Technology Fact Sheet for Mitigation
3.

Technology Name:	**Optimal Forest Plantation**[i]

Introduction

Optimal forest plantation is not yet welled defined and assessed or lack of information. So instead of assessment and describes such optimal forest plantation system, this factsheet provided information on forest plantation in general as a mean for further exploration of optimal forest plantation.

Forest plantation is a form forest development which, in principle, is defined or designed to preserve and to develop forest resources in order to supply timber and other forest products in a sustainable manner including preserve water resources, soil, aquatic life, wildlife and ecosystem. The development of the plantation is usually follow the following principle:

1) Survey the situation of reproductive conditions of trees species in the forest area that would be planting;
2) Demarcate the area by marking boundary with signs;
3) Select tree species suitable for the forest area;
4) Formulate forest plantation plans or projects. The project is required for registration so that source of the products can be checked, leading to ease of commercialization and transportation of the products;
5) Implement the project, management and maintenance;

Technology characteristics

Forest plantation in Laos uses both agro-forestry or integrated (Taungya) and mono plantations systems. However, describe below is mainly on the mono plantation.

The mono forest plantation system means forest plantation for purely species (one species only at an area). This model has been implemented mainly by companies and international plantation investors with a larger scale area. This system has conducted frequently with Eucalyptus and eagle wood species, which are based in the central and Southern parts of Laos.

The spacing of forest plantations depends upon rotation, for a long or short rotation and mono or integrated planting. Generally, for a long term harvesting and integrated planting purposes, tree is grown more widely spaced. Furthermore, the spacing for forest plantation is highly depended on tree species; some trees species prefer wider space for its growing for example rubber tree. On the other hand, some tree species prefer narrower space for its higher growth and as well as reducing for its branches, for instance teak and eucalyptus tree species. However establishing tree plantations in Laos, 2x2, 2.5x2.5, 2x3, 3x3 and 3 x 7 m are usually practiced in Laos (Phimmavong 2004). The planting hole is dug in advance at 30-45 square width and depth, which is sufficient to allow addition of manure or organic matter for the trees, especially for teak and eucalyptus tree species. It would bigger hole for rubber tree. The best time to plant trees in Laos is at the beginning of wet season at the end of May (Laos). The optimum tree seedling for planting is around 30-50 cm

in height which takes at least three months growing at a nursery. The number of seeding depends on the spacing of plantation. For example, teak planting at different spacing: 2 x 2 m (2500 trees/hectare), 2.5 x 2.5 m (1600 trees/hectare) and 3 x 3 m (1111 trees/hectare). Spacing does not appear to be related to tree properties, productivity and is dependent upon the number of seedlings and the land area available. There is no scientific documentation for the best spacing of plantation teak (MAF 2001)(Ministry of Agriculture and Forestry and Department of Forestry 2001).

Forest plantation thinning and pruning are technical terms which are very important factors for a faster growth rate of tree as well as wood quality. The purpose of thinning and pruning is to reduce the number of trees planted in an area, increase dimensional growth rate (diameter and height) and straightness and improve wood quality. In theory, wider space planting allows greater light for trees and allows trees to grow much faster. However, tree stems are not straight and not as high as trees from narrower plantings. Thinning and pruning also aims to eliminate defective or infected trees from an area and is commonly practiced as a form of plantation management. There are different global practices in terms of plantation tree age. The practices depend upon the factors of tree growth rate, rotation harvest plan and market use for the thinning trees. Generally, the first thinning should be conducted when trees are four-five years old or when their canopy becomes dense. It is recommended to apply a low thinning method and selection cutting system by cutting deformed trees and leaving vigorous well formed trees. Further thinning is carried out when the tree crowns in the stand start to touch each other (Chadiphith 2006).

In Laos, over 80% of forest growers do not thin and prune their own tree plantation (Ministry of Agriculture and Forestry and Department of Forestry 2001).The main reasons for this may be that the farmers have small areas of trees and therefore need to keep all the trees, there is no market for their thinned trees and/or there is a lack of scientific data available to the farmers describing the advantages of thinning and pruning. In contrast, some Lao farmers have conducted teak thinning at different tree ages (4-15 years, 1-3 times). There is no market for small trees from thinning at four-seven years. Therefore, it is preferred to thin plantation teak after 14-15 years. Cut trees can be used and sold for other purposes (fuel wood and materials for new house building), however late thinning will affect tree growth as well as quality (Ministry of Agriculture and Forestry and Department of Forestry 2001).

Two thinning systems exist, mechanical thinning (cutting in system) and selection thinning. The selected cut is the defective tree, the trees too close to others and sometimes the smallest or biggest trees. In system thinning sees whole lines of trees cut to increase spacing for the remaining trees. Theoretically, plantation trees can be thinned up to two-three times (depending upon the rotation purposes). The percentage of thinning trees varies between 25% and 60% (Midgley et al. 2007).

Recent research in Laos by Kham An (2010) investigated the average productivity per tree in plantation teak aged 15 years and grown with three different thinning models (selection, mechanical and non-thinning systems). Results are presented in Figure 1.

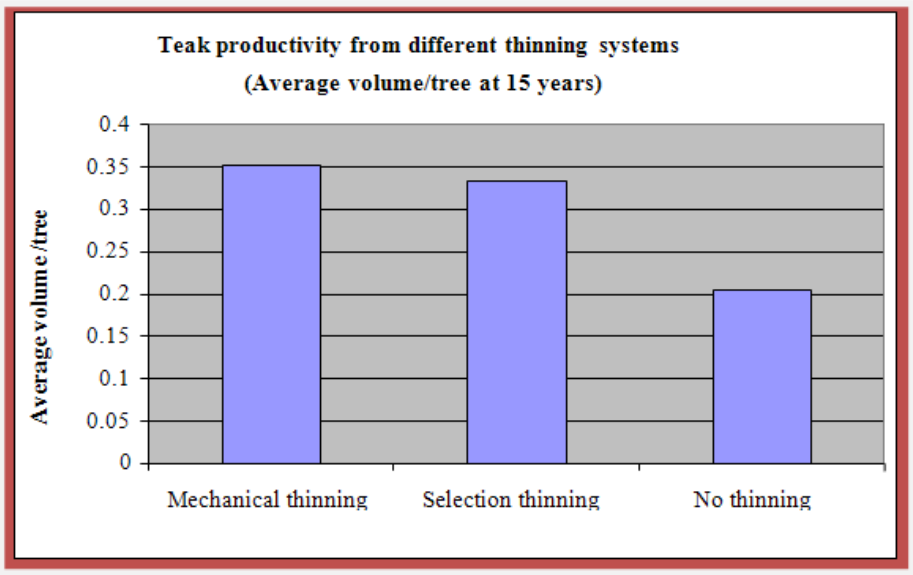

Figure 1: Teak plantation productivity with different thinning systems (Kham An 2010)

Plantation spacing is the most important factor for controlling the number, size and distribution of branches and knots in plantation trees. Wide spacing is favorable for the appearance of more knots and branches (Ngueho 2005).

Potential application in the country

Plantation is anticipated to be a fast growing of forest sub-sector due to policy supports, wood demand and also potential area for the plantation.

Plantation forests have become a priority development since the government realized that the total forest area had decreased dramatically from 70% to 41.5%(MAF 2005). Tree planting has therefore been strongly supported by the government (in 1980 the government set up a national tree planting day on June 1 and each year several tree seedlings are provided to provincial and district offices, farmers and private sectors to grow trees nationwide). Furthermore, the Lao government has several incentives supporting plantation forest such as exempting land taxes and fees, supporting loading credit and gaining rights of land use over 35 years for plantation forest investment (MAF 2001). Recently the Lao government has a target to rehabilitate forests or increase forest plantation up to 500,000 ha by 2020 (MAF 2005), increased from 223 000 ha of plantation (FAO 2006). The demand for wood for both domestic use and export is increasing (MAF, 2005) is one the driver for future development of plantation. In addition, availability of land such as large degraded forest, forest land and bare forest area also indicates a potential for the plantation.

However, the development of the plantation is required for a careful planning and approval or optimal plantation is required as previous land concession and expansion of the plantation was criticised by various stakeholders (Phimmavong. S, Ozarska. B, Midgley. S and KEENAN. R 2009 and Voladet. S 2009). Furthermore, Laos needs a vision to guide the sustainable forest plantation; and also improvement of legal, administrative procedures, management standards, human resources, community participation, research and information, marketing and financial support (Midgley, 2006).

Status of technology in the country

Forest plantation in Laos has started for over 90 years. Rubber tree (*Hevenbrasiliensis*) and teak (*Tectonagrandis*), which have been grown in Laos in the early 1900s, were introduced by French colonialists. Eucalyptus species were brought to Laos in the late 1960s (Phimmavong 2012). The forest plantation during 1900s and 1990s were conducted on a small scale, mainly for experimental purposes. However, presently there has been increasing investment in plantation by many sectors: private, national and multi-national companies.

There have been three main tree planting booms in Laos since 1993. The first occurred in mid 1993 and consisted mainly of teak planting by small farmers in the northern part of Laos. The second took place in 2000, consisting predominantly of Eucalyptus (globules and cladocalyx) planting (led by an Asian Development Bank loan project), and took place mainly in the southern and central parts of the country. At present, tree planting includes many species (rubber "Heveabrasiliensi", eaglewood "Aquilaria" and teak) which are used in a variety of sectors including international, national and private sectors as well as local farmer investment (Table 1). The total estimate of plantation forest in Laos is over 146,600 ha, mainly grown in the middle part of the country (MAF 2006). However, the figure of Laos natural forest and plantation areas were updated by FAO (2010) that total forest area in Laos is 16. 14 million ha, comprising of natural forest 14.43 million ha and 223,000 ha of plantation.

Table 1: Industrial plantation species of Laos (Midgley*et al.* 2007)

No	Tree species	Area (ha)	Main site growth
1	Teak (*Tectonagrandis*)	15,000	Mainly in Luangprabang Province (98% belongs to farmers and small private sectors)
2	Rubber (*Heveabrasiliensis*)	12,000	Every part of the country (farmers, private sectors and Chinese investors)
3	Eagle wood (*Aquilaria*)	-	Mainly grown in the middle part (Vientiane, Bolikhamxay Provinces) involving farmers and private sectors.
4	*Eucalyptus globules* (blue gum)and *Eucalyptus cladocalyx* (sugar gum)	100,000 (expected to 2012)	Central and southern parts, involving mostly foreign investors.

Benefits to Economic development

Plantation forest development has high potential, contributes to the national economy and is an important source of labour in Laos, especially in rural areas (Phimmavong *et al.* 2009). The cost of plantation establishment consists of labour for planting, seedlings, fertilization, weeding and many others. These are the predominant source of income for rural workers in Laos. SomvangPimmavong (2004) reports that the gross revenue for timber sale of Eucalyptus tree plantation of a rotation of 7 years plantation bringing a net benefit of 6,531,202 Kip per hectare for the company, which is equivalently US$628 (Table 4). Midgley et al (2007) notes that in Luangprabang Province, it is about 15% of annual local household income was derived from the timber sale of teak plantation. And the research also concludes that in the villages, teak wood production was the second most important agricultural source of income, which ahead of livestock (Figure 4).

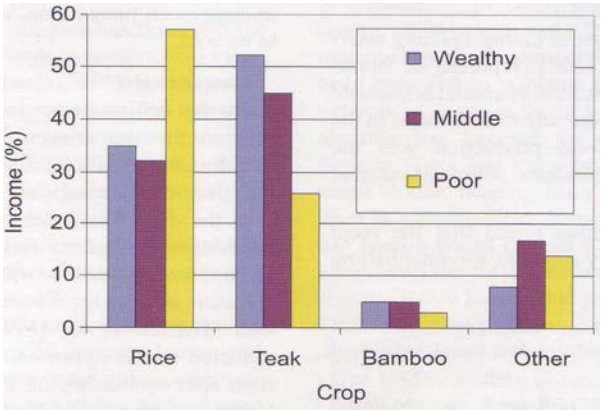

Table 5: Cost structure of Eucalyptus plantation in Laos

Catalogues	Costs (Kip/ha)	Revenues (Kip/ha)
Net benefits (timber sale at 7 years)		6,531,202 ($628)
Clearing of ground (degraded forest)	2,236,000	
Wage to farmers: planting, fertilization, fencing and fire brake	1,424,320	
Wage for farmers: Weeding	300,000	
Annual costs (Kip/year)	173,056	
Other extra costs	1,554,535	
Capital (interest =7%/year)	10,321	
Land tax (net revenue*15%)	440,231	
Income tax (net revenue*20%)	586,975	
Sum	6,725,438 ($646.67)	

Source from (Phimmavong 2004)

Benefits to Social development

The cost of forest plantations depend on several factors such as topography, soil type and remoteness of the area, as well as labour costs, plantation technology and the intensity of management and rotation of management. Furthermore, cost of forest plantation also depends on the spacing for growing per hectare. Midgley*et al*. (2007)reported that the cost of a teak plantation in Laos was estimated between US$1000-1500 per one ha of three year old plantation. However, a research conducted by SomvangPhimmavong (2004) confirmed that the cost of Eucalyptus plantation in the Southern part of Laos is about US$ 671.50 per one ha for the first year planting. This cost not includes for the land cost (Table 5).

Table 5: Cost structure of Eucalyptus plantation in Laos

No	Practices	Year 0	Year1	Year2	Year3	Year4	Year5	Year6	Year7
1	Land	266.50							
2	Fire break	50.00							
3	Road	15.00							
4	Seedling	100.00							
5	Planting	80.00							
6	Fertilizer	110.00							
7	Weeding		100	100	50	50	0	0	0
7	Fencing	30							
8	Other costs	20	20	20	20	20	20	20	20
Sum Total cost:		**671.50**	**120**	**120**	**70**	**70**	**20**	**20**	**20**

Resource: Modified from Somvang Phimmavong (2004)

In contrast, the cost of tree plantations in regional countries, the cost teak plantation in Costa Rica with 3 x 3 m spacing without genetically improved seedlings is $US1052 and with genetically improved seedlings is $US1150, calculated as the average per year for the first five years (Ball *et al.* 1999). The cost of a teak plantation in Indonesia, based upon seed planting spaced 3 x 1 m and 3 x 2 m, with about 25% lose replacement in the first and second years, is $US1400 per ha (Ball *et al.* 1999). In northern Australia, the investment cost of a teak plantation is US$1 6000/ha (1000 trees) with rotation at 20 years and a growth rate of around 14 m^3/ha/year (ITC professional tree farming 2006). In Vietnam, the estimated cost of tree plantation is about US$539.38 per ha, however, this cost not includes the cost of fertilizer transportation and seedling (Phimmavong 2004)

Benefits to Environment development

The forest plantation not just benefits for local people social-economics for poverty reduction in the rural area, but it also improve for environmental issues development in terms of climate change, water resource and stocking for quantities of carbon in the atmosphere. According to the report of MAF (2011) states that forest plantation at degraded forest areas as an integral part of rural livelihood improvement. About 40% of the 3.1

million ha of Production Forest Areas is badly degraded, but has sufficient stock, which with protection and management, will re-grow and sequester substantial quantities of carbon. Other areas of Production Forests and parts of Watershed Protection and Conservation Forest Areas are too degraded to regenerate naturally and require substantial investment for enrichment planting or re-stocking (Ministry of Agriculture and Forestry (MAF) and Department of Forestry 2011). Both forest plantation and natural forests are bringing to bear on the core objective of 'reduced greenhouse gas (GHG) emissions from deforestation and forest degradation, which can be brought about by sustainable management of forests and conservation and enhancement of forest carbon stocks'. Attainment of the core objective has become a global concern in view of the effect of increased GHG concentration in the atmosphere on global warming and climate change. Nevertheless, global efforts to reduce GHG emissions must continue, since vulnerable populations are already facing severe consequences from changing climate and impacts may multiply and impact social, environmental and economic systems that sustain global populations if global temperatures were to exceed 2oC and approach 5oC above pre-industrial levels.

Climate change mitigation potential

The forest plantation plays important roles for climate change mitigation or carbon sequestration. The increase of forest plantation could increase the carbon sequestration. Based in the 2nd greenhouse inventory for the year 2000 for SNC, plantation is one of two sources of carbon sink and if the 500,000ha of forest plantation is realized as targeted (MAF, 2005), the carbon uptake by forest plantation would be about 3,625kt or 13,292 Gg of CO2 by 2020 (MONRE, 2012). However, carbon offset depends on the area, forest plantation planning and management schemes or techniques and also existing land use where the plantation is located. This means good planning and effective plantation development would increase the carbon uptake or otherwise.

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Mitigation – Laos. You can access the complete report from the TNA project website http://tech-action.org/**