traits which identify the plant characteristics. This theme should be further explored within the MPTS research framework.

The relevance to the small farmers in respect of the large scale private tree plantations is that they are unlikely to benefit much from the growth of tree planting. Firstly, the land that is to be used may be the land that they are presently occupying, even though they may not have full legal entitlement to the land. This is the case in the Social Forestry program in the Philippines, which was forced to recognize the squatter's rights and tailor the forestation program to meet their income and food security needs while integrating trees into the farming systems. In Thailand, private tree farming has met with variable resistance. When the land to be reforested, usually under a concession agreement with the government, is the so-called "degraded" reserved forest which has been occupied by villagers but is now being asked for by the large scale tree planters, resistance to the reforestation effort can be quite strong, while the occupant is quite willing to relinquish the land claim if the land is bought from him by the same planter.

The response to the drive to reforestation varies from one region to another. In the southeastern region of Thailand, where cassava has long been the main cash crop and land fertility has declined, and where much of the farmland has come under private ownership, with legal title deeds, individual farmers are themselves undertaking tree planting on a commercial basis. In contrast, in Thailand's northeastern region, where agriculture is more oriented toward subsistence, with rice as the main crop and some dry season crop as the cash

crop, and where much of the farmland is still held without legal titles, there is strong opposition to the government's attempt to establish tree plantations by giving concessions land in degraded forests to private persons to plant trees.

So far there has been little information on private small scale tree planters, though these are likely to make up a considerable share of the total reforestation area in the near future.

3.3.3. Non-Commercial Private Organizations

Some non-profit organizations have assisted with social forestry efforts in Thailand, in the form of community woodlot projects, mainly in the Northeast, but there are also some projects in the North, involving tree planting by villagers, assisted by the NGOs.

It appears that most of these projects rely on seedlings provided by the government for their projects. However, there is a strong sentiment against the use of *Eucalyptus spp.* for such projects, on the ground of the possible ecological damage caused by planting of it in large blocks. Also, the farmers are pushing for control of the land and the products from the trees, rather than getting the government give the land to large-scale tree planters.

In these projects, reforestation is usually seen as a part of the rural development program, and the focus is on using the trees as a source of fuelwood and to meet household needs for small timber products.

However, there is little experience in the use of trees from these community woodlot. So far, the planting has been initiated and paid for mainly by the outside agency, with the involvement of the villagers limited to the provision of the communal land in the village to the project, and the use of village labor, either paid or unpaid, in the planting of the trees.

Given the structural limitations of many NGOs -- limited scope, lack of continuity, among others -- it is unlikely that the NGOs can be relied upon to provide more than a small fraction of the total requirement of the seedlings and other support for tree planting by farmers.

3.4. Effects on Other Rural Sectors

We have touched upon the distributional issues, but this is worth repeating, since the institutional arrangement in association with the product supply will have a strong impact on how the benefit is distributed and to make sure that the small farmers are the beneficiaries from the project.

Following on from the previous discussion, the role of agribusiness is likely to become more prominent with regards to the three biotechnologies concerned. Since the biotechnological products will be largely introduced from outside the rural setting, there will be a need to enter into monetary transactions for the inputs. The

transformation of the rural economy from subsistence to market oriented production is occurring in any case, but the introduction of biotechnology will help to accelerate the rate of change.

The question with respect to the small farmer is how quickly he can adapt to the continuing transformation and benefit from it. Here again the experience gained in cases where agribusinesses have been established may provide some useful insights.

From the study of agribusinesses in developing countries (Business Research International), the factors which make for a successful partnership between the farmer and the large-scale business is that the risk is reduced to the minimum on the part of the farmer. Risks are borne by the company – which is in a better position to bear the cost – due to its larger reserve. However, for both parties, risks are minimized by the use of proven technology, with adequate supervision from the company, and by secure marketing arrangements for the final products which are marketed by the company. The playoffs are distributed at many points along the production process. Firstly, the company benefits from the sale of inputs to the farmers. The farmers benefit from having a guaranteed market for his produce at a price which he finds favourable. The company also benefits from the marketing of the final product. In cases where marketing of the final product is problematic, the relationship may run into trouble.

The study also highlights additional features associated with successful schemes: on the question of finance, it says that direct financing of inputs by the farmers is more effective than relying on publicly-funded subsidy schemes because the latter usually involves an excessive amount of red tape that the farmers cannot cope with. On the land question, it observes that it is advisable for the corporate core not to own land, but instead try to work with smallholders who cultivate their own land. It also recommends that the farmer uses not more than one third to a half of his land for growing the company crop, and keeps the remainder for growing his own food and other income earning crops. In this way, the farmer maintains some independence for action and is not entirely at the mercy of the large company for his livelihood. Such dependence, if it exists, can lead to attitudes which are unfavourable to a smooth working of the small farmer-large company relationship.

In conclusion, the effects on other rural sectors of the proposed biotechnologies will depend on a number of social and economic factors, particularly the organizational aspects of the market for tree products, as well as the land tenure situation. For this reason, it will be difficult to generalize about the applications of the specific biotechnologies under consideration.

4. Prospects and Recommendations

4.1. Prospects

4.1.1. The Key Links

The focus of the discussion has been placed on the relationship between farmers, MPTS and biotechnology research. We have found that there are problems at each stage of the linkage. Between farmers and trees, there are as yet some uncertainty, principally on the part of the farmers, but also among researchers and envimonmentalists, about the role of trees in general and some trees such as *Eucalyptus* in particular, in the farming systems. Attempts to establish various agro-forestry systems are however gaining recognition and acceptance as the way to combine the interests of the farmers in securing a livelihood with the nation's concern to protect the environment. Community forestry programs also include agroforestry schemes as part of their implementation.

4.1.2. Traditional Farmer's Practice

Another strand in approaching the farmer and tree problem is to evolve ways of allowing the farmer and the rural community to have better access to the forest, while giving them greater responsibility for taking better care of the forest they are using. This part will require assistance in MPTS research as to the most suitable management practices, and also to provide supporting service and supplies where necessary.

4.1.3. Biotechnology Research

As for the relationship between trees and research, we find that there is limited work carried out on the selected technologies with regard to MPTS. Clearly this is the area where expanded effort can be made to get a better understanding of the technical aspects of the trees in question. For example, more work would be useful on the micropropagating properties of selected MPTS species, or of their mycorrhizal properties under different soil conditions, etc. Given the range of species included in MPTS research, the first step should be to further narrow the selection by focusing research efforts on species that are shown to meet the preferences of the small farmers, who are the intended beneficiaries of the research.

4.1.4. Technology Transfer

Finally, there is the problems of the research-farmer linkage. Here, the problem of transferring knowledge from the laboratory to the field remains. There is a need to have an institutional framework which can operate the transfer of knowledge gained effectively to the intended beneficiaries – the small farmers in the developing countries – and the need to spell out the

necessary government policies and supporting procedures to enable this to be realized. At present, forestry extension in each country included in the study is still in an formative stage, especially when compared with the agricultural extension systems.

4.2. Recommendations

In presenting the recommendations, we shall proceed by discussing the technologies individually first, then consider the institutional context in which these technological recommendations can be implemented.

4.2.1. Technical Recommendations

Tissue Culture

The principal criterion for using micropropagation as a means of increasing the supply of planting materials is quite well accepted: that the plant should be difficult to propagate by other means, or only in inadequate quantity in a short time. The existing methods of producing seedlings seem to be adequate to provide enough seedlings for the demand from the community forestry projects. So there appears to be no urgency to use tissue culture for propagation purposes.

However, for purposes of research into plant selection, there is continuing need to undertake research for plants with superior qualities. Of particular importance are disease-tolerant and stress-tolerant species or varieties. The assumption here is that small farmers will be somewhat confined to areas with bad soils. However, successful research in this area will make it possible to make better use of marginal land and degraded forest areas for human settlement, and thus widening the scope for public assistance to the poor and underprivileged rural population. However, where good soils are accessible, the farmer's choice will be to maximize income from the land, and in this case, high yielding varieties should be the focus of attention. The choice of species to concentrate on would depend to a large extent on the market situation prevailing in each country. In Thailand, for instance, there may be a case for concentrating on producing trees with high timber content – to support the forest-based industries such as pulp and paper, furniture and basic wood industries. In Nepal, in contrast, there may be a shift of focus to producing more fodder content to supplement the fodder supply for the livestock in the hill areas. The important consideration is to identify the final end use of the tree to be produced first. On this note, the emphasis on fuelwood and energy may be somewhat reduced, in view of the low prices prevailing of petroleum-based fuels in Thailand and high potential for hydroelectricity generation in Nepal.

Mycorrhizae and Rhizobium

With mycorrhizae and Rhizobium, the prime focus is to use it to reclaim degraded land and for use as fertilizer substitute. As has been suggested elsewhere, the development of mycorrhizae should best be undertaken in conjunction with a seedling supply enterprise. In the technical aspect, the specific sites of degraded land should be identified then the associations established for the necessary mycorrhiza required for successful seedling establishment and growth. In this case, areas earmarked for reforestation, either by community forestry projects or by commercial tree farmers, should be the first consideration. The next step is to examine whether knowledge about the mycorrhizae is required for the area. This will need to be done in conjunction with the choice of the tree species which are intended for planting.

4.2.2. Institutional Recommendations

More Private Participation in MPTS Research

Current MPTS research activities appear to be entered on the public sector at present. Given the trend in biotechnological development, it is useful to consider how more private sector involvement can be effected.

However, such research should have a clear target with regard to the use of the tree under consideration. In this case, forest industries should be brought in and their views sought about how research may be directed toward commercial use.

Improve Forestry Extension Service

The use of public extension officers will be a novel feature of forest management. However, valuable lessons from the history of agricultural extension should not be overlooked. The use of the public agricultural extension agent has been shown to be in many cases a failure, since the required support is usually not forthcoming to make the work successful. In contrast, the use of technical supervisors by commercial agribusiness has often proved highly successful, at least in the technical aspect. In the case of successful enterprises, the relationship between the extension personnel, acting on behalf of the company, with the farmer is more than one of business dealing, but extends into areas of social and community development, as well as having personal friendship and a respect for each other as human beings. With more awareness of the need for forestry personnel to become extension agents, such cases should be studied for guidance.

The one situation to avoid is to have the farmers and the large commercial core locked in an adversary yet dependent relationship, as happens between the sugar mills and the cane growers in Thailand, bargaining over the cane

price. Fortunately, in a growing market which is the case for forest products, the situation is less likely to arise.

Greater Role for Private Sector Forest Resource Development and Management

The drift of the preceding argument can be summarized in terms of having more private sector involvement in the management and development of the forest resources. With reference to the biotechnologies concerned, the private sector can undertake more research, with a view to developing commercial possibilities for the various technologies under consideration. These can be the patent seedling, soil improvement tablets like "mycogroe", and so on. The forest industries must also become more involved in the creation of resources – actively engaging in reforestation and forest extension – than has been the case in the past. In this respect, the emergent trends of commercial plantations should be carefully examined, to avoid problems that have been known to arise in the case of large scale monocropping concerns, where the needs of the farmers are often sacrificed in favour of corporate profit, when it is in fact possible to combine the two for mutual benefit.

Government Role to Encourage Private Sector Participation

Finally, there is the role of the government. Given the premise that a more active role for the private sector in forestry development is desirable, the government role should become more supervisory, and less active as resource manager. This means, regulations should be changed to encourage commercial reforestation, with innovative organizational structures to induce private sector participation. In addition, spending on research and extension should be considered for preferential tax treatment. In addition, the true costs of using the natural forest products should be charged to users so that reforestation becomes a commercial proposition.

With respect to MPTS technology, government policy should be to encourage research and development activities by making available sites for field tests of products under development. This should help bear the cost of the development stage. However, at the basic research stage, the burden of the work should perhaps be borne by the academic institutions and the commercial ventures who are willing to take the risk. For the government, the return relative to the risks may be too low, and the alternative ways of using public money offer more socially beneficial returns.

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