Emerging research issues in the management of teak

C.T.S. Nair and O. Souvannavong

The evolution of priorities and institutional arrangements for research on teak in the context of changing management scenarios and increasing involvement of the private sector

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A young teak seedling, Myanmar

With its long history of management as a forest plantation species and its wide geographical spread (through introduction to areas far outside its natural distribution), teak is one of the most researched tropical hardwood species. A bibliography on teak literature lists more than 4 000 documents spanning over more than 150 years and covering different aspects of management and utilization of teak forests and plantations (Tewari, 1992). Until the early 1970s teak was one of the most important plantation species in a number of tropical countries (Evans, 1992), but with the growth of the pulp and paper industry most of the attention shifted to fast-growing plantations of eucalypts and acacias. Forestry research in most teak-growing countries was naturally centred on topics related to teak cultivation and plantation management, ranging from seed production, stand management and harvesting to processing, utilization and marketing.

Notwithstanding the substantial research and development efforts, the gaps in knowledge about teak remain large, particularly with the emergence of new, more intensive management systems. A number of developments have influenced the management of teak forests and plantations during the last few decades, and most notably during the past ten years. These include:

- the global decline of tropical timber supply from natural forests, increasing reliance on plantations to meet the growing demand for hardwood;
- involvement of the private sector, including farmers, in the cultivation of teak;
- extension of teak to areas far outside its natural distribution and, more particularly, into areas with very different ecological conditions;
- the growth in international trade of forest products and the emergence of new consumption centres;

C.T.S. Nair is Senior Forestry Officer in the Forestry Planning and Statistics Branch, FAO Forestry Department.
Oudara Souvannavong is Senior Forestry Officer in the Forest Conservation, Research and Education Service, FAO Forestry Department.

- new opportunities arising from developments in processing technologies;
- increased attention to the ecological and environmental functions of forests in their sustainable management.

This article gives a brief overview of some of the research issues in the context of the changing management scenarios. Research needs are largely related to the characteristics of the production systems, so these systems are first briefly described. Following an analysis of key research issues, especially in the context of changes in the production systems, the article examines institutional arrangements for research, including the potential for networking.

TEAK PRODUCTION SYSTEMS

Based on ownership, objectives of management, intensity of management and technology adopted, teak production systems can be broadly grouped into three categories: natural forests; block plantations; and farm forestry, including home gardens.

Considering the wide variation in the intensity of plantation management, it is useful to make a distinction between low-intensity/low-investment plantations and high-intensity/high-investment plantations. The systems prevailing in different teak-growing countries depend on the history of teak management, the availability of resources, the local site conditions, the policy and legal framework, the nature of the demand for teak wood and the state of production and utilization technologies. In several countries, especially those with a long history of teak cultivation, a mosaic of different production systems caters to different market needs. Key features of the production systems are summarized as follows.

Natural forests

Historically forests in India, Myanmar and Thailand have been the most important source of teak wood (Gyi and Tint, 1998). However, with the drastic decline in the area of teak forests, at present Myanmar is the only country that still relies on natural forests for most of its teak wood production.

Management of natural forests traditionally involved removal of trees above a specified exploitable diameter, leaving a sufficient number of trees in the pre-exploitable class to provide timber during successive felling cycles (Gyi and Tint, 1998). This system was viable at low intensities of logging, but with increasing demand for teak wood, felling cycles and harvestable diameter were reduced and increased harvesting intensities, coupled with other causes of degradation, undermined sustainability of wood production (FAO, 1985). Even in Myanmar, it is clear that with increased logging intensities and the low investment in postharvest treatments, fire protection and tending of regeneration, natural forests may cease to be the most important source of teak wood.

Plantations

The first systematic efforts to establish teak plantations were made more than 150 years ago in India and Myanmar (FAO, 1993). From the beginning of the twentieth century the pace of teak plantation increased considerably. Until about ten years ago, most plantations were established and managed in the public sector, by forestry departments or parastatal agencies. The primary objective of early plantation efforts was to compensate for the depletion of natural teak in India, Myanmar and Thailand. The goal of producing large-dimension logs, which took into account the prevailing market demand and utilization technologies, favoured the adoption of long rotations and low-intensity/low-investment silvicultural regimes with minimal interventions.

Such low-intensity plantations are not confined to traditional teak growing areas. During the early part of the twentieth century, teak was introduced to several African, Caribbean and Central American countries. These early introductions have enhanced the supply of teak wood to the global market, sometimes, paradoxically, to meet the growing demand from countries where teak originated. For example, at present India is the major buyer of teak wood from Côte d'Ivoire (cf. article by Maldonado and Louppe in this issue).

Changing demand and utilization technologies have resulted in a gradual reduction in teak rotations. In India, for example, rotations of plantations managed by the Forest Department were shortened from 100 years to 80 years and currently vary in most cases from 40 to 60 years (Tewari, 1992). Nevertheless, most public-sector plantations continue to be managed on low-intensity regimes. The uptake of research results is low, partly because of financial constraints and partly because their relevance is not recognized in the context of long rotations.

Significant private-sector involvement in teak cultivation is a recent phenomenon, encouraged over the past ten years by the relatively new perception of teak planting as a commercially profitable venture, as well as by policy and legal changes. In several countries the government historically controlled the right to harvest and utilize teak. Even for teak grown on private land, landowners had to abide by cumbersome regulations for harvesting and transport, which discouraged cultivation of teak. In recent years changes in these laws,

together with favourable markets and an investment-friendly environment, have contributed to a shift in the location of teak plantations and the emergence of the private sector as an important producer of teak. In many new areas, particularly in South and Central America (especially Brazil and Costa Rica) and in Malaysia, planting of teak is emerging largely as a private-sector initiative. To meet their commercial objectives, the new plantations are grown on shorter rotations and with high-input management including intensive site preparation and improved pest and disease control as well as the use of good-quality planting material.

Smallholder cultivation

Changes in land and tree tenure and improved access to markets in some countries have encouraged cultivation of teak by farmers as an integral part of their farming system, in small woodlots, in home gardens or in mixtures with other trees and agricultural crops (cf. Subramanian *et al.*, 1999). Commercial considerations and the desire to enhance overall profitability from the land are foremost in farmers' decision to cultivate teak. The practices adopted vary considerably, however. The major concerns for smallholders include availability of quality planting materials, assured demand and prices, and access to information related to teak establishment and management, especially to deal with any problems.

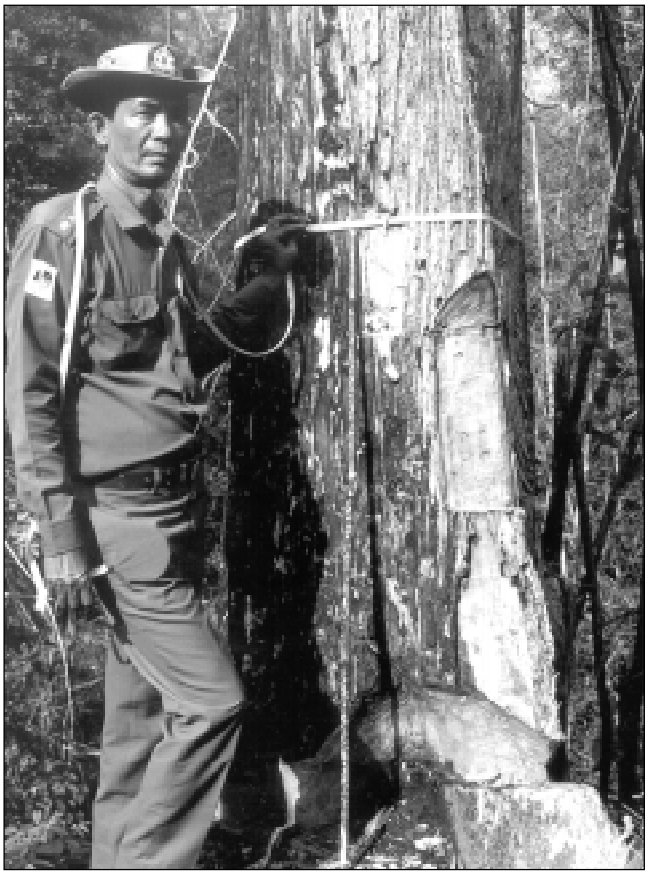
CHANGING CONCEPTION OF RESEARCH

The development of research and technology has been influenced by a number of factors, most important the interest and response of the resource owners and the institutional arrangements for research. Chronologically, teak research has followed the evolution of the prevailing production systems it was to support, in the following pattern.

Research on narrowly defined problems

Under low-intensity management systems applied to natural teak forests and older long-rotation plantations, productivity was largely determined by natural conditions and processes and the low levels of investment did not support major interventions. Research interventions were required only when there were significant perturbations that were thought to affect productivity. Since perturbations were seen as isolated events, they were often dealt with in a reactive manner. Problems in obtaining regular harvests during successive felling cycles led to research on yield and stand dynamics, specifically focusing on the number of trees in the exploitable and pre-exploitable classes (cf. Gyi and Tint, 1998); pest outbreaks led to studies on the life cycle of the pests and the development of control measures (Beeson, 1941); poor growth of trees led to studies on nutrient requirements and measures to augment the nutrient status (Davis, 1940; Seth and Yadov, 1959); and so on.

With long rotations and low intensity of management, teak growing was not seen as a commercial investment; hence there was generally little incentive to implement research results effectively to enhance productivity. However, early research efforts generated substantial basic knowledge on growth and yield,



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Management of natural teak forests in Myanmar involves removal of trees above a specified diameter

as well as on provenance variation, which paved the way for more targeted research to support the more recently developed high-intensity plantations.

Research in the context of narrowly defined objectives

The recent increase in commercial investment in teak with a focus on profitability has made research more purpose oriented, albeit in a narrow sense. Private-sector and parastatal organizations in particular have aimed to develop packages of practices designed to enhance productivity in the short term. Efforts in this direction include improvement in the quality of planting material (selection of suitable provenances; tree improvement and multiplication techniques including tissue culture and clonal propagation) (Kaosa-ard, 1996), more efficient site preparation and planting practices, productivity-enhancing technologies such as irrigation and fertilizer application, and techniques to improve bole form by pruning, thinning, etc. Another area of research was the quality of wood from short-rotation plantations and the use of small-dimension logs (Bhat, Bhat and Dhamodaran, 1985; Sanwo, 1987).

Research in the context of a wider set of objectives

The shift from sustainable timber management to sustainable forest management would imply that plantation management should be widened to fulfil other objectives besides timber production, to ensure that timber production does not have negative environmental or social impacts (Thampi, 1997). This broader type of management will require better understanding of the ecosystem processes and of the implications of various interventions and fine-tuning of forestry practices. Input-intensive practices are likely to be replaced by more knowledge-based interventions. Managing forests for wider objectives will also enhance flexibility in responding to social, economic and technological changes. Recent initiatives to develop criteria and indicators for sustainable forest management and efforts towards certification and labelling necessitate more holistic research.

SOME CURRENT RESEARCH ISSUES

The management issues vary for the different systems in which teak is grown, and the research topics vary accordingly. The Table gives an overview of the main issues and current research topics for different teak production systems. The following are the subjects of major concern.

Management of natural teak forests

As for other natural forests, an important research issue is to obtain the information and knowledge necessary for sustainable management of teak forests which takes into account their social and environmental functions (including, for example, environmental protection and contribution to biological diversity).

Globally, natural teak forests represent a relatively limited area and, although accurate data are not available, their share in timber production is likely to continue to decrease relative to the production from plantations. Consequently, the focus on production from the remaining natural teak forests is generally decreasing in favour of environmental protection and conservation of biological diversity. However, in Myanmar, natural forests still contribute an important part of teak production. One issue is whether and how management of these forests, initially rather conservative, could be intensified to satisfy higher timber demand while maintaining the forests' environmental functions.

Intensification of teak plantations

The rotation of new high-intensity teak plantations is generally between 20 and 25 years (Torres, 1999; Ugalde Arias and Pérez Cordero, 1999), which is three to four times shorter than for older low-intensity plantations. The expected mean annual increment (MAI) is more than 10 m^3 per hectare per year (as compared with 3 to 8 m^3 per hectare per year in low-intensity plantations on good sites) (Subramanian *et al.*, 1999; Maitre, 1983). With intensive management, there is growing concern about the adverse effects of short-rotation monoculture, particularly on the environmental and productive sustainability of successive rotations with high nutrient uptake. The decline in productivity during the second rotation was already an important concern many decades ago (Blanford, 1933; Davis, 1940). The evidence suggests that this is most often a result of the failure to implement various prescriptions (Evans, 1999).

Nevertheless, the current intensification calls for more studies on soil properties, nutrient cycles and possible impacts on productivity. Other concerns related to intensive management include the narrowing of the genetic base in production stands and its consequences for long-term productivity, and environmental impacts of application of fertilizers and pesticides. Growth rates and yield under different conditions and treatments are of particular interest, particularly in the context of increasing investment in teak and unrealistic claims of productivity (Gangopadhyay, 1997).

Smallholder cultivation

The economic and ecological implications of integrating teak in farming sys-

Research issues for teak under different production systems

Issues, by production system	Current research topics
Natural forest management	
Sustainability of logging/production	Growth and yield studies Natural regeneration Stand structure and composition
Environmental protection and conservation of biological diversity	Impact of intensified management for timber production on ecological processes and biological diversity
Low-intensity plantations	
Plantation establishment	Site-species matching Tree selection and improvement Seed technology and production, nursery techniques, planting techniques, seed technology Low-cost techniques for weed control
Management	Silviculture, including maintenance and thinning Growth and yield studies Impact of pest and disease outbreaks and adoption of silvicultural measures for their control
Harvesting and utilization	Harvesting techniques Marketing of thinning materials
Economics	Reducing plantation establishment costs
High-intensity plantations	
Plantation establishment	Tree improvement and application of biotechnology Site-species matching Seed technology and production, nursery techniques, planting techniques, seed technology Improved site preparation techniques
Management	Nutrient management Growth and yield under short-rotation management Silviculture, including maintenance and thinning Pest and disease management, including application of biological control measures
Harvesting and utilization	Wood quality Utilization of small-dimension logs and poles
Economics	Commercial profitability
Sustainability	Sustainability of wood production over successive rotations
Smallholder woodlots and home garden planting	
Technical aspects	Cultivation techniques Access to seeds, planting materials and expertise
Social and economic aspects	Demand for wood, access to markets, economic and financial viability and profitability Suitability to the livelihood strategies of small farmers
Ecological aspects	Suitability of the species for growth in mixed cropping systems

tems need to be better understood. Teak research hitherto has mostly focused on technical and economic aspects of growing the species under a plantation system. While some aspects of this research are relevant to smallholders, several other areas require detailed research. Interaction among different crops is an important issue, especially the effects of teak on the yield of agricultural crops, as well as the effects of agricultural crops on teak productivity. Many smallholders require information on demand and prices of teak as well as technology (in particular planting and post-planting treatments, access to improved planting materials, insect and fungal control, etc.) to enable them to take appropriate decisions.

Expansion of teak to areas with diverse ecological conditions

Many of the new high-intensity plantations are in areas that would have been considered marginal for teak growing two decades ago. Some plantation sites in Latin America are in areas with extremely high rainfall (over 4 000 mm per year) and no or very slight dry seasons. These conditions are not found in the natural range of distribution of the species but seem favourable to its growth. However, as most research has been done in other areas, new problems could be encountered.

Particular attention to pest and disease monitoring is especially called for in plantations newly established in ecological conditions that are marginal for the species. In Côte d'Ivoire, for example, root rot disease caused important damage in a young plantation at the limit between the evergreen and the mixed deciduous forest zones. This type of problem could be related to environmental factors but could also result from inadequate silvicultural practices (lack of thinning). Pest and disease problems may be aggravated by the low level of genetic diversity of the selected planting material used in high-yielding plantations. Integrated pest management (IPM) research is thus indispensable to expanding the frontier of teak planting, as well as additional research on provenance or genetic material and site matching.

Genetic resources, tree improvement and propagation

Teak provenance testing was initiated as early as the 1930s in India. International

provenance trials were established in the early 1970s under the coordination of FAO and the Danish International Development Agency (DANIDA) Forest Seed Centre; 75 provenances, both from within the natural range of the species and from areas of introduction, were collected and exchanged for trial establishment at over 50 sites in 16 countries. Coordinated evaluations undertaken from 1981 to 1984 and from 1991 to 1992 showed important differences among provenances for growth and stem quality traits. These evaluations resulted in recommendations concerning provenances to be used in different regions (Keiding, Wellendorf and Lauridsen, 1986; Kjaer, Lauridsen and Wellendorf, 1995).

Development of a bud grafting technique allowed the establishment of clonal seed orchards in the late 1960s and early 1970s, first in Thailand (Wellendorf and Kaosa-ard, 1988) and India, following phenotypic plus tree selection in natural forests and old plantations. Clonal seed orchards were also established in countries outside teak's natural range from the late 1970s onward, generally following selection of individual trees of the best provenances in comparative trials. Scarcity of seed production in clonal seed orchards in Thailand and in other countries in Asia (Kaosa-ard, Suangtho and Kjaer, 1998) is however hindering the progress of teak improvement programmes by overly delaying the establishment of progeny trials. The seed production problem is seriously limiting benefits derived from the important investments made in these programmes. There is no problem, however, with seed production in clonal seed orchards established in Africa (Côte d'Ivoire) (O. Souvan-navong, unpublished).

Following the development of micropropagation techniques (Kaosa-ard, Suangtho and Kjaer, 1998; Monteuuis and Goh, 1999), some authors are questioning the breeding strategy implemented to date and are calling for increased use of clonal selection and clonal plantations (White and Gavinlertvatana, 1999). Although the development of high-intensity plantations will probably boost clonal selection and plantation, a sound long-term strategy should combine sexual and vegetative reproduction to retain genetic diversity while continuing to capture intensive genetic gain (Kaosa-ard, Suangtho and Kjaer, 1998). Studies on reproductive biology should be directed towards eliminating the current bottleneck in sexual reproduction and enhancing seed production.

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A future research issue could be how to intensify management of natural forests to satisfy higher timber demand while maintaining the forests' environmental functions; here, a young plantation established in the natural teak forest to supplement natural regeneration, Myanmar

SOME EMERGING ISSUES

As discussed earlier, research and development efforts in teak have followed a pattern largely in response to the changing needs of the systems. It is important to try to visualize the issues that are likely to emerge with regard to teak management in the future.

Fine-tuning ecological processes

Notwithstanding the long history of research, there are major gaps in the understanding of various aspects of managing teak on a sustainable basis. The shift from a low-intensity management regime (as in the management of natural forests and long-rotation plantations) to high-intensity plantations has involved serious modification of the environment, the consequences of which are yet to be assessed systematically.

With conservation of biological diversity and environmental protection underpinning all land uses, the main issue will be how to move to a management regime that focuses on fine-tuning ecological processes rather than making extreme alterations. Efforts to develop criteria and indicators for sustainable management and certification and labelling point in this direction, but eventually far more in-depth research on ecological processes and measures may be necessary for their fine-tuning.

Impact of changes in utilization technology

Teak has maintained its unique position among tropical hardwood species thanks to its inherent qualities of strength, durability, workability and appearance. With plantations becoming an important source of supply of teak wood, the quality of wood from plantations *vis-à-vis* that from natural forests and long-rotation plantations is a key concern. Developments in processing technologies have enabled the use of small-dimension logs and even sapwood (Sangkul, 1998). The way technological changes have been developing suggests that inherent properties are likely to become increasingly less important, as many of the characteristics could be incorporated during processing. An important question is what will be the future of teak if such developments take place. Could teak become one of several species that just provide a biomass base to be modified and adapted depending on market needs and the prevailing technology? Or will there still be a market to cater to the demand of consumers who continue to value its inherent natural characteristics (Manger, 1998)?

Marketing in a global economy

A related issue is marketing of teak wood, especially in the context of the emergence of new production centres and, more important, the growth of farm planting. No systematic studies are available on the future demand for teak, specifically taking into account the potential changes in consumption pattern, including the potential for substitution. There is also an urgent need to develop information systems that focus on assessing and analysing supply, demand, prices, etc. and that make the information accessible to those involved in cultivation, processing and marketing of teak wood.

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Improvement of seed production is needed to boost teak improvement programmes; here, a seed orchard for collection of quality teak seeds in Myanmar

INSTITUTIONAL ARRANGEMENTS FOR RESEARCH

Until recently, research on teak was almost exclusively undertaken by public institutions to serve government forest management and development programmes, which focused on teak production systems characterized by low investment and low-intensity management. Globally, publicly funded research was able to produce the basic knowledge necessary to these non-intensive production systems.

The recent large-scale development of intensive commercial plantations has favoured the involvement of the private sector in research, mainly aimed at short-term gains and financial benefit. Arrangements now include research and development programmes that are part of the activities of important integrated industrial companies. It is foreseeable that, as industrial teak plantations develop, a dynamic and productive private teak research effort will emerge, as has been the case for poplars and eucalypts. After a phase of transfer of knowledge and expertise from the public sector, which has already begun, research conducted by private enterprise will rapidly become a major contributor to knowledge on teak. In this new era of teak research, the challenge will be to ensure an adequate balance between short-term and long-term objectives and concerns, as well as the availability of research results to a wide range of users. This would require substantial

TEAKNET

The primary objective of the TEAKNET network is to strengthen interaction among all those concerned with the conservation and sustainable management of teak-bearing forests and plantations through sharing of information and promotion of collaborative efforts to deal with common problems.

Prior to the founding of TEAKNET, there was no mechanism to share the wealth of information on teak and to facilitate improvement of techniques for the conservation, management and utilization of teak forests and plantations. The need to develop such a mechanism was discussed during the China/ESCAP/FAO Regional Seminar on Research and Development of Teak, held at Guangzhou, China, in 1991. There was a general consensus regarding the proposal to establish a network of institutions and individuals concerned with the conservation, management, utilization and trade of teak. The issue was discussed in detail during the second Regional Seminar on Teak held at Yangon, Myanmar from 29 May to 3 June 1995, and the participants unanimously endorsed the proposal to establish the TEAKNET Asia-Pacific Region network.

TEAKNET's activities include review of teak research and knowledge through periodic seminars (every three years), information dissemination (including a quarterly newsletter and database development), support for collaborative research and training programmes, and exchange of germplasm and technical expertise among the countries and institutes collaborating in the activities of the network.

Membership of TEAKNET is open to institutes in both the private and public sectors and to individuals involved in managing natural teak forests and plantations, undertaking research and studies on teak and/or involved in processing and trade of teak products. TEAKNET has a steering committee with representatives from Myanmar, Thailand, China, Indonesia, India and Malaysia and a secretariat based in and supported by the Forestry Department of the Government of Myanmar.

Further information on TEAKNET can be obtained by contacting Mr Mehm Ko Ko Gyi, TEAKNET Coordinator, Forestry Department, Ministry of Forestry, Bayintnaung Road, West Gyogone, Yangon 11011, Myanmar (Tel.: 951 63413; Fax: 951 64336).

strengthening of public-sector research, which has declined in recent years. New institutional arrangements will have to be developed to promote effective collaboration among stakeholders. Some research cooperatives and associations involving industrial companies, universities and forest research institutes, particularly in Brazil and Chile, provide positive examples that could be followed at both the national and regional levels.

International cooperation has had an important role in teak research and has been instrumental in the success of programmes in provenance selection and tree improvement. Regional research networks and programmes – including, in Asia and the Pacific, the United Nations Development Programme (UNDP)/FAO Regional Forest Tree Improvement Project (FORTIP), FAO's Forestry Research Support Programme for Asia and Pacific (FORSPA) and the Asia Pacific Association of Forestry Research Institutions (APAFRI); and in Africa, the West and Central African Council for Research and Development (WECARD) – have facilitated cooperation and transfer and exchange of experience and knowledge among countries, sometimes through regional research projects. However, they mainly involve public-sector research. For reasons made clear above, it is essential that existing networks facilitate the involvement of the private sector in future teak research programmes. Initiatives such as TEAKNET and TEAK 2000 (see Boxes), which aim at associating private and public efforts and interest at the global level, may contribute to this end.

CONCLUSIONS

Teak is one of the most planted and most researched tropical forest tree species. Historically, teak research followed the needs of the prevailing production systems, which gradually became more intensive over the years, until more extreme changes in objectives and management took place during the past decade following the development of intensive industrial plantations.

The future management of teak forests and plantations will require research that is more holistic, especially as new problems and issues emerge.

TEAK 2000 and the Consortium Support Model

TEAK 2000 is an initiative in sustainable forestry development, launched in October 1996, which has the objective "to establish quality hardwood plantations in a socially acceptable and environmentally friendly manner, under new regimes, to produce a significant output of high-grade timber, on a sustainable basis, to satisfy future domestic and international markets". It is currently focused on teak because it was felt important to begin with a clear focus on a species whose silviculture is well understood. However, the initiative is intended later to include other species.

TEAK 2000 is based on the Consortium Support Model (CSM), a system for facilitating provision of financial and technical support to groups of growers to enable them to produce more and better-quality timber in a sustainable manner. CSM emphasizes linkages among donors, government, investors, the private and community sectors and environmental non-governmental organizations (NGOs). A Technical Foundation Committee of 20 experts from 11 countries, set up in August 1998, is exploring mechanisms for translating the CSM concept into a working reality.

The aim of TEAK 2000 is to use existing and new financial mechanisms to redirect and channel substantial capital flows towards plantation development, industry and marketing in ways that support rural communities and enhance the environment. The initiative is geared towards establishment of large- and small-scale plantations by both the private and community sectors using recognized best practices. Established plantations may be incorporated into the scheme if they obey strict social and environmental criteria.

CURRENT STATUS

Interest has been expressed from the private, community and government sectors on three continents. In Africa, growers in Ghana have requested technical and financial support and expressed interest in establishing a branch of the initiative in the country. In Latin America, particularly El Salvador, Panama and Costa Rica, many small- and large-scale growers and several growers' associations have approached TEAK 2000 requesting technical and financial support. Government bodies have also expressed enthusiasm. In Asia, several private teak-growing companies and a consultancy firm in India have expressed an interest, while the Sri Lankan Government has indicated a willingness to lease out lands for the activities of the initiative.

Organizations that have expressed potential interest in the scheme include the World Bank, the African Development Bank, the International Tropical Timber Organization (ITTO) and the Danish International Development Agency (DANIDA), the International Cooperation Centre on Agrarian Research for Development (CIRAD) and FAO.

TEAK 2000 has built up an internal working database on teak and other quality hardwoods consisting of more than 200 general references and more than 300 regional and country texts, covering a wide range of technical and non-technical material. The references are indexed by keyword to facilitate location of information.

It is likely that the initiative's name will be changed in the new millennium (perhaps to "Tropical Hardwood Growers – Consortium Support Initiative") to demonstrate its concern with quality hardwoods in general. It will continue of course to devote attention to teak.

Further information on TEAK 2000 can be obtained by contacting Raymond M. Keogh, Coordinator TEAK 2000, 27 Loreto Grange, Bray, County Wicklow, Ireland (E-mail: rmkeogh@teak2000.iol.ie; Tel.: 353-1-2864697; Fax: 353-1-2861188) or by consulting the TEAK 2000 Internet site, http://ireland.iol.ie/~teak2000/.

Future research efforts will be driven by the need to adopt sustainable forest management coupled with changes in markets and utilization technologies. Thus there will be a need for research arrangements that involve all stakeholders in the private and public sectors. Ongoing initiatives such as TEAKNET and TEAK 2000 may serve as platforms for these arrangements, building on the experience with other industrial tree species and on the successful history of international cooperation in teak research. ◆

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