Site, technology and productivity of teak plantations in Southeast Asia

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Teak (Tectona grandis), a hardwood species indigenous to India, Myanmar, the Lao People’s Democratic Republic and Thailand, has a long history of systematic management. It was introduced in Indonesia (Java) hundreds of years ago and the earliest teak plantations in Sri Lanka have been traced back to the late seventeenth century. The first intensive natural forest management systems were developed about 150 years ago in Myanmar, from whence active management of the species spread to India and Thailand over a period of some 40 years. Today, teak is found in many other Asian countries, and extensive teak plantations have also been established in Africa and Central and South America. It has become evident that harvesting from the natural forests cannot continue to meet the demand for teak wood, and the expected shortage has led to increased interest in teak plantations.

Teak planting, which was once mainly the domain of government forest departments, is today also attracting the interest of the private sector. In tandem with the involvement of farmers in planting teak, a shift from large- to small-scale plantations and from long to shorter rotations can be observed. Advances in tree breeding and mass multiplication techniques enable the production of healthy and uniform planting material on a large scale. Many private companies have taken advantage of the latest technical developments, incentives offered by a number of governments and the growing interest in teak by publicizing potentially attractive returns on investments in teak. However, in several countries policies and legislation restricting harvest and transport of teak, designed to protect natural forests but applying even to teak grown in plantations, act as disincentives to private-sector investment.

The “teak rush” is at times based on inadequate knowledge and a limited understanding of available technologies and potential yields. In addition, the highly optimistic claims of productivity and financial rates of return made by some promoters for investment in teak planta-
tions have misled the public and investment institutions. As a result a decline in investors’ interest has been observed.

In response to these shortcomings, TEAKNET (a network of institutions and individuals in the Asia and the Pacific region concerned with the conservation, management, utilization and trade of teak – see Box on page 52) and the Forestry Research Support Programme for Asia and Pacific (FORSPA) organized the Regional Seminar on Site, Technology and Productivity of Teak Plantations, held in Chiang Mai, Thailand, from 26 to 29 January 1999. The objectives of the seminar were to assess the current state of teak plantation management, to review linkages of site, technology and productivity, to identify strategies for improving plantation management and to develop a framework for collaborative studies and technology improvement.

This article summarizes the main conclusions and recommendations of the seminar.¹

TECHNOLOGY AND PRODUCTIVITY
The state of teak plantation technology
Many teak plantations do not make use of current knowledge; growers often lack access to relevant information and therefore do not adopt research results and/or apply known technologies effectively. Small-scale growers and farmers are particularly disadvantaged in this respect. Information on the spread of technologies and their effect on productivity is lacking. Most public-sector teak plantations are managed under low-intensity/low-investment regimes and with a reliance on low-cost technologies. Public-sector investment in plantation establishment ranges widely from US$100 to more than US$1 000 per hectare, depending primarily on site conditions and input levels. The private sector, on the other hand, is generally more keen to maximize profits through the use of fertile sites, the application of new technologies and the reduction of costs.

Site selection and plantation management
Differences in management objectives, the level of investment and environmental conditions explain the variability in production systems and technologies adopted. Teak can be produced under diverse conditions, but high productivity can only be expected on good and accessible sites for which competition from a number of cash crops such as oil-palm, fruit-trees and vegetables is intense. In many countries teak is being planted on degraded land, which explains, at least in part, the poor performance.

Tree breeding
Tree breeding work on teak, as for many other species, is producing significant results, yet it tends to be fragmented and hindered by shortage of financial resources and high staff turnover.

Teak-growing countries and supporting institutions should define a long-term breeding strategy which should take into account all aspects of long-term tree improvement, including the conservation of natural populations, the identification and evaluation of provenances and landraces, and progeny and clonal trials. The means identified (e.g. mass propagation through seed orchards, propagation through cuttings, tissue culture) should be developed in an integrated approach facilitating continuity and links with other fields.

Production and dissemination of planting materials
Production of planting materials from seed orchards has been poor and warrants attention. The advent of tissue culture and other mass multiplication techniques has enhanced the ability to produce uniform planting materials with desirable attributes (e.g. fast growth, improved stem form) on a large scale.

To improve the management of clonal seed orchards for enhanced seed production, the following areas should be explored: consideration of the potential of more efficient pollinators; increased study of the phenology and reproductive biology of the species and clones; and improvement in the layout and design of seed orchards.

¹ A more detailed summary of the seminar (Site, technology and productivity of teak plantations – regional seminar – conclusions and recommendations) is available from FORSPA and TEAKNET. The full proceedings of the seminar are in preparation.
So-called superior teak phenotypes are already produced and sold on a commercial scale. Sound information should be provided to end users on the potential benefits and risks associated with large-scale deployment of genetically identical or closely related materials, including ways to buffer potential risks through a mixture of clones and site matching.

Guidelines for the international transfer of teak germplasm should be formulated, taking into account international and national regulations and phytosanitary requirements. Purchasers of such material require advice on the need to test transferred germplasm in its new site and on the need for adequate records of the source of the material. Agencies concerned with collecting, distributing and using seeds should adopt a system for identifying and registering the source of reproductive materials (seed, cuttings, pollen, germplasm, etc.). Application of a seed zone classification based on genecological information should be considered in the absence of any other reliable differentiating system.

**Conservation of genetic resources**

In situ and ex situ conservation strategies need to be designed. The genetic base of planted or secondary populations and alleged landraces should be examined based on historical records and the use of modern techniques (e.g. genetic markers). Studies based on a combination of genecological parameters, plot experiments and molecular verifiers should be carried out with the aim of obtaining consistent information on the extent and patterns of genetic variation in both natural and planted stands.

**Productivity**

Most available estimates on growth and yield are derived from experimental plots. Figures from existing plantations covering a range of environmental conditions and management regimes are limited. Moreover, the ambiguous use of the terms “productivity” and “mean annual increment” (MAI) makes comparisons difficult. MAI sometimes refers to the total volume, and sometimes to the commercial volume, obtained from thinnings and final felling over the rotation. In addition, many estimates do not specify whether they are for over or under bark, trees standing in the forest or wood delivered to the mill.

MAIs (in terms of commercial volume) obtained from government plantations range from 2 to 5 m³ per hectare and are often below the potential yield of the site. The poor performance is mainly a result of low inputs and poor management, coupled with yield-reducing factors such as illicit removal, fire, pest infestation and disease outbreaks.

A combination of rigorous site selection and application of known technologies, good planting materials adapted to the site, appropriate silvicultural practices and improved protection could increase the MAI to 8 to 12 m³ per hectare. Yields of 15 to 20 m³ per hectare per year on a short rotation of 20 years should be viewed as the upper limit with present technologies. Claims of higher yield levels should be treated with caution.

In view of the critical role of site in productivity, the criteria for selecting land for teak plantations should be refined, harmonized and widely disseminated. Improved national tables giving growth and yield estimates under a range
of site and treatment conditions should be prepared and disseminated. A network of permanent sample plots covering the entire range of growth conditions and intensities of management should be established and regularly monitored, with common standards and definitions adopted to facilitate comparison.

**Potential areas for management research**

The environmental and production impacts of successive rotations have not yet been systematically assessed. Although some evidence has emerged regarding site changes that may be induced by teak plantations, the causes of productivity decline remain elusive. Current site quality assessments rely primarily on growth parameters. While this is appropriate for timber production purposes, a monitoring system for detecting changes in critical site parameters (especially biophysical and chemical characteristics) should be designed. A review of available information covering the spectrum of conditions and technologies under which teak is grown in successive rotations is urgently required. Site management to sustain productivity may involve, *inter alia*, changes in silvicultural prescription, soil conservation measures and fertilizer applications. For control of pests and diseases, further research is required on biological control measures (e.g. *Bacillus thuringiensis* and nuclear polyhedrosis virus), especially to facilitate large-scale application and to overcome resistance; integrated pest management (IPM); and the impact of pest infestations so that economically viable practices can be designed. Mixed stands are reported to act as barriers to the spread of infestations, but this role (as well as the management of such stands) needs to be better understood.

**Impact on site and long-term sustainability**

Coordinated efforts should be initiated through a network of permanent sample plots to assess the long-term, on-site impacts of various clones and rotations of teak plantations, e.g. on nutrient status, soil structure, erosion, ground cover and water balance. Factors important for maintaining the growth potential should be identified, and more appropriate silvicultural prescriptions developed.

**UTILIZATION, MARKETING AND ECONOMICS**

**Teak wood markets and prices**

Considering the declining supply from natural forests, the long-term prospects for plantation-grown teak seem promising, but price data are lacking. The limited studies on historical prices for teak wood (largely from natural forests) suggest an upward trend. However, global, regional and national studies need to be undertaken to assess the long-term demand, supply and price trends for teak (as well as for other quality hardwoods). Such studies need to take into account the segmented nature of the market and the variation in wood quality and dimensions.

Existing national grading systems for teak timber need to be reviewed and changed as necessary, taking into account the quality and dimensions obtainable from plantations as well as from natural forests.

**Short rotations and small-dimension wood**

Investors in teak plantations are concerned about the markets and prices of small-diameter wood obtained from thinnings. Profitability is substantially influenced by the high proportion of sapwood, the variability in physical and mechanical properties, the appearance of the wood in comparison with large-diameter wood from natural forests and long-rotation plantations, and the feasibility of processing and marketing smaller dimensions. In areas with a long history of teak plantations, short rotations and small dimensions seem to be less of a problem, as diverse demand structures have evolved over time. Utilization technologies have also considerably improved, facilitating the use of smaller dimensions. The current and potential uses of small-dimension wood from teak plantations should be assessed and conversion rates enhanced.

**Cost-benefit analysis**

With an MAI of 3 m³ per hectare (total volume from thinnings and final felling), plantations grown on a long rotation (over 50 years) yield a rate of return of over 15 percent. The high rate of return is largely attributable to assumptions about the low initial investments; exclusion of the opportunity cost for land; the marketability of the products from early thinnings, facilitating recovery of the initial investments; and the high price of the timber.

The available studies suggest that, if properly managed, teak plantations could generate attractive returns to investment. However, reliable financial appraisals are very limited. Rigorous cost-benefit analyses that consider the different environmental conditions, management regimes and markets must be carried out and disseminated to prevent speculative investment based on misleading claims. Such studies should clearly define and describe the labour and material inputs and should take into account opportunity costs of land and the possible variations in input costs and output prices.

**Certification**

Both the public and private sectors should be aware of certification and the
measures to be taken to comply with environmental standards. The potential to obtain higher prices in niche markets where consumers are prepared to pay a premium price for timber obtained from sustainably managed areas may be an incentive to produce certified timber. However, the opportunities to obtain higher prices may be limited, and the additional costs involved in obtaining certification may act as disincentives, particularly for small-scale producers. Furthermore, considerable time may be needed for the widespread emergence of consumer preferences for certified timber. The costs and benefits of certification should be assessed and the results disseminated.

Other benefits

Intensively managed plantations can provide employment and income to the rural economy. However, few studies have been done on the socio-economic benefits of teak plantations.

Teak plantations could have a role in carbon sequestration, but this role must be quantified and compared with that of other plantation species. Studies on the potential of teak plantations in carbon fixation could help them to obtain carbon offset funds that may become available in the context of the Kyoto Protocol. National and international agencies should strive to promote best practices in the management of teak. Such efforts are particularly required to ensure small-scale growers’ ability to manage plantations sustainably.

POLICIES AND INSTITUTIONS

Enabling policies to promote investment

Existing policies and legislation in several countries are not conducive to private-sector involvement in planting of teak. Tenure insecurity and restrictions on felling and transport of teak, intended to protect public-sector plantations and natural forests, act as disincentives.

Current policies relating to tenure, royalties, taxes and rules and regulations covering the harvesting and transport of teak wood, and their impact on investment in teak plantations, should be reviewed at the national level. Enabling incentives should be identified and efforts should be made to facilitate appropriate policy changes. Existing systems for financing investments should be evaluated and funding mechanisms that encourage teak as a long-term investment should be designed.

Direct incentives, including loans

Current loan financing arrangements are often inadequate. In addition, mechanisms that link potential investors with growers remain underdeveloped, particularly in the case of small-scale growers whose access to institutional financing is limited. Financial and tax incentives could have an important role in promoting investment in teak as a “green investment”. Efforts in this direction could facilitate higher investment in establishing and managing teak on a long-rotation basis.

Research and extension

The linkage between public- and private-sector research and teak growers is generally very weak and there is no effective mechanism to facilitate a two-way flow of information. The role of different players is ill defined and competing interests often lead to unnecessary secrecy and failure to share information for mutual benefit.

Most current research is fragmented and supply-driven. Sparse attention is paid to the needs of teak growers. Areas that require more research efforts include the long-term sustainability of teak plantations, management of mixed plantations and agroforestry systems.

REGIONAL AND INTERNATIONAL SUPPORT MECHANISMS

Regional and interregional collaboration

Coordinated efforts are required to identify gaps in the conservation, sustainable management, breeding and enhancement of teak genetic resources and to avoid duplication of efforts. International collaboration should be strengthened in such areas as in situ and ex situ conservation, provenance identification and testing, standardization of the registration and description of clones, and formulation of common methodologies and procedures to allow comparison of results across countries. Collaborative efforts at the regional and global levels are particularly important for testing clones in a variety of sites and under diverse conditions and for developing technical guidelines for the exchange of genetic materials.

National efforts to collect growth and yield data could be complemented through a network of permanent sample plots. In addition, there is an urgent need for collaboration on products and markets and for standardization of definitions for collection and dissemination of information, especially in relation to technology, markets and prices. Regional collaboration is particularly relevant for the standardization of grading rules for teak timber and the conducting of outlook studies on demand, supply and prices.

Support mechanism for small-scale farmers

Considering the potential role of farmers in plantation management, it is important to develop appropriate institutional arrangements and support services (such as extension). Consideration should be given to the development of international support mechanisms for common problem areas such as access to
technology, availability of inputs and processing and marketing of teak wood and products.

**Public-private partnership**
Partnership arrangements such as cooperatives and consortia involving the public and private sectors should be encouraged, especially to deal with problems that cannot be handled effectively through individual efforts. The conservation of teak genetic resources and the monitoring and control of transboundary pests and diseases are potential areas for collaboration.

TEAKNET and TEAK 2000 (an international initiative promoting the establishment of quality hardwood plantations in a socially acceptable and environmentally friendly manner to satisfy future demand for high-grade timber on a sustained basis – see the Box on page 53) should facilitate such initiatives at the regional and global levels.

**Networks and associations**
Existing networking arrangements such as TEAKNET, TEAK 2000 and the International Union of Forestry Research Organizations (IUFRO) working unit on teak (Unit 5.06.02 – Quality teak timber from plantations) have considerable potential to support conservation and scientific management efforts. For example, the IUFRO working unit should promote collaboration between research institutions and industries in the study of utilization technologies.

Further benefit could be taken from TEAKNET’s role as a forum for exchanging information and facilitating collaboration on teak cultivation, management, utilization and trade. It would be desirable to extend TEAKNET activities to other regions, i.e. Latin America and Africa.

A global framework is necessary to facilitate investor-grower dialogue and to set standards for best practices. TEAK 2000 should be developed as a mechanism for facilitating global interaction among growers, investors and experts. Associations and cooperatives could provide the necessary technical support to small-scale growers as well as assisting in the marketing of teak wood.

There is also a need to develop a mechanism to provide advice to teak investors; currently most investors have limited reliable information on technical, financial, economic and environmental aspects of teak. Institutional arrangements developed to promote investment in other sectors need to be reviewed and, where appropriate, adapted to the needs of teak producers.

The feasibility of establishing a body to support global efforts to strengthen the conservation and management of teak, and, in particular, to mobilize resources and expertise for the establishment of teak plantations, needs to be examined.
IMPROVING ACCESS TO INFORMATION

Systematic efforts are required at the national, regional and global levels to assess existing areas of teak plantations and natural stands. Other areas of interest are trends in the area under teak plantations and rates of adoption of different technologies, as well as their impact on growth and yield. Regional and global databases should be developed as a collaborative effort by networks such as TEAKNET and TEAK 2000 and international organizations such as the International Tropical Timber Organization (ITTO) and FAO (including the FAO Global Forest Resources Assessment). An Internet site (or network of related sites) allowing rapid access and linkages to information should be developed and information made available in a user-friendly form.

Countries that have many years’ experience in scientific research on growing and utilizing teak should be encouraged to review their work and archival materials and to summarize information relevant to current challenges.

CONCLUSIONS

With more than a century of experience in cultivating teak, it is often assumed that all aspects of site, technology and productivity of teak plantation management are well understood. However, most knowledge is situation- and site-specific. One basic question that needs to be asked is to what extent the existing (and accessible) knowledge is adequate to deal with current and emerging problems.

This question is particularly important since teak has increasingly attracted the interest of the private sector. Advances in tree breeding and mass multiplication techniques have enabled the production of healthy and uniform planting material on a large scale. The private sector has taken advantage of technical developments and fiscal incentives and has succeeded in attracting private individuals to invest in teak.

Recently some of the “teak schemes” have collapsed or their reputations have declined because of the unjustifiably high financial returns they had promised. These negative developments motivated the organizers of the regional seminar on teak to identify strategies for improving plantation management and to develop a framework for collaborative studies and technology improvement. The seminar brought together a wide range of people and knowledge. Yet the papers presented provided only a glimpse of the current knowledge on site, technology and productivity of teak plantation management.

This highlights the importance of the seminar’s last three recommendations: the need to build partnerships between the public and the private sector, the development of networks and associations for facilitating global interactions among growers, investors and experts, and the improvement of access to existing information. If taken seriously, teak has a bright future; if not, the species may come to be seen as another fad that has gone out of fashion before it could prove itself.