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Teak: a global overview

By D. Pandey and C. Brown

Devendra Pandey is Director, Forest Survey of India.
Chris Brown is Forestry Officer (Forest Plantations),
Forest Resources Development Service, FAO.

An overview of global teak resources and issues affecting their future outlook.

Teak (*Tectona grandis*) is one of the world's premier hardwood timbers, rightly famous for its mellow colour, fine grain and durability. It occurs naturally only in India, Myanmar, the Lao People's Democratic Republic and Thailand, and it is naturalized in Java, Indonesia, where it was probably introduced some 400 to 600 years ago. In addition, it has been established throughout tropical Asia, as well as in tropical Africa (including Côte d'Ivoire, Nigeria, Sierra Leone, the United Republic of Tanzania and Togo) and Latin America and the Caribbean (Costa Rica, Colombia, Ecuador, El Salvador, Panama, Trinidad and Tobago and Venezuela). Teak has also been introduced in some islands in the Pacific region (Papua New Guinea, Fiji and the Solomon Islands) and in northern Australia at trial levels.

Although relatively unimportant in terms of the volume of world timber production, because of its strength and aesthetic qualities teak is the tropical hardwood most in demand for a specific market of "luxury" applications including furniture, shipbuilding and decorative building components. It is thus of major importance in the forestry economies of its main producing countries.

Teak logs, India - teak is prized for its long, straight bole

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Experiences with growing and marketing teak are of considerable relevance to growers of other high-value hardwood species, particularly in the tropics. Species such as mahogany (*Swietenia macrophylla*), red cedar (*Cedrela odorata*) and rosewood (*Dalbergia sissoo*) face similar challenges of competing in high-value niche markets, have longer growing cycles than many softwoods and present similar environmental concerns associated with harvesting from tropical forests. While some of the issues discussed in this article are largely unique to teak as a species, many are relevant to other valuable hardwood species.

During the past 20 years most supplies of teak wood from natural forests have dwindled and increased interest has developed in the establishment of teak forest plantations. The transition towards greater utilization of plantation-grown teak is not, however, being made without difficulty or controversy. Until recently, misgivings over the environmental impacts of teak plantations - particularly controversies regarding possible soil deterioration and erosion in pure teak plantations - rivalled those often associated with eucalypt plantations. Further controversy has been generated in several countries by the promotion of teak plantation investment schemes based on unlikely growth and yield projections, unrealistic pricing scenarios and dubious fund management strategies. Problems have mainly resulted from insufficient regulation and inadequate information or investor education. The long time horizons and broad range of price predictions associated with teak plantation investment have provided opportunities for less scrupulous entrepreneurs to exaggerate figures and deceive even moderately wary investors (see Box).

Nonetheless, with teak remaining one of the world's most valuable timbers, interest in growing and investing in the species will remain high. Legislation and vigilance in both the commercial and the environmental spheres will be necessary to ensure that the teak-growing industry develops in an orderly fashion.

ECOLOGY

Tectona grandis is a large deciduous tree with a rounded crown and, under favourable conditions, a tall clean cylindrical bole of more than 25 m. The base of the tree is often buttressed (having outgrowths at the base caused by exaggerated root swelling) and sometimes fluted (having irregular involutions and swellings in the bole). Leaves are broadly elliptical or obovate and usually 30 to 60 cm long. Over most of its range, teak occurs in moist and dry deciduous forests below 1 000 m elevation and is one of the several species constituting mixed forest stands. It grows best in localities with annual rainfall of 1 250 to 3 750 mm, minimum temperature of 13º to 17ºC and maximum temperature of 39º to 43ºC.

Natural teak forests mainly grow on hilly and undulating terrain with traps, basalt, granite, schist, gneiss, limestone and sandstone as underlying rocks. The best teak forests, both natural and plantation forests, grow in well-drained deep alluvium. Teak plantations have failed completely when they have been

established on low-lying, poorly drained land with clay soils (Seth and Yadav, 1959).

In the natural forests of Myanmar, teak grows mainly on hilly and undulating terrain and is one of several species constituting mixed stands

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Teak is a light-demanding species; it does not tolerate shade or suppression at any stage of its life and requires unimpeded overhead light for its proper development. Teak coppices and pollards vigorously and sometimes retains its coppicing potential even after attaining large size. Teak begins flowering and seeding at a young age, about 20 years from seedling and about ten years from coppice, and produces abundant seeds almost every year (Seth and Kaul, 1978). The hard thick pericarp of the seed prevents easy germination and a considerable portion of fresh seeds remains dormant in the first year. Teak seeds remain viable for many years.

Plantation areas and planting rates

Teak plantations constitute about 8 percent of the total plantation area in countries with climates suitable for teak growing. In 1995, about 94 percent of global teak plantations were in tropical Asia, with India (44 percent) and Indonesia (31 percent) accounting for the bulk of the resource. Other countries of the region with significant planted teak resources were Thailand (7 percent), Myanmar (6 percent), Bangladesh (3.2 percent) and Sri Lanka (1.7 percent). About 4.5 percent of global teak plantations were in tropical Africa (largely in moist West Africa, particularly in Côte d'Ivoire and Nigeria) and the remainder were in tropical America (mostly in Costa Rica and Trinidad and Tobago) and the Pacific Islands.

FAO's most recent regional estimates (Table 1) suggest that the increase in the global net area of teak plantations has been negligible since 1990 (FAO, 1995),

despite a reported rate of new planting of more than 100 000 ha per year. This anomalous result reflects discrepancies in historical reported national planta-tion areas as well as the fact that a large, although unquantified, part of the reported new planting is actually replanting of existing plantations following harvest. The rate of new plantation establishment in many tropical countries does, however, appear to have slowed notably since 1990. Most planting reported in 1995 was in India, Myanmar, Thailand and Indonesia in tropical Asia, and in Costa Rica and Panama in tropical America.

TABLE 1. Estimated net plantation area of teak by subregion, 1995 (1 000 ha)

Subregion	Estimated net area of teak plantation	Estimated annual planting
West Sahelian Africa	4.02	0
East Sahelian Africa	14.85	-
Moist West Africa	87.88	4
Southern Africa	2.80	0
Tropical Africa	**109.55**	**4**
South Asia	1 099.60	55
Continental Southeast Asia	302.28	26
Insular Southeast Asia	706.01	12
Tropical Asia	**2 107.89**	**93**
Tropical Oceania	**3.03**	**0**
Central America	22.29	4
Caribbean	8.06	-
Tropical South America	2.72	0
Tropical America	**33.07**	**4**
TOTAL	**2 253.54**	**101**

Source: Pandey (1998).

This plantation in Dong Nai Province, southern Viet Nam, is one of the oldest teak plantations in the country

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Plantation management

Teak plantation management regimes vary between and within countries, mainly according to site-specific conditions and prevailing markets. Typically, however, it is recommended that initial stocking rates be in the range of 1 000 to 2 000 stems per hectare to allow for early mortality rates and to provide an opportunity for selecting the better individuals during thinning operations. Partially depending on the intensity of planting, an initial thinning should be considered as soon as the branches start to make contact with those of surrounding trees; this may occur when the plantation is around four to five years old and the intensity of removals may be as high as 50 percent of the initial stocking. A production thinning may follow at about age ten to 15, and a final production thinning at around 15 to 20 years. Again depending on market requirements and other factors, an ideal final stocking is likely to be around 200 to 300 stems per hectare, or approximately some 300 m^3 of wood. Management practices may vary significantly, however, depending on whether teak is grown on short or long rotations.

One of teak's major advantages over other tropical hardwood timber species is the amount of technical information on production and management that is available for the species, as it has been researched and grown across a wide variety of locations and sites.

Productivity and volume estimates

The productivity of teak plantations has been studied across a broad range of countries through permanent sample plots. The earliest yield table for teak was constructed by von Wulfing (1932) for plantations on Java, Indonesia. Laurie and Ram (1939) constructed a yield table for teak plantations distributed over present-day India, Myanmar and Bangladesh. More recently, yield tables have been developed using data from permanent and temporary sample plots for plantations of teak established outside its natural range, including provisional yield tables for Trinidad and Tobago (Miller, 1969), Côte d'Ivoire (Maitre, 1983), Nigeria (Abayomi, 1984) and Sri Lanka (Phillips, 1995).

An important feature of all teak yield tables is the early peak of mean annual volume increment (MAI), generally between six and 20 years. Because teak is planted and managed for timber production, size plays a decisive role in determining harvesting, rather than the age of maximum volume production. The rotation age of plantation teak in its natural range has varied between 50 and 90 years, while outside its range the rotation age is between 40 and 60 years. Table 2 compares the MAI at 50 years (taken as the average age at harvest) and at the age of maximum volume production, as derived from the various yield tables.

There is a paucity of data on actual yield obtained at harvest of teak from different site classes and countries. Limited data available from Indonesia and India

suggest that the actual harvest obtained from teak plantations is much lower than the yields indicated in Table 2. In Indonesia, the average actual MAI at harvest age, with rotation varying
between 40 and 90 years, was 2.91 m^3 per hectare per year (FAO, 1986), while Table 2 estimates an average of 13.8 m^3 per hectare per year. Perum Perhutani, the State-owned company that manages the major teak plantation areas in Indonesia, has confirmed that the actual yield of teak at final felling is about 100 m^3 per hectare at about 70 years, with a similar volume obtained from thinnings. The MAI at rotation age is, consequently, about 3 m^3 per hectare per year (Perum Perhutani, unpublished data).

Similarly, in India, the actual yield obtained from thinnings and final fellings in Koni Forest in Kerala State averaged 172 m^3 per hectare with a 70-year rotation, giving an MAI of about 2.5 m^3 per hectare per year (FAO, 1985). The site class for teak in Koni Forest was considered to be between the average and the best, but poor stocking was considered the main reason for such a low yield. Similar yields were also found during plantation inventory of teak in Bangladesh. However, in teak plantation inventories in Benin and Côte d'Ivoire, the estimated MAI with a 40- to 50-year rotation age was found to range between 8 and 11 m^3 per hectare per year. The estimated yield in Costa Rica with 40-year rotation is 6.9 m^3 per hectare per year (M. Gomez, personal communication).

TABLE 2. MAI maximum and at 50 years rotation age for different site classes (m^3/ha/year)

Country	**Best**		**Average**		**Poor**	
	MAI (max)	MAI (50)	MAI (max)	MAI (50)	MAI (max)	MAI (50)
Côte d'Ivoire	17.6	9.5	12.2	7.5	6.8	4.3
India	12.3	10.0	7.9	5.8	2.7	2.0
Indonesia	21.0	17.6	14.4	13.8	9.6	9.6
Myanmar	17.3	12.0	12.5	8.7	5.9	4.3
Nigeria[a]	23.8	13.3	18.5	9.0	13.1	6.8
Trinidad and Tobago[a]	10.2	6.5	7.5	5.0	5.5	3.9

[a] Yield tables have been prepared based on an inadequate number of sample plots and are provisional.

The general conclusion is that the actual productivity of teak plantations has often been much lower than indicated in yield tables; this is probably because sample plots are likely to receive more management attention than field plantings and because of statistical inadequacies of the samples.

Pandey (1996) has developed a model to predict the potential productivity of teak plantations at the global or regional level using climatic factors. Climatic variables explain 59 percent of the variance of the potential yield of teak plantations. Relative humidity and annual rainfall were identified as the most important climatic factors influencing the growth of teak. Above certain upper limits, however (70

percent and 2 000 mm per year, respectively), increases in their values result in successively less increase in the potential yield.

ROUNDWOOD PRODUCTION AND TRADE IN TEAK

Since teak plantation establishment is relatively recent in most countries outside its natural range, current production of mature teak is largely restricted to the traditional large producers, Myanmar, India and Indonesia (Table 3). Sri Lanka, Bangladesh, Trinidad and Tobago and a few other countries produce mature roundwood from plantations. Production of immature round-wood from plantation thinnings, mainly for utilization as posts and poles, is more widespread.

Myanmar - the only Asian producer that allows relatively unconstrained export of teak logs - dominates the export trade in teak logs, while China and Thailand are the two largest importers. The other substantial exporter of teak logs has been Côte d'Ivoire, which until recently excluded teak from its log export ban. Other exporters of teak logs, including several African countries and some Latin American countries (such as Trinidad and Tobago and Ecuador), deal in relatively minor volumes.

TABLE 3. Indicative annual production and exports of teak roundwood and sawn timber (m^3)

Country	Roundwood production	Roundwood exports	Sawn timber exports
Myanmar	358 000	179 200	33 100
India[a]	250 000	0	0
Indonesia	750 000	0	35 000
Thailand	12 900	0	5 000
Other countries[b]	424 100	134 300	14 800
Total	**1 795 000**	**313 500**	**87 900**

[a]This estimate, the most recent for India, dates back to 1970.
[b] A rough approximation based on a range of diverse sources and estimation methods for each producer country.

Exports of teak sawn timber are mostly from Myanmar and Indonesia, with Thailand and Côte d'Ivoire also exporting significant volumes (Table 3). A range of other countries, including Ghana, China, the United Republic of Tanzania and Ecuador, export more modest volumes. All of India's teak production is processed within the country. India is also a significant net importer of teak, including shipments of logs and sawn timber from Africa and Latin America.

The largest manufacturers of teak products are Indonesia, Thailand, India and China. India produces sawn timber (for construction and decorative uses) and decorative plywood almost exclusively for use in its domestic market. China and Thailand have relatively large teak processing industries based on imported roundwood, while Indonesia processes its own plantation-grown teak. Much of this production is exported to Europe and North America as finished consumer items

such as furniture, or as sawn timber, particularly destined for decorative uses, boat building and outdoor applications such as decking. In general, volumes of national imports (and often exports) of teak products are poorly documented or inaccessible.

Thinnings from immature teak plantations comprise a substantial proportion of the production of the "other countries" shown in Table 3. Because of teak's durability much of this production is utilized as posts and poles, although a part also finds its way into higher-value end-uses. For example, Zamora (1998) reports that companies in Costa Rica produce furniture components and small flooring boards from six- to seven-year-old teak thinnings.

POLICIES AND LEGISLATION AFFECTING TEAK MANAGEMENT, PRODUCTION AND TRADE

Natural forests

Policies and legislation ban or severely restrict harvesting in natural forests in all the countries within teak's natural range except Myanmar. Logging in Myanmar is conducted according to the Myanmar Selection System: the Forest Department selects mature trees for harvest and Myanmar Timber Enterprises, a government corporation, is the sole agency responsible for extraction. As a result of Myanmar's long experience with harvesting under this system, teak management is generally well regarded in terms of environmental sustainability (Wint, 1998).

All industrial harvesting in the natural forests of Thailand has been banned since 1989, although logging of teak has reportedly continued illegally in some areas, notably along the Myanmar border (for example, in Salween National Park) (*Bangkok Post*, 1998). One effect of the ban appears to be an increase in harvest levels in neighbouring Myanmar (as well as in Cambodia and the Lao People's Democratic Republic). For example, where average annual log exports from Myanmar had been 400 000 m^3 in the period 1985 to 1989, they increased to 1 225 000 m^3 in the period 1990 to 1994 (FAO, 1999b).

In India, clear-felling of teak has been banned in most teak-growing provinces since 1986. In 1997, a Supreme Court order placed further restrictions on the felling of any tree in natural forest areas. Harvesting in natural forests may only be carried out in accordance with the working plans of state governments. As a result, Indian teak imports have increased dramatically. Within India, the absence of recent data on teak production makes it impossible to quantify market effects.

Teak harvesting in the Lao People's Democratic Republic has been largely prohibited since 1989. Much of the current production is the recovery of old logs from previous harvesting and from areas of shifting cultivation, which is estimated to amount to around 500 m^3 per year. In principle, the country applies a ban on log exports, although significant volumes of roundwood are still exported as a result of technical loopholes (Gyi and Tint, 1998).

Log export restrictions or taxes in a number of other teak-producing countries, particularly Indonesia but also

the Philippines, Viet Nam, peninsular Malaysia and Ghana, also have an influence on the global teak trade.

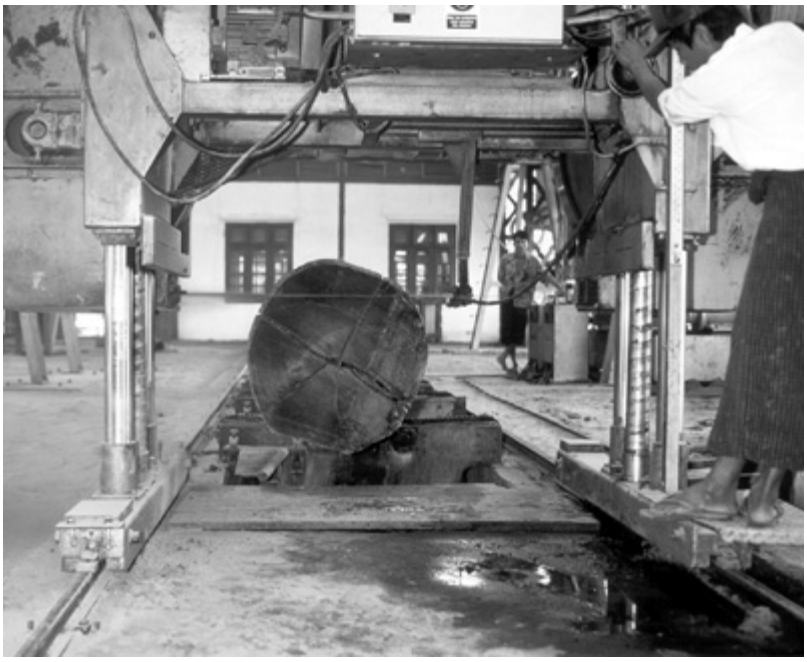
Plantation establishment

Government influences on plantation establishment generally fall in two categories: direct government planting programmes and the payment of incentives for plantation establishment.

The great majority of the world's teak plantations have been established under government planting programmes. The government has had a dominant role in plantation establishment in India, Indonesia, Myanmar and Thailand, countries that account for about 87 percent of the world's teak plantations. In the future, however, the role of the private sector in plantation establishment in these countries is likely to be significantly greater. For example, the Government of Thailand currently offers subsidies of up to US$780 per hectare for tree planting. This reflects a shift in government policy from direct to indirect involvement in tree planting.

Several countries in Central America and Africa also have utilized incentive policies to promote teak planting. Policies in Central America, particularly in Costa Rica and Panama, are currently attracting much attention. Costa Rica's incentive system includes a direct payment to plantation owners for provision of environmental services, financed by a selective consumption tax on hydrocarbon fuels. It also includes exemption from various taxes as well as access to credit and payment of a subsidy in the first five years of the plantation's life. In Panama, investments in forestry (including land costs) are fully deductible for income tax purposes. This policy has triggered speculation leading to an upward spiral in land prices. Import duties are also waived on equipment and machinery used in plantation activities.

In Africa, much planting is still carried out by government agencies or as part of externally assisted afforestation or reforestation projects. Nonetheless, private-sector interests are becoming increasingly active in plantation establishment, often assisted by government incentives. Examples in Ghana include the development of several private-sector-funded out-grower schemes and plans to establish a Plantation Forest Development Fund which would be initiated through an export levy on air-dried timber (Odoom, 1998).



Myanmar is the largest exporter of teak sawntimber; here, processing of a teak log at a sawmill of the Myanmar Timber Enterprises

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Trade policies and related measures

Trade-related measures that may influence teak growing and markets include national import tariff structures applied to teak products, non-tariff measures such as requests for certification, and boycotts by retailers or consumer groups.

The Uruguay Round of the General Agreement on Tariffs and Trade (GATT) formalized a general trend in trade liberalization for forest products, which applies also to trade in teak. In general, the most significant restrictions on trade in primary teak products are those applied by potential exporting countries, particularly log export bans and export taxes on sawn timber. Nonetheless, considerable import tariffs, commonly 10 to 15 percent, are still applied to some processed products, such as joinery and furniture, in important developed-country markets. Such tariffs can lead to discouragingly high prices for teak products. Probably the most significant recent change influencing global teak trade was the removal, in 1992, of import licensing requirements for logs in India. As a consequence India is now able to import large volumes of teak logs, particularly from Africa, to make up for the domestic shortfall caused by the country's restrictions on teak logging.

ENVIRONMENTAL ISSUES

Indiscriminate, unmanaged cutting has been the primary cause of clearance or degradation of most natural teak forests in Thailand, the Lao People's Democratic Republic and India. In Myanmar, the use of the Myanmar Selection System, or

variants of it, should continue to help avoid controversy. Nonetheless, at least one recent consumer crusade in the United States has campaigned against buying Myanmar teak.

A natural teak stand managed under the Myanmar Selection System

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The increasing proportion of teak coming from plantation forests may avoid some environmental controversies - but sometimes attracts others. Teak is a pioneer species and as such is generally susceptible to competition from other plant species. Clearing undergrowth and debris may assist teak growth in the short term, but almost inevitably at the cost of longer-term site degradation. Practices that expose the soil to the elements, such as litter raking and excessive burning, may particularly exacerbate erosion and leaching problems in teak plantations, which tend to have wide tree spacing and are prone to leaf drip. In general, most of the environmental criticisms directed at teak plantations are the result of such inappropriate management techniques rather than irrevocable plantation characteristics. In some countries the abandonment of poor management practices has assisted in retaining site fertility.

Although not specifically targeted, teak plantations have been included in general anti-plantation campaigns which are based on the premise that plantations - especially single-species plantations (forest monocultures) - tend to have lower levels of biodiversity than natural forests and may also be more susceptible to catastrophic damage, especially from pests and diseases but also from wind, storms and fires. In a number of countries, mixed plantations are being established to provide better soil cover and stability, to increase biodiversity and to reduce commercial risks.

Certification of forest products has potential to affect teak products. Companies and countries supplying markets in Europe and North America, where the interest in certified forest products is highest, may find some form of certification for teak a cost-effective option for increasing market share. That teak is generally sold into high-value niche markets adds to the attractiveness and viability of the option. To date, the area of teak forests with internationally recognized certification appears relatively small, as suggested by the fact that plantation forests in general have been certified, according to standards set by the Forest Stewardship Council, in only four of the 35 countries currently known to be growing teak: Costa Rica, Indonesia, Panama and Sri Lanka.

CONCLUSIONS

As the sustainable supply of teak from natural forests (now almost exclusively from Myanmar) diminishes and the demand continues to increase, the general trend in the future of teak growing will be towards increasing production and utilization of plantation-grown teak. This suggests a need for enhanced knowledge regarding diverse aspects of teak plantation establishment as well as silviculture, management, utilization and ecological aspects of both plantations and natural stands. In particular, further investigation is required regarding the possible differences in timber properties between short-rotation plantation-grown teak and teak grown in natural or other long-rotation stands. Such research needs to encompass the effects of seed source (origin and provenance) and site on growth rates and wood quality. New research is also needed on the effects of pruning on growth and wood quality, the effects on the site of growing teak in mixed plantations (where experiments established in the past might be re-evaluated) and the environmental impacts and sustainability of productivity of short-rotation plantations, including the differences in yield or timber properties from second or subsequent rotations.

Several countries are interested in improving financial returns from teak plantations through utilization of thinnings and small roundwood. To this end studies are being conducted on conversion techniques for small round-wood, techniques for reconstituting small sawnwood as larger material, and market opportunities for small-dimension timber or components.

The increasing importance of plantations in teak production suggests varying prospects for other valuable hardwood species in terms of future commercial timber production. Species that adapt readily to plantation management, such as mahogany, should continue to be important sources of high-quality timber. Those that are less ecologically robust or that perform poorly under intensive management regimes are likely to be marginalized as commercial wood producing species. Thus, in the long term, it is likely that a handful of tropical hardwoods, including teak and mahogany, will occupy niches at the high end of solidwood markets, while the range of competing species is likely to be significantly reduced.

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