ITTO-TEAK IN MEKONG

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Policy Brief

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TEAK Mekong Newsletter support and facilitates teak networking in the Mekong sub-region through ITTO member countries and partners, and support sharing lessons of the project results through short news release, occasional papers, project related teak-based research and development information. The bi-monthly newsletter is released online through TEAKNET webpage www.teaknet.org and co-hosted by Kasetsart University, Thailand.

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Comprehensive Policy Recommendations for Supporting Community and Smallholder Teak Plantations in the Greater Mekong Sub-region

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Teak comes up very well both within the forests ecosystems as well as on cultivated lands of the Mekong sub-region. Till a few decades back almost the entire production of teak timber in the world used to come from publicly owned forests managed by government forest departments. But the situation today is markedly different with a large part of demand for teak timber being met by private teak growers. As more and more growers are entering the field the problems they face in growing the best produce, in managing the crop to maturity, in growing interim crops for regular incomes, in harvesting and transporting timber, and fetching the best prices for their produce, are also increasing. There is pressure on them to get their plantations certified by authorized agencies because rich developed countries would not allow finished products made of uncertified wood enter their countries. But the cost of such certification is clearly beyond the reach of even the most well placed of smallholders. As the world warms up there are increasing incidences of fires, insect attacks and diseases which often originate in adjacent large natural forest areas. There are also new opportunities like the market and non-market approaches of the Paris Climate Agreement where the smallholder teak planter hopes to be linked up with the evolving opportunities that can make him more competitive in the market place.

Efforts have been made in all the countries of the Mekong region to address the problems of this section of teak growers. But much more needs to be done because private smallholder teak planters continue to face difficulties in their ventures. This policy brief presents governance and management issues involved in various countries of the region and suggests possible measures.

Defining smallholders

In the heavily populated Mekong sub-region the per capita land availability is very low ranging from 0.12 ha in Vietnam to 0.34 ha in Thailand. Landholding in the region is typically small with as many as 85% landholding in Vietnam, 38% in Laos, 34% in Myanmar, and 23% in Thailand being less than 1ha. The Lomé Statement for Smallholder Forest Landscape Restoration (FLR) in West Africa of November 2019 notes that smallholders "are most often classified according to their size, which can vary from less than one hectare up to 10 hectares and more. Legally, smallholders can be individuals, family or clan structures,

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communities, churches or associations. Within the framework of FLR, smallholders include tree planters (woodlots for timber or fuelwood), tree crop producers and farmers who incorporate trees in their farming systems, as well as those who restore and protect remaining natural forests."

What would be considered smallholding will, therefore, be context specific. Given the nature of landholdings it would perhaps be appropriate to consider landholdings upto 2 ha as smallholdings in Vietnam and upto 5 ha in other countries of the region for the purpose of raising tree plantations.

Smallholders shifting from growing food to growing trees

Till about three decades back the owners of these smallholdings were almost exclusively subsistence farmers relying exclusively on family labour but the situation has gradually changed since 1980s with rapid expansion of the southeast Asian economy giving attractive employment opportunities to the landless and those living the life of subsistence. With self-labour no longer available for cultivation of their lands many began either renting out their lands for cultivation or opting for tree based crops like rubber and teak among others.

Teak planting on community lands

This is usually confined to those hills in the region where shifting cultivation is still being practiced as in parts of Lao PDR, Myanmar and Cambodia where indigenous people live in communities. In Lao PDR the policies on the utilisation and management of natural resources emphasizes the need to reduce shifting cultivation and control deforestation. To achieve these goals the Government has sought to establish permanent habitations for 277,000 upland families practicing shifting cultivation and protect the watersheds of 80 streams and rivers by rehabilitation and protection of the forests situated in these watersheds and by the reforestation of the eroded areas. These people so settled are allocated forest lands, both degraded and well-forested, to manage and protect on a household basis thereby granting security of land tenure to the rural people and enable transmission of their inheritance to their heir. Government forestry units at all levels are expected to act as the servicing units for the local people and provide technical assistance in extension techniques for farming, forest and fruit tree planting, seed and fertilizer supply.

These policy measures, combined with expanding road network and access to credit up to 40–60% of the estimated value of plantation, have led to teak being successfully raised over considerable extent of hill lands in Luang Prabang province in northern Laos. However, one clear outcome of this household centric approach in Lao PDR is the conversion of community centric shifting cultivation covering large sized community owned hillsides to individually held small-sized teak plantations that are, in practice, no different from smallholder teak plantations elsewhere in the region.

Other countries of the region like Myanmar that still have many communities practicing shifting cultivation may also encourage similar shift away to family owned teak plantations and teak based agroforestry over such lands. However, this will have to be primarily a socio-political decision that would decide whether these countries are willing to hasten the process of conversion of community-owned land assets of indigenous hill peoples accessible to the entire communities on the basis of their needs into small-sized individual family assets that completely excludes others in the communities. This is because, this process will also result in fundamental, deepset, social changes at a great pace with consequences for the overall governance of the countries.

Delineating better sites

Site quality has a dominant role in determining the productivity, and profitability of teak plantations and, therefore, it is important that the smallholders should be guided and encouraged to opt for the best available sites. Criteria for site selection for teak plantations should be refined, harmonized and widely disseminated.

A network of permanent sample plots covering the entire range of growth conditions and management conditions should be established in the countries of the region and improved national tables giving growth and yield estimates under different parts of this range of site and treatment conditions should be prepared and made available to teak growers.

Presently site quality assessments are based almost exclusively on growth parameters, but increasingly ecological and biodiversity values are also becoming important even for smallholder plantations particularly when they hope to benefit from national and international

financing geared towards Sustainable Development Goals. The growth and yield estimates for these sites should, therefore, be prepared in such a manner that the farmer is able to understand the moderation in yield when ecological goals are also expected to be fulfilled. This will better prepare them for negotiating the prices of these societal and ecological goals with the relevant authorities.

Enhancing site quality

Site management to sustain and enhance productivity may involve changes in silvicultural prescriptions, soil conservation measures and fertilizer application. Existing protocols, where they exist, are inadequate and serve only large government and private plantations. The government forest departments of the region may develop these protocols specifically for smallholder plantations and make them easily accessible to all concerned.

High quality planting stock

Smallholders most often use the planting stock available closest to the planting site and realize their teak crop is of poorer quality when it is too late to do anything. Low returns on account of low quality and quantity of teak timber produced deters more smallholders from opting for teak. Sometimes high-quality teak planting stocks are available through large plantation companies but these are high priced and incur considerable costs in transportation or tied to conditions that smallholders are reluctant to agree to. The smallholders expect assured quality of planting stock delivered at reasonable prices at locations that are manageable for them.

The forestry departments of the region may produce certified high-quality teak planting stock offering a good range of choices that are well advertised, and make it available through local extension offices of all land related government departments like horticulture, animal husbandry and agriculture departments besides their own outlets. The planting stock should be offered at low prices but not free of cost so as to avoid wastage. Since there are primary schools in the remotest villages it would be useful to engage the services of resident teachers as short term planting material stockholders and extension workers during the planting season.

Discouraging speculative investments

During the period of 1980 - 1990, there was a surge of speculative investment in teak plantations across the tropical lands in the expectations of excessive profits with cost-benefit analysis of long rotation plantations exceeding 50 years suggesting return on investment of 15% with an MAI of 3 m^3 ha^{-1} including all wood removed from thinnings to final felling assuming low initial investments, no opportunity cost for land, marketability of wood from all thinnings, and continued increase in the prices of teak timber. The expectations of the investors were rarely met leading to large scale disappointment and collapse of the so -called teak schemes across the tropical world. Had a rigorous cost-benefit analyses been undertaken before going into the venture taking into account the true opportunity cost of the land to the smallholder in addition to the site and environmental conditions, management regimes, and accessible markets this large scale speculative investment based on misleading claims could have been easily avoided.

The governments of the countries of the region should commission rigorous cost-benefit analysis of teak plantations on all likely sites within their countries at different rotations taking into account the true labour costs and the opportunity costs of the land under plantation to be carried out by their forestry universities and institutions. This will not only give a true picture to potential investors in smallholder teak plantations but also build capacity for quality cost analysis within their own institutions.

Tenure security and felling permission

Smallholders in some countries of the region, particularly Thailand, have this fear that if they plant trees on their lands they may not be allowed to cut the trees and use the land for agriculture or for house construction at a future date. This is more likely to happen on trees planted on landholdings located on steep slopes, on other ecologically fragile areas, and on places of tourist interest with high expectations of green surroundings. Thus, while the smallholder would continue to be the owner of his land, his economic choices related to his land become severely restricted once trees are planted on it.

It needs to be appreciated that the only reason a smallholder planting teak on his land is to maximize his earnings and not for aesthetic purposes or for binding soils, and certainly not for inviting restrictions on his existing freedom on the enjoyment of his land assets. If such social objectives are to be added to his personal goals in planting teak by the government under extraordinary circumstances for public good, then, as a matter of principle, the government must be willing to compensate the smallholder for all the consequential losses incurred by him. In the interest of promoting teak planting by smallholders every country in the region should make incorporate this principle in their policies.

Restrictions on transport

Existing policies and legislation in some countries of the region place restrictions on the transport of teak harvested from private lands by farmers. But these restrictions, introduced during colonial times to protect government owned natural forests from illegal logging, act as severe disincentive for smallholders who find it difficult to obtain the required permissions to transport their timber to the sawmills and market and often become victim of corrupt practices.

Many states in India that had the same restrictions have now removed them at least for species that are not found in natural forests in the neighbouring districts which has greatly eased the situation for tree growers. The task of protection of teak in natural forests belonging to the State is a duty of the larger society and of the State, the cost of which should be borne by the State and not by individual smallholders who take to teak growing as a normal economic activity. And now DNA based technology is available that can establish and track the source of timber. This technology needs to be further refined and made easier and quicker which task can be undertaken by countries like Thailand and India that have the technological knowhow.

It is strongly recommended that the governments of the countries in the Mekong region may consider removing the restrictions on transport of teak from plantations altogether and instead rely on *in-situ* protection of their natural teak resources using appropriate technologies.

Attracting investment in smallholder teak plantations

Sourcing funds for financing long-term investments in teak plantations is a difficult task on account of the plethora of risks involved. Even when there are potential investors willing to risk their capital in such ventures like the European and American Pension Funds mandated to invest a small part of their portfolios in such green investments, there are no official mechanisms that can link them with genuine smallholder teak growers.

The forestry departments of the countries of the region should provide a platform on which genuine smallholder teak growers are brought in touch with potential green investors. Investment in teak plantations of all sizes should be officially declared as a "green investment" and attractive financial and tax incentives provided to promote teak investments. The tax incentives can also be linked to the length of rotation which would help encourage the growing of larger sized teak timber.

Loan financing of smallholder teak plantations

Institutional assistance for loan financing for raising teak plantations across the region is inadequate at best and often absent altogether. Loan financing for these long-term investments pose serious problems and currently there are not many instruments that can satisfactorily link the financial institutions providing loans with the teak growers needing loans. The forestry departments of the countries of the region should provide a platform on which genuine smallholder teak growers are brought in touch with financial institutions mandated and willing to extend loans to smallholder teak plantations.

Tax Relief

As the availability of public lands for raising teak plantations are limited everywhere due to both ecological constraints and competing demands for other uses, the trend is to encourage raising teak plantations over private lands by individuals, communities and companies through subsidies and other incentives. In India the income accrued from agriculture is exempted from income tax without any upper limit and, since tree growing is considered agricultural activity, there is no income tax on the sale of trees harvested. This is a major attraction for tree growers and is worthy of emulation. It is, therefore, recommended that the countries of the region may exempt income from tree growing from income tax.

Support under REDD+ and Article 6 of Paris Agreement

Teak forests in their natural zone provide a range of ecosystem services that are highly valuable for the welfare of larger global and national societies including mitigation and adaptation to climate change. The forest departments and other authorities in the Mekong sub-region have long been discussing about additional incomes for community and individual tree planters by way of carbon credits for mitigating climate change through carbon sequestration, and through other ecological services that the forests and tree plantations render to the society. Teak growers across the region expect their governments to enact policies and take steps that enable them to financially benefit from these new possibilities.

The very rigid eligibility conditions of the Clean Development Mechanism (CDM) under the Kyoto Protocol, the excessive technical complexities and very high transactional costs involved in implementing CDM projects placed the smallholder teak plantations outside the reach of this facility. REDD+, which stands for reducing emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks, addresses a part of the limitations of the CDM but REDD+ is essentially meant for national or sub-national level efforts where the achievements in sequestering carbon have to be measured against the national or sub-national baselines. This means that till a country, or atleast a significantly sized region within it, is prepared and ready for REDD+ the communities and smallholding teak growers would not be able to access financial benefits from the climate change mitigation services that they provide to the world.

Article 6 of the Paris Agreement on Climate Change has provisions for both market and non-market mechanisms in support of climate change mitigation and adaptation activities that need to be utilized creatively to finance smallholder teak plantations. The recently held COP26 at Glasgow in Nov 2021 had made much progress in finalizing rules for operationalizing these mechanisms in practice and some more guidelines are expected to be finalized by the subsidiary bodies of the UNFCCC in June 2022 following which ITTO may commission a small pilot activity to test ways to use these Article 6 mechanisms in support of the smallholder teak plantations.

The forestry departments of the countries of the region should explore the possibility of creating provisions for pooling the smallholder plantations into larger sized carbon sequestration schemes like REDD+ and other schemes that enable payment for ecological services rendered by these tree plantations. The country negotiators in UNFCCC, UNCCD and CBD Conferences of Parties should be asked to bring these concerns into international negotiations appropriately for ensuring that the international systems arrived at enable the participation of smallholders through cooperative efforts and the participation costs are kept low.

Developing markets for short rotation timber

Smallholders cannot wait for half a century for harvesting teak and getting returns on their investment. For them even twenty years is a long rotation. Investors in large teak plantations also expect interim incomes from small-diameter wood obtained from thinnings. Profitability is affected by the higher proportion of sapwood in short rotation teak, the variability in physical and mechanical properties, and the appearance of the wood in comparison with larger diameter wood from natural forests and long rotation plantations. Difficulties in processing and marketing smaller dimensions also deters small growers.

In Java, Indonesia, short rotations and small dimensions do not seem to pose problem since demand for small sized teak has evolved over time and with improvements in utilization technologies thereby facilitating the use of smaller dimensions. And in recent years teak has been harvested in as short a time as 8 years in places where small sized teak fetches good value in the market. The current and potential uses of small dimension plantation wood from teak plantations should now be assessed recognizing these dynamic changes.

For hastening this process of market acceptance of small sized teak from short rotation plantations the governments of the countries in the region should promote the use of small timber utilization technologies that are already in use in Indonesia and elsewhere and also encourage further innovations. Chemical treatment of higher sapwood timber can impart it greater longevity and protection against insect attack. Specific time bound projects should be awarded to forestry universities to conduct research on these subjects.

Also, in order to facilitate comparisons between teakwood of different sizes and localities, common standards, definitions and nomenclature need to be adopted across the teak producing countries. This is a very big task not entirely within the capacity of producing countries in the Mekong region but it can begin here adopting features and language that would make the standards evolved acceptable all over the world over time. Existing national grading systems for teak timber need to be reviewed and changed as necessary, taking into account the quality and dimensions obtainable from shorter rotation plantations in end harvest as well as thinnings.

International collaboration is required to be promoted on products and markets and for standardization of definitions in relation to technology, markets and sizes. Such collaboration is particularly relevant for the standardization of grading rules for teak timber and for carrying out research on demand, supply and prices of varying grades of teak timber.

On pruning, thinning, and girdling before harvest in smallholder plantations

Pruning is typically required to maximise the production of high-quality teak timber. It is best to prune young teak up to 50% of the tree total height at the first thinning. The first pruning should be carried out when the stand reaches a total height of 4–5 m, second pruning when the stand reaches 9–10 m in height and the last pruning should be done when the stand reaches 12 m of total height.

Thinning is an important tool for ensuring high quality and higher volume product at the end of rotation. It results in improved growth and yield of stands as well as individual tree sizes and tends to have positive effects on stem form. But many smallgrowers use it to remove best quality trees years before the rotation period which results in reduction in both quality and quantity of the timber produced at the end of rotation.

The extension wings of the forestry departments of the region may hold regular workshops in localities that have large number of teak plantations to demonstrate best thinning and pruning practices. The final decision on thinning, however, must be left to the teak growers because sometimes their immediate need of money may be more important to them than the returns that may come at the end of rotation.

Girdling trees well before harvest at rotation age has been an age old practice in Myanmar that makes the tree loose sap and get seasoned ready for immediate use as timber. But this also results in loosing growth that would have occurred during the period between gridling and harvest which is important in short rotation plantations. If girdling is done in summers just three months before harvest at 20 year rotation the loss in growth may be insignificant but the possibility of immediate use may enhance its commercial value considerably. The forestry departments of the region may examine this closely in different localities and seasons and advise the smallholder teak growers in the neighbourhood accordingly.

On harvesting teak in natural forests

Harvesting of teak in natural forests is banned in Thailand since 1989 where most of these natural forests having been declared Protected Areas. Teak harvesting in natural forests of Lao PDR is also prohibited since 1989 with most of the naturally grown teak entering markets is said to be coming from shifting cultivation areas of north-western uplands of the country and from left over harvested teak logs. There is also a ban on export of logs from the country but there are problems in effective implementation of the ban.

In Myanmar, teak harvesting in natural forests is carried out under the Myanmar Selection System with both allowable annual harvest and marking of harvestable trees being done by the Forest Department while the actual act of tree felling, conversion and transport to depots, and sale, is conducted by the sole authorized government agency, the Myanmar Timber Enterprises.

Teak from natural forests processed in a sawmill at Yangon, Myanmar

While this has promoted teak plantation activities within Thailand and also in neighbouring Cambodia, Laos and Vietnam it has also led to increased demand for teak harvesting in natural teak forests of Myanmar where restrictions on natural teak harvesting are limited by the principles of sustainable forest management. There are also reports of increased illegal logging of natural teak in Myanmar close to its borders with Thailand.

While the total ban on teak felling in natural forests everywhere is often lauded as a very effective approach to conservation of this great gift of nature, in the opinion of this author the benefits are overvalued and the outcomes are not without great risks. The increased risks are in having precious natural forests with large number of old and often diseased and decaying trees that become host to very huge infestations of *Hyblaea puera*, a leaf defoliator commonly found on teak, and other local pests. During drought season these old decaying trees greatly increase the risk of fire as they provide plentiful fuel to the fires.

Also in National Parks and other Protected Areas with natural teak forests too high a density of teak trees discourage grass growth on the forest floor reducing the carrying capacity for wild ungulates which in turn affects the populations of predators. So a regular but moderate selection felling of old, dead and dying teak trees is advisable in these forests.

Containing environmental damage and human injuries during harvesting

Harvesting and extraction operations are the activities that generally cause the most significant impact on the environment. The impact of harvesting and extraction can be reduced through proper planning and control of harvesting operations using sound principles, systems, and techniques that have stood the test of time. Successful harvesting should be (a) technically feasible considering physical limitations, engineering knowledge, and environmental relationship of the forest, (b) economically viable considering the costs and benefit of short and long range consequences, (c) environmentally sound considering impacts on the natural and social environment, and (d) institutionally feasible considering laws and regulations, landowner objectives and social values.

The most common cause of accidents during harvesting is the workers' lacks of knowledge or skills and repeated training is the most effective tools for reducing risks. Wearing suitable Personal Protective Equipments (PPE) provides protection when all other control measures cannot adequately eliminate or minimize risks to a worker's health and safety.The extension wings of the forestry departments of the region should conduct annual workshops in each important teak plantation district to communicate with the teak growers on the best harvesting practices.

Certification

There is increasing demand from EU and North American countries for certification of timber exported to their countries in raw or processed form. And since the economies of the Mekong region rely to a considerable degree on their exports there is pressure on the teak producers to get their timber certified. Higher prices in niche markets where consumers are prepared to pay a premium price for teak obtained from sustainably managed areas are an incentive to produce certified timber. But the costs of complying with the environmental standards required in certification process are quite high and often prohibitive for smallholders. And also the niche markets willing to pay higher prices for certified timber may not be accessible to all small growers. It would be quite a while before a clear consumer preference for certified timber emerges in a widespread market for timber and its products.

The choice to go for certification or not is best left to the teak grower but for this choice to have any real meaning, there should first be easily accessible, and internationally acceptable, certifiers within their physical and economical reach. In this, the ITTO can perhaps play a role by helping set up an autonomous independent certification body for the Mekong region on the lines of international certifiers like the Forest Stewardship Council (FSC).

Reducing losses incurred by smallholders by theft, fires, diseases and insect attacks

Illegal felling of valuable teak trees by miscreants is a major concern of smallholders particularly those whose lands are located in remote sites away from the watchful eyes of villagers. They are not able to engage the services of plantation watchers as big plantations do because of the high cost of individual plantation watchers. The smallholders expect a reasonable degree of protection of their standing assets as an important duty of the State.

The forestry departments of the countries of the region may identify hotspots of theft and organize villagers to combat the problem in these areas. Selected villagers can also be given, after due training and under competent supervision, the legal powers of a forest official to book offences against the culprits. But this has to be done with great care and under close supervision, otherwise it has the potential of creating conflicts within village communities.

The smallholders are able to deal with the fires, diseases and insect attacks on their teak trees located within agricultural fields close to the habitations but they sometimes find their plantations located adjacent to the government forests exposed to fires that originate within forests and cannot be controlled by outside efforts. Less often, they face similar problems with tree diseases and insect attacks too, that originate within adjacent large sized government forests. A clear expectation of the smallholders is that reducing these losses is the responsibility of the State.

Fire damage to smallholder teak plantations in a hill slope: *A view from Luang Prabang, Lao PDR*

While these expectations of the smallholders cannot be fully satisfied by the governments of the region because it would encourage tendencies to turn private responsibilities into public duties there can be little doubt that government policies should actively prevent the escape of fires, and insects and pests, from government forests to the adjacent teak plantations by smallholders.

Prevention of escape of fires, and of plant diseases and insect attacks, from government forests to adjacent plantations of smallholders must be accepted as a public duty and a protocol for taking adequate and timely steps must be developed in consultation with smallholders and followed strictly.

For this purpose well managed firelines, cleared of all vegetation and debris, along the boundaries between fire-prone government forests and smallholder teak plantations would reduce the chances of fires, diseases and insects spreading outwards. It must, however, be made clear that the protocol does not lessen the duty of the smallholder towards the protection of his own land and crops growing there.

Research needs

There are several areas related to teak and its planting by smallholders for economic purposes that need to be explored thoroughly to enable governments to lay down appropriate policies to promote this economic activity over larger extents of lands suitable for growing teak in the countries of the region. In the paragraphs below the more important of these have been described briefly.

An important area for research is the impact of complete ban on teak felling in natural forests and Protected Areas, including thinnings that were planned earlier, on the quality of habitat for wild animals by way of availability of ground flora as feedstock for herbivores, effect on water sources, frequency and intensity of forest fires, and on the socio-economic conditions of the indigenous people residing inside and in close vicinity of these forests. The forest departments and universities in the region should be encouraged by the respective national governments and the ITTO to undertake several independent research projects on different sites so that a truer picture may emerge of the realities on the ground which can then be utilized to review the ban on teak felling in natural forests.

There are unsubstantiated claims of teak plantations having a deleterious effect on the productivity of agricultural lands downstream and even on the site quality of forests below. This needs deeper investigations by forestry universities and research institutions in collaboration with agricultural universities and quick dissemination of the outcomes that may emerge.

Another potential area for management research in teak is the impact of long, medium and short rotations in teak natural forests and plantations on soil, ground vegetation, water regime and on teak productivity which have not yet been systematically assessed and are subject to much speculation. This research task is also best undertaken by forestry universities and research institutions in the region and ITTO is well placed to facilitate this process.

Research is recommended on biological control of pests and diseases that are common in teak plantations in the region in order to facilitate large scale application of these measures by smallholders and to overcome resistance. Raising mixed plantations instead of pure teak plantations may also help control the spread of infestations but this needs to be established by data based research. Integrated pest management models that are effective as well as economical need to be designed.

Smallholder investors in teak plantations expect assured periodical interim incomes from their lands from agricultural crops in the first three to four years and later from small-diameter wood obtained from thinnings. This requires research on incomes from suitable agricultural cover crops under different site qualities and from wood obtained under different thinning regimes.

On generating rural employment

Intensively managed plantations requiring continuous care have the potential to provide considerable employment and income to the rural economy and thereby provide a crucial public good which needs to be acknowledged in policies and appropriately compensated through tax relief or subsidies. Very few studies have, however, been carried out on the socio-economic benefits of teak plantations. The country governments of the Mekong region should, with the help of bilateral or multilateral international financing agencies, commission forestry universities and institutions in their countries to undertake such studies. The outcome of these studies can help decide the quantum of compensation or relief to the smallholder teak planters for the services rendered to the Society.

On international collaboration

There is need to strengthen international collaboration in *ex -situ* conservation for provenance identification and testing, 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. The conservation of teak genetic resources and the monitoring and control of trans boundary pests and diseases are other important areas for collaboration.

Obtaining prices for teak logs and sawn timber is difficult because no common international log grading rules have been established, most exporting countries' definition of log dimensions as well as measuring units are different. Teak prices are very closely related to wood quality which is determined by dimension, bole shape in terms of roundness and straightness, heartwood-sapwood ratio, regularity of annual rings, number of knots, colour, texture and the soundness of the butt log. Teak from natural forests sells at comparatively high prices as teak harvested from plantations is typically smaller in size and rarely reaches the dimensions and quality that fetches the best prices.

Picture shows teak boards and products from smallholders meant for domestic markets in Laos.

The ITTO is best placed to facilitate this kind of collaboration by bringing two or three forestry universities of the region work on a collaborative project of this nature with institutions in Japan, South Korea, Australia, India and other countries that have the requisite technological know-how. The fact that the countries named above have existing bilateral agreements of cooperation and assistance in the field of environment and forests with most countries in the Mekong region will help in joint financing of such a project.

Acknowledgements

I am indebted to Dr. Hwan Ok Ma, Prof. Yongyut Trisurat, and many learned scholars, forest practioners and scientists who presented their ideas during the scores of physical and online workshops organized across the countries of the Mekong region under this project. I am particularly thankful to Dr. Thomas Enters for several ideas encapsulated in his article titled *"Site, technology and productivity of teak plantations in Southeast Asia"* published in *Unasylva* 51(201):55-61. I also owe thanks to Dr. Nopparat Kaakkurivaara for the insights she provided in her many presentations on teak harvesting in the Mekong region.

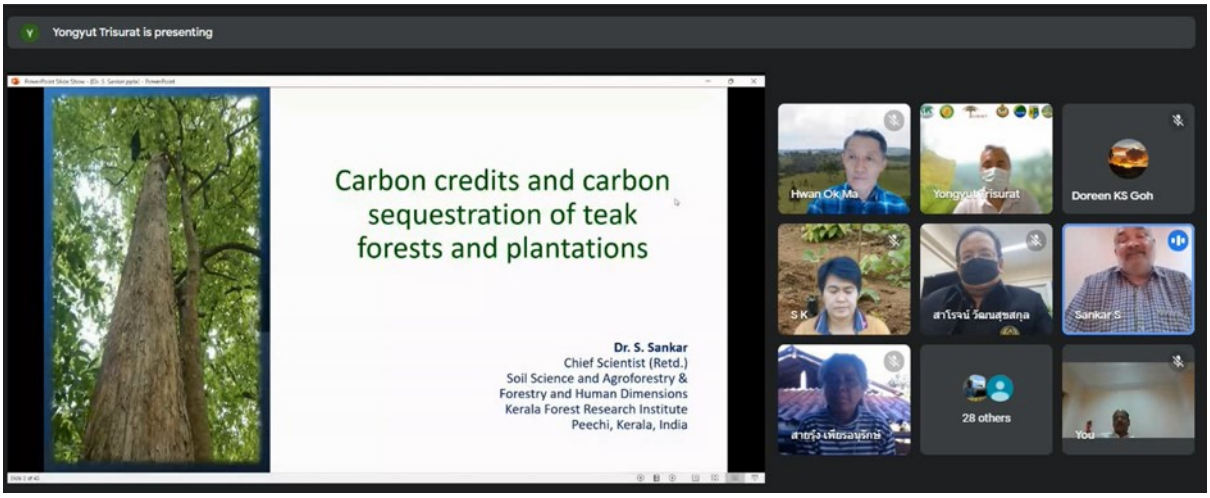
ITTO-BMEL Teak Project

10th Monthly Webinar

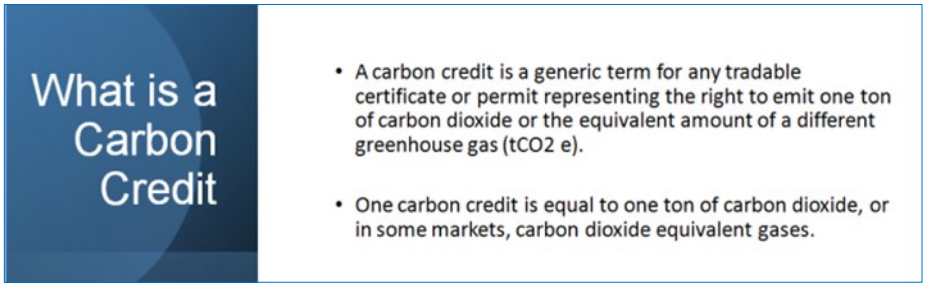
Tuesday, 7th December 2021

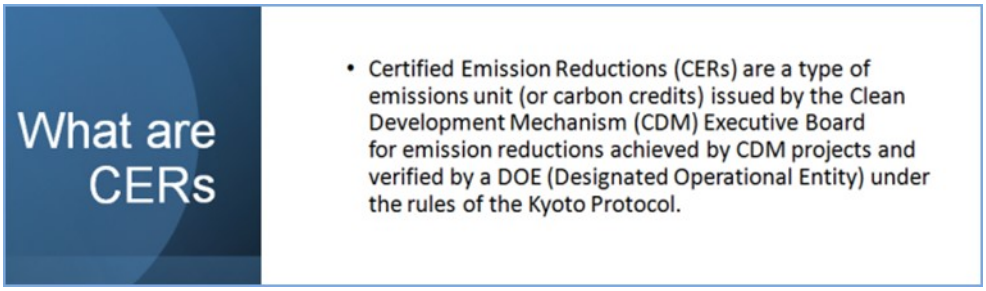
The 10th Webinar Series of ITTO-BMEL Project was conducted on 7th December on the topic "*Carbon Credits and Carbon Sequestration of Teak Forests and Plantations*". The talk was delivered by Dr. S. Sankar, Chief Scientist (Rtd), Kerala Forest Research Institute, Peechi, India.

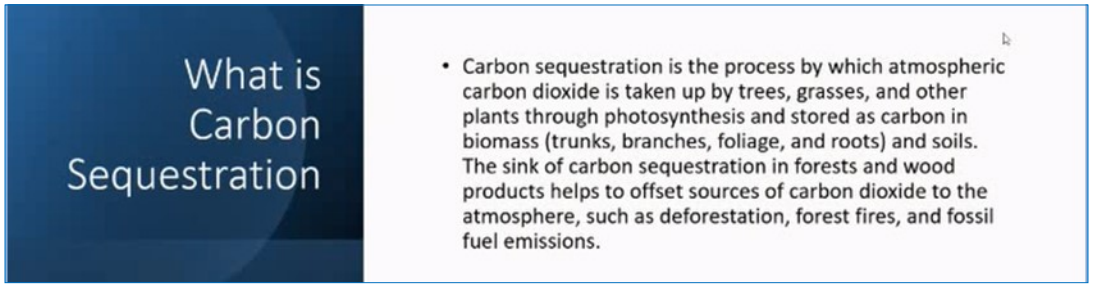
Moderator of the Webinar was Prof. Yongyut Trisurat, Project Team Leader of ITTO Teak Mekong, Kasetsart University, Bangkok and Dr. MA Hwan-ok, ITTO, Japan delivered the opening remarks.



Dr. Sankar started off his talk by giving an overview of his experience as a soil scientist studying the soil properties of teak plantations in 1st, 2nd and 3rd rotations in India, the Taungya system of intercropping with tapioca and other cash crops for first 4 years, soil erosions in teak plantations, clean development mechanism, carbon credits and carbon sequestration potential, and his experience with CIFOR, Indonesia on criteria indictors of sustainable plantation management in India especially on teak and eucalyptus. He described in detail, the Clean Development Mechanism, Carbon Credits and Certified Emission Reduction as defined in the Kyoto Protocol citing examples. The Kyoto protocol permits the developed countries to reach their targets through several mechanisms.





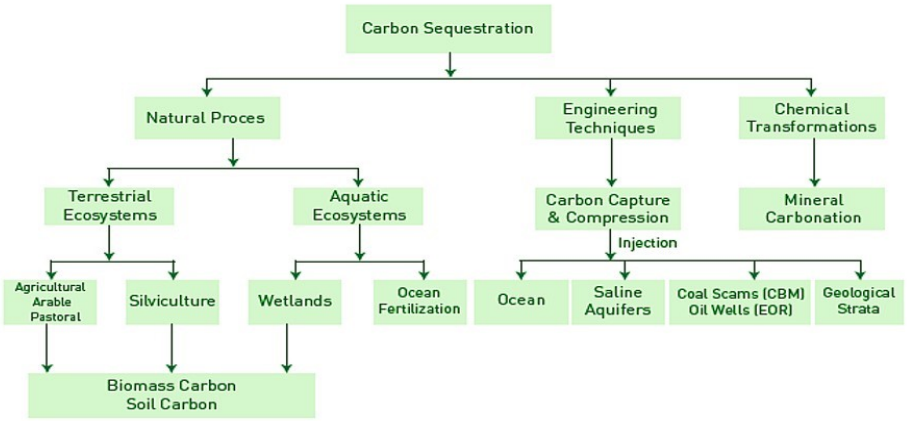


The benefits of carbon sequestration and its sink in forest trees/biomass and wood products helps to offset CO_2 emission to atmosphere. CO_2 accounts for 64% increase of heat in atmosphere.

The contribution by forest in carbon sequestration is commendable. India with 69.2 million hectare forest cover (FSI, 2013) including a wide range of forest types from wet to dry forest in temperate to tropical climate has high capacity in absorbing and retaining carbon.

Carbon is also stored in harvested wood, wood products and dead organic matter. 195 million tons of carbon was reported to be stored in harvested wood products in the household sector and 62 million tons locked in commercial sector. 24 million tons of carbon is being locked annually in harvested wood products (FSI, 2013). But still carbon is always stored more efficiently in forest stands than in wood products.

"Carbon sequestration is the long term storage of atmospheric carbon dioxide in different sinks such as biomass, soil, ocean, rocks, etc., in such a manner that it is not re-emitted into the atmosphere in the near future" (Lal, 2004)



Carbon Sequestration in Teak

An area of 2.4 million ha of teak in the world would have the potential to sequester 240 million tons of carbon. It is reported in 2015 that an average carbon accumulation of 532 kg C m^{-2} yr^{-1} in teak across the mono and multi-specific stands.

Carbon storage by teak increases with age of the plantation from 51.32 t ha^{-1} in 19 year old plantations to 101.40 t ha^{-1} in 33 year old teak plantations. An average above ground carbon storage of 2.9 Mg ha^{-1} in the first year to 40.7 Mg ha^{-1} in the 10^{th} year of teak plantation in Western Panama.

Carbon sequestration potential has been found to increase with high input management. It has been reported that there has been an improvement in carbon sequestration from 0.816 Mg ha^{-1} without any management to 1.76 Mg ha^{-1} with high input management in 5 year old teak plantations. Young plantations can sequester relatively larger quantities of carbon while a mature plantation can act as a reservoir.

Carbon sequestration in vegetative compartment of teak

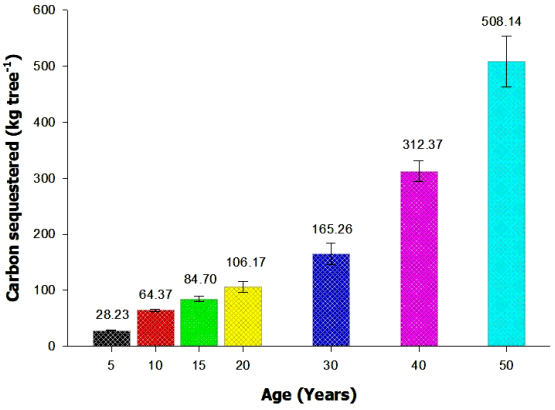
The carbon content in the various compartment of teak at different ages of plantations up to harvestable age of 50 years was estimated and is shown in the below table and graph.

Carbon content in various compartments of teak

Age (Years)	Carbon content (%)			
	Bole wood	Branch	Bark	Root
5	$45.19^{a} \pm 0.23$	$40.87^{a} \pm 0.29$	$37.65^{a} \pm 0.27$	$41.38^{a} \pm 0.52$
10	$45.43^{a} \pm 0.22$	$42.17^{b} \pm 0.17$	$39.96^{b} \pm 0.37$	$41.85^{a} \pm 0.30$
15	$45.99^{a} \pm 0.24$	$42.29^{b} \pm 0.24$	$40.69^{bc} \pm 0.38$	$42.70^{ab} \pm 0.28$
20	$46.03^{a} \pm 0.22$	$43.72^{c} \pm 0.22$	$40.93^{bc} \pm 0.33$	$42.81^{ab} \pm 0.30$
30	$47.73^{b} \pm 0.39$	$44.33^{c} \pm 0.33$	$41.25^{bc} \pm 0.50$	$43.53^{b} \pm 0.45$
40	$48.14^{b} \pm 0.35$	$44.38^{c} \pm 0.33$	$41.46^{bc} \pm 0.36$	$43.71^{b} \pm 0.45$
50	$48.85^{b} \pm 0.47$	$44.45^{c} \pm 0.35$	$41.78^{c} \pm 0.48$	$44.24^{b} \pm 0.50$

Values in the table are Mean ± SE, n=12, significant at 0.05 level, (Values with same superscripts do not differ significantly and are homogenous within a column)

Total carbon sequestered in teak with age



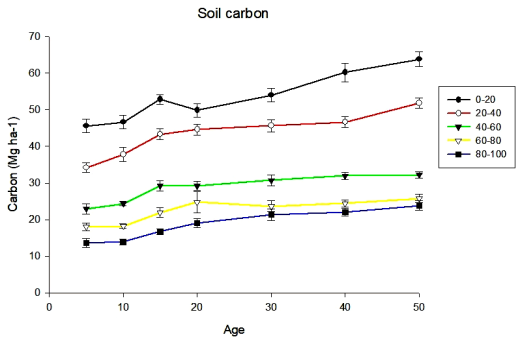
In short, the carbon sequestration potential of teak plantations can be summarised as below:

* Carbon sequestration in aboveground parts ranged from 25 kg/tree at 5 year to 428 kg/tree at 50th year. The respective contribution from belowground was 3.29 kg and 80kg/tree
* Total carbon sequestration at final felling was found to be 508 kg/tree. Significant increase in carbon sequestration was noted after 20th year
* Contribution of bole wood towards total carbon sequestration considering all ages together was 63%, that by branch was 14%, by bark 7% and by root 16%
* The initial years were not significantly different in carbon content irrespective of components but older trees were significantly different from younger trees in this respect.

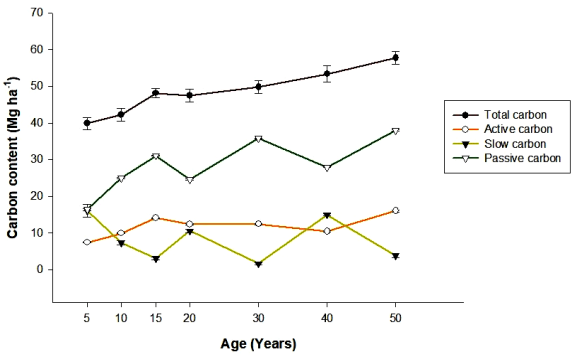
Soil Carbon in Teak

The soil carbon in teak plantations of different age groups were estimated right from 5 year to 50 years of harvestable age as shown in the graph below.

Pattern of soil carbon with growth of teak



Pattern of variation in soil carbon fractions with age



Soil carbon - summary

* Carbon content in the soil was found to be around 2% in the surface soil and it was found to decrease significantly down the soil profile with the bottom most depth recording about 0.5% of carbon.
* Carbon sequestered on a hectare basis was 166 ton on an average when all plantations were considered together.
* Among the different fractions of soil carbon, the passive carbon which remains sequestered for very long periods was found to be double that of active carbon
* The intermediate fraction, slow carbon, was always less than the active carbon pool.

Dr. Sankar then elaborated the carbon sequestered per hectare in different plant parts at various thinning regimes (grant total of 2500 trees per ha, spacing 2 x 2 meter).

Carbon sequestered at various thinning regimes of teak

Age	Trees removed	Carbon sequestered per hectare (tons ha-1)				
		Bole wood	Branch	Bark	Root	Total
5	1250	22.78	4.48	3.92	4.11	35.29
10	448	17.95	4.58	2.52	3.79	28.84
15	264	12.83	3.80	1.72	4.01	22.36
20	190	12.00	2.94	1.47	3.75	20.17
30	103	10.91	1.82	1.04	3.24	17.02
40	85	17.51	3.27	1.52	4.26	26.55
50	160	53.26	10.98	4.25	12.81	81.30

Carbon sequestration in different teak compartments showed strong relationship with DBH. The best regression Model $\sqrt{Y} = a + b\ D$ was found to be the best for predicting carbon sequestered in most of the compartments of teak.

Dr. Sankar concluded his talk by citing a latest report of an assessment of overall carbon storage in a teak plantation studied in Kanchanapuri province, Thailand indicating average carbon stocks of 55.9 MgC ha− 1, and the remaining carbon in harvested wood products (HWPs) at final felling was 41.7 MgC ha− 1 of the first management cycle. When three management cycles are considered, the average carbon stocks in the standing plantations were 60.5 MgC ha− 1, 42% of which are stored in the HWPs. If global Teak forests are managed, emission reductions could be equivalent up to 31% of the European Union's Emission Reduction Target by 2030.

URL:
https://doi.org/10.1016%2Fj.cesys.2021.100023

Conclusion

⇒ Height, DBH and biomass increased in teak with age. Remarkable increase occurred after 30 years.

⇒ At the final felling age of 50 years in long rotations, a teak tree was found to attain 23 m height, 46 cm DBH and 1080 kg biomass.

⇒ Carbon content in teak varied from 45-49 % in bole wood, 41-44% in branch and root and 38-42% in bark compartments during its growth from 5th to 50th year.

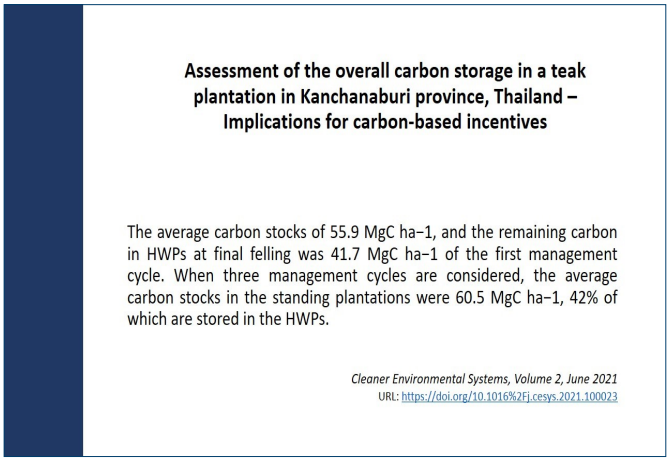
⇒ Significant difference in carbon content was observed with age in the latter stages only.

⇒ Carbon sequestration by a teak tree at final felling of 50th year was found to be 508 kg carbon per tree of which the above ground contributed 428 kg and the below ground 80 kg of carbon.

⇒ Carbon sequestered in the soil up to 100 cm depth of a teak plantation was 166 tons per hectare.

⇒ Among the different fractions of soil carbon, the passive carbon contributed double the active carbon; the intermediate fraction, slow carbon, was always less than the active carbon.

⇒ Model $\sqrt{Y} = a + b\ D$ was found to be the best model for predicting carbon content in all the compartments of teak except in the case of branch and bark where model $Y = a + b\ \ D$ and $Y = a + b\ D + c\ D^2$ were found to be the best.



The recorded presentation is available with ITTO- Teak Mekong project leader Prof. Yongyut Trisurat. *Email:* fforyyt@ku.ac.th

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