Invisible Forests – Trees in Rice Landscapes in Lao PDR

Technical Report · November 2015

DOI: 10.13140/RG.2.2.36600.03846

1 author:

Sean Foley
EcoAsia Limited
11 PUBLICATIONS **141** CITATIONS

SEE PROFILE

Invisible Forests

Trees in Rice Landscapes in Lao PDR

Vientiane, Lao PDR
November 2015

Table of Contents

List of Tables

List of Figures

List of Annexes

Acknowledgements

I am grateful to Dr Stephen Rudgard, FAO Representative in Lao PDR, for providing the opportunity to undertake this fascinating work on trees in rice landscapes. Mr Somvang Phanthavong, Director Regulatory Division, Ministry of Agriculture and Forestry, Lao PDR provided welcome assistance on a number of occasions.

For more than assistance in fieldwork my thanks to Mr Phouvong Keomany, of PAFO Champassak and FAO National Project Coordinator. Phouvong and I worked together preparing, conducting and analysing preliminary field surveys on trees in ricefields with FFS participants in Champassak and Savannakhet.

Thanks also to Ms Chanthavong Vornthalom, National Farmer Field School Coordinator. In the FAO office many thanks to Ms Manola Soukhavath for assistance in navigating the FAO administration!

In the FAO Bangkok office, Dr Kenichi Shono, Forestry Resources Officer, and Johannes Willem Ketelaar provided essential technical support and advice. Support also came from Simone Borelli and Michela Conigliaro of FAO Rome. These colleagues also kindly reviewed the inital drafts of these reports.

Many thanks.

Personal Note

In 1990 I joined the team starting to popularise IPM in Indonesia using Farmer Field Schools (FFS). Then I had the privilege and good fortune to be working with a talented team of energetic young Indonesians and innovative foreign campaigners. The team was led by Dr Russ Dilts, who remained a close friend but, sadly, died prematurely several years ago - Russ taught me many things. I was able to learn more about how IPM had evolved and spread to 14 countries in Asia when I was a member of the FAO IPM regional evaluation team in 2000. In 2006, working with ICRAF, we adapted the FFS approach to teach farmers about establishing and managing agroforestry nurseries in Aceh - after the tsunami and the war there had finally ended.

For some forty years, on and off, I have been studying rice farmers and the ecology of rice farming across SE Asia. In all this time, sadly, I never paid serious attention to the trees growing in an around the rice fields - *mea maxima culpa*! I've certainly noticed them but never thought deeply about their many benefical products or functions in ricefield ecosystems, until recently.

Undertaking this work for FAO Laos has provided me with an opportunity not only learn a great deal about the ecology and benefits of trees growing in rice landscapes in Laos and NE Thailand, but also to renew my links with active FFS. For this fortunate opportunity I could not be more grateful.

Invisible Forests[1]

Trees in Rice Landscapes in Lao PDR

1. Background

The current studies are part the second phase of FAO's three nation Regional Rice Initiative (RRI) and FAO's new global strategy of 'Save and Grow' (S&G). In collaboration with relevant government agencies in each country (Indonesia, the Philippines and Lao PDR) RRI is undertaking field studies and conducting Farmer Field Schools (FFS) on rice Integrated Pest Management (IPM) and initiating studies and training on fish and aquatic food sources (rice-fish) as part of the same regional programme.

Earlier studies (FAO 2013) by FAO focused on aquatic biodiversity in rice landscapes in Xieng Khouang in northeastern Laos, followed in 2014 by pilot studies in the same locations on 'trees in rice landscapes' (FAO 2014).[2] Early in the current study a brief field visit was made in August 2015 to the same locations. This clearly showed that in the north, in contrast to central and southern Laos, farmers do not allow trees to grow within paddy fields or within the valley bottom rice landscapes because, as they explained, shading reduces rice yields. However, as elsewhere in Laos, many trees and shrubs can be found growing in gullies, along streams, on hillocks and in dense mixed woodlands on hillsides adjacent to rice fields.

Prior to undertaking further field work a rapid survey of typical rice landscapes was made of all 18 provinces using satellite imagery provided by Google Earth (GE). Recent imagery (2012-14), when cloud or haze free and especially during the dry season (November-May), has high enough resolution in most locations to be able to clearly distinguish individual trees growing in paddy fields. This rapid survey clearly showed that north of Vientiane (about 17° N) farmers do not allow trees to grow within paddy fields, and the pattern broadly conforms to that seen in Xieng Khouang (see below). In central and southern areas in Laos trees within paddy fields - on floors and levees - are a common occurrence, as they are in NE

[1] The phrase 'Invisible Forests' seems particlarly apposite for the functions and appearance of the trees, woodlands and ricefield mosaic in central and southern Laos and also NE Thailand (Isaan). It was coined by Susanna Hecht and Sassan Saatchi: Hecht, S.B., Saatchi, S.S., "Globalization and Forest Resurgence: Changes in Forest Cover in El Salvador ." BioScience 57(8):663-672. 2007, doi: http://dx.doi.org/10.1641/B570806.

[2] "Aquatic biodiversity in rice-based ecosystems - Studies and reports from Indonesia, Lao PDR and the Philippines ." FAO, Rome, 2014, and "Assessing and Promoting Trees Outside Forests in Asian Rice Production Landscapes." FAO, Rome, 2014.

Thailand (Isaan). This pattern appears to be independent of altitude (range 150 m -1,100 m) or landform (river plains to broad midland and upland valleys).

Given the close linkage in Laos between FFS being conducted in four provinces - Xieng Khouang (northeast), Xayaboury (northwest), Savannakhet (central), Champassak (south) - and the occurrence of trees in paddy fields this difference immediately raises the issue of whether it is appropriate to include a module (special topic) on 'trees in paddy fields' (as it is sometimes called) in the FFS curriculum for northern Laos? This and related issues are discussed below.

2. Agroecological Settings

Agroecological environments in Laos have been divided into six zones - see map below. The characteristics of these zones goes a long way towards explaining the marked differences observed in the occurrence of trees in rice landscapes.

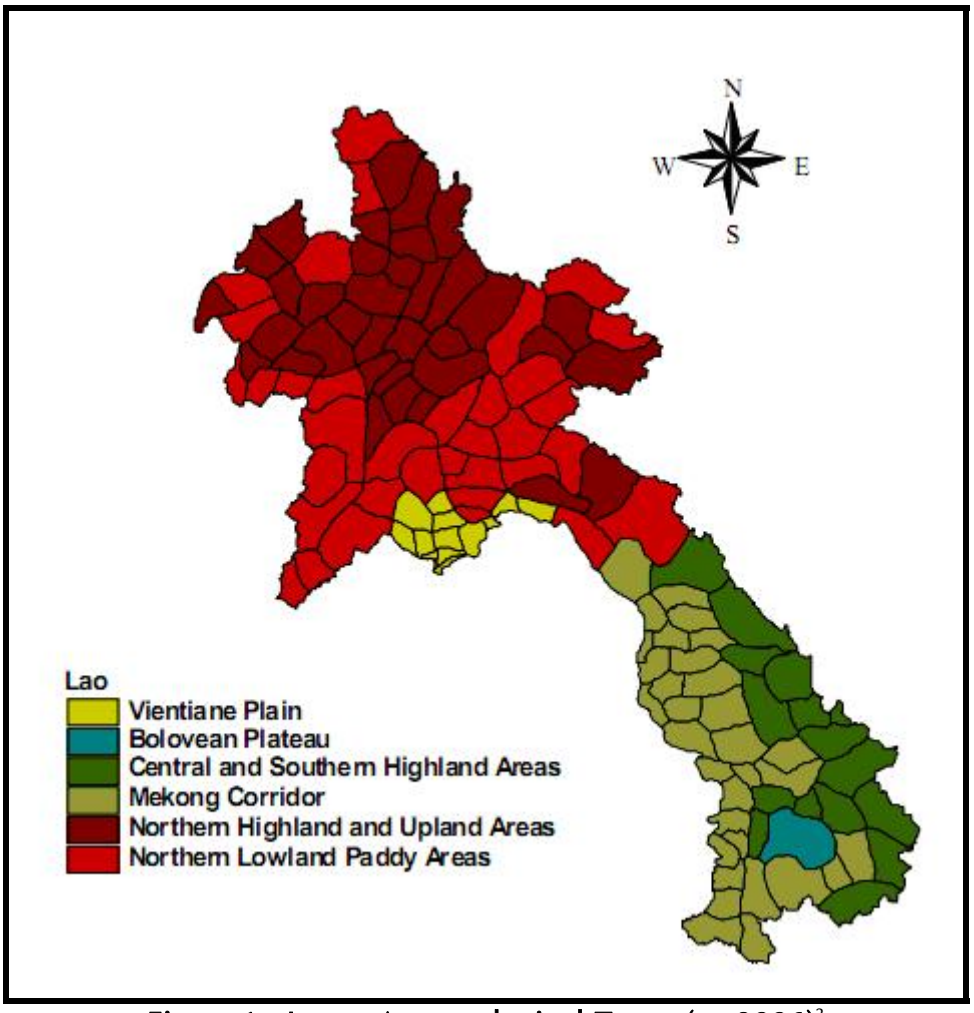


Figure 1 - Laos - Agroecological Zones (ca 2006)[3]

As noted above, only south of Vientiane - south of the Vientiane Plain zone in yellow on the map - are trees in rice landscapes a common feature of the agricultural environment. The Mekong Corridor zone along the Mekong River -

[3] "Lao PDR: Rural and Agriculture Sector Issues Paper", Rural Development and Natural Resources Sector Unit, East Asia and Pacific Region World Bank, May 2006

marked in light green - corresponds closely with observations - direct and satellite imagery - of where rice-tree systems are to be found. In the other northern zones - marked in light and dark red - trees are largely absent from *within* rice landscapes, although woodlands almost always are adjacent to and surround rice growing plains and valleys, watercourses and gullies and, of course, villages.

The differences between northern and southern Laos in the distribution of trees in rice landscapes is illustrated in Figure 2 and Figure 3.[4] In Champassak there are many clumps and single trees in the paddy fields, in Xieng Khouang and other northern areas virtually none, except along water courses and the surrounding woodlands.

Figure 2 - Muang Phongtong, Champassak (south)

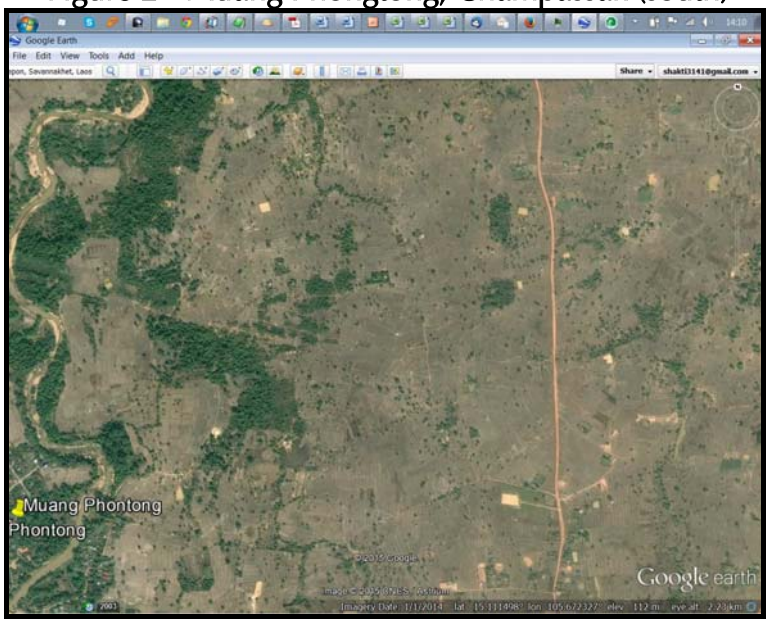


Figure 3 - Ban Thoum (FFS), Xieng Khouang (northeast)

[4] Satellite images are almost all captured late in the year in the dry season, making it easy to identify the trees (even single trees) against the earthen background.

3. Structure of the Report

This report is composed of four parts, the main body of the report - an extended literature review, and four separate annexes. The first annex contains the draft modules for the FFS Special Topics on trees, rice landscapes and food security. The second annex reports on the field work undertaken in Champassak and Savannakhet provinces in September-October 2015. This includes an extended discussion of the relevance of the results to broad range of issues related to trees and biodiversity. The last annex is a supporting bibliography and abstracts of a wide range of literature related to trees in rice landscapes, with a focus on the Mekong Region. This will be accompanied by a full text digital collection of this literature plus other related literature that is not included in the bibliography.

4. Rice Landscapes in Laos

Rice landscapes in Lao PDR span the length and breadth of the country, from the lowland rice paddies at about 100 m asl along the eastern side of the Mekong River at the border with Cambodia. Paddy fields in eastern central Laos stretch to the foothills of the Annamite Range bordering Vietnam. They cover some 1,200 km along the Mekong to the border with Myanmar in the northwest in Bokeo at about 500 m asl, and to the high paddy fields in the narrow valleys of Huaphan and Phongsaly and broader highland plains of Xieng Khouang at about 1,000 m asl. In addition, there are substantial areas of paddy on the western side of the Mekong in Champassak in the south and Xayaboury in the central west of Laos. All but a small fraction of these paddy field grow rain-fed wet-rice.

In addition, dry rice is grown as part of swidden farming on the hills of Laos, along the Annamite Range and all across the steep hills of central and northern Laos.

In the south - Attapeau, Sekong, Champassak - and central provinces - Saravan, Savannakhet, Khammouane - trees grow scattered *within* and along the edges of the paddy fields, as they do on the western side of the Mekong in Thailand in a region traditionally called *Isaan*. This is an agroecological feature unique to this region, one that is slowly disappearing.

Much of the research into the 'trees in paddy fields', as it is often called in Thailand, has been conducted by or in conjunction with Khon Kaen University. This includes the majority of the work on 'trees in paddy fields' in central and southern Laos, with much of the work done by Japanese researchers. Except for one recent article (Watanabe etal 2014) based on doctoral research, there has been little further work undertaken in about the last decade.

In contrast, in paddy fields north of Vientiane it is unusual to find trees growing with the paddy field, or on levees or even within the paddy field landscape. The exceptions are trees growing in gullies, along streams and on hillocks (often large clumps of bamboo) within the broader paddy field landscape and, of course, dense woodlands of mixed species along the valley hillsides at the edge of the paddy landscape. In some places, there may be well defined stand of planted and managed of commercial species, e.g. teak, rubber - within the paddy landscape.

The clear differences between northern and southern Laos in the distribution of economically and ecologically important trees and woodlands presented a conundrum, in terms of defining how best to orientate and structure training modules to be used in FFS. It is evident from the literature and recent field work that the trees within the rice fields, on paddy floors and dykes, are important in central and southern Laos. However throughout Laos trees growing along ricefield watercourses and in adjacent woodlands are important throughout Laos as part of the 'rice landscape'. This issue and an option for resolving the conundrum are discussed later.

Throughout Laos villages are usually the centre of broad swathes of agroforestry, with the most valuable fruiting trees planted in the home garden.

The case studies are arranged as follows: first a brief overview of the history of 'trees in paddy fields' in NE Thailand, because of it similarity and proximity, is provided, followed by sections on this topic for central and southern Laos. This is followed a discussion of various aspects of biodiversity in paddy fields in Laos, as part of the broader compass of the TOR for Trees Outside Forests.

5. Trees in Paddy Fields - A Brief History

To see what may be feasible in terms of promoting farmer's stewardship of trees in paddy fields. It is necessary to understand the recent agroecological history of the Isaan region in NE Thailand and central and southern Laos. Until borders between Laos and Thailand were formally established at the beginning of the 20th Century, Isaan was culturally, socially and agriculturally unified. The region was sparsely populated and almost wholly covered with dry dipterocarp, dry evergreen and mixed deciduous forests; it was home to a wide range of species, including megafauna such as tigers and elephants. After WWII in NE Thailand the process of clearing forests, establishing rice agriculture and settlements took several decades to complete and proceeded by identifiable stages. The area of forests in NE Thailand decreased from about 71,000 km^2 in 1961 to 22,000 km^2 by 1991 largely as a result of 'land pioneering' (*ha na di)* (Prachaiyo, 2000:61); his wide-ranging studies covered many aspects of the changing agricultural landscape and economy in NE Thailand.[5] Remnants of the original forests, are sometimes referred to as the 'Invisible Forest', and may all too soon disappear.

Possibly the first broad scale and systematic study was conducted by Grandstaff et al (1986) in NE Thailand.[6] This identified four stages in the process of conversion from forest to paddy fields, the changing status of remnant trees, and agricultural, economic, and social values farmers placed on trees and their products. The four stages are as follows (paraphrasing Grandstaff et al):

Stage 1 Forested or partially forested areas are converted to paddy; swiddening may be involved; a few trees, usually older or dead, are removed each year, mostly from paddy floors; the process spans a decade or longer;

Stage 2 Once the paddy is "finished" tree density slowly declines as flooding or natural mortality kills some trees and others are cut for timber; seedlings on dykes are not protected; nearby forest is still available for fodder;

Stage 3 Little forest remains, density may increase due to trees being planted, on dikes or other higher places: fruit, nut, food or medicine trees plus bamboo, valuable natural trees are protected.

Stage 4 Tree density is similar to stage three, but most trees are planted, almost all on dikes and mounds, for human food, fodder, fuelwood, poles; almost no trees remain on paddy floors; no nearby forest remains; private property rights are well developed, with few communal rights.

---

5 Prachaiyo, B. " Farmers and Forests: A Changing Phase in Northeast Thailand ." Southeast Asian Studies, Vo1.38, No.3, December 2000

6 Grandstaff, S. W, Grandstaff, T.B. Rathakette, P. Thomas, D. E. and Thomas J. K. " Trees in Paddy Fields in Northeast Thailand." Chapter 13, from Gerard D. Marten "Traditional Agriculture in SE Asia: A Human Ecological Perspective." (1986) Westview Press, Boulder Colorado.

Grandstaff also identified the main uses of trees in Isaan: shade, for humans and livestock, human foods and medicines, fuelwood, habitats for wildlife (especially birds), insect predators and prey, sources of large and small timber, litterfall and nutrient cycling, stabilising paddy dikes, livestock fodder, and storage for rice straw.

The same pattern of slow deforestation and paddy field expansion almost certainly took place on the Lao side of the Mekong river, albeit starting later, given agroecological, social and cultural affinities spanning the Mekong. As the later discussion of what is continuing to occur in NE Thailand shows, Laos can also anticipate continuing decline in the current number of trees growing on the floor of paddy fields, due to a combination of mechanisation (trees get in the way of machinery), commercialisation (land being monocropped with annual crops or trees), and declining biodiversity due to use of agrochemicals (replacing organic fertilizers) and pesticides (killing 'non-target' species).

6. Rice and Trees - Central and Southern Laos

Research on 'trees in paddy fields' in central and southern Laos commenced in the first decade of new millennium; recently in NE Thailand only a limited amount of work has been conducted, mostly by staff from or working with Khon Kaen University, following Grandstaff et al's and others earlier work.

A range of articles on 'trees in paddy fields' for central and southern Laos have been identified, no articles for this topic for north of Vientiane could be found. This is not surprising, given trees are mostly absent or excluded from paddy fields in northern Laos.

For central Laos seven papers on trees in paddy fields were reviewed, these were based on field research by a group of collaborating Japanese authors; one paper is in Japanese. For southern Laos two papers were reviewed, based on field research conducted by some of the same authors working in collaboration with Lao researchers.

6.1. Central Laos

Work by Kosaka (2006 a,b,c) and his colleagues documented a process of forest-to-paddy conversion in Savannakhet in Central Laos, providing significant amounts of detail on the types, number and distribution of tree and plant species affected by the transition.[7] This was followed detailed work on the effects of agricultural practices on species composition by the same team and other teams of Japanese and Lao researchers.[8] Research reported in 2011, on rice landscapes adjacent to Vientiane, but published only in Japanese, provides a very detailed

[7] Kosaka Y., Takeda S., Prixar S., Sithirajvongsa S., Xaydala K. "Species Composition, Distribution and Management of Trees in Rice Paddy Fields in Central Lao, PDR." Agroforestry Systems 67(1):1-17 2006c, DOI: 10.1007/s10457-005-1109-1

[8] Kosaka,Y., Shinya,T., Sithirajvongsa,S., Xaydala, K. "Plant Diversity in Paddy Fields in Relation to Agricultural Practices in Savannakhet Province, Laos." Economic Botany, 60(1), 2006b, pp. 49–6.

spatial analysis of distribution of tree species and their uses in a location north of Savannakhet.[9]

Kosaka et al studied two villages, in one village (Bak) they identified 104 forest species used by villagers, seven species were planted and 25 species had economic value (sold in local market or to traders); useful plants were mainly used as food (47 spp.), timber (39 spp.), or fuel (52 spp.). In Nakhou village, forested land (not sacred or crematorial forests) hosted a total of 48 useful plants mainly used as food (20 spp.) and fuel (25 spp.). In Bak village 18 useful species were recorded in paddy fields, 14 were herbaceous and four were woody; the majority (17 spp.) were edible. Paddy fields in Nakhou had the largest number of useful plants: 116 useful species. Of these, 30 were herbaceous and 86 woody species, of these 40 species had been planted and 40 species had economic value; mainly used as food (62 spp.), timber (24 spp.) and fuel (26 spp.). In a second study (Kosaka 2006c) included a third nearby village (Dongmakngeo).

Almost all plants in paddy fields had indirect, secondary utility in all villages. Cattle and buffaloes grazed the paddy fields after harvesting; trees in paddy fields provided shade for both humans and livestock. Villagers in Nakhou village said shade from trees protected rice plants from strong sunshine (Kosaka et al 2006a).

They concluded factors contributing to high species diversity were: i) presence of species unique to different paddy types; ii) the presence of remnant species from original vegetation; and iii) the impact of agricultural practices. Multiple plant species coexisted in paddy fields under various agricultural practices, with some species were essential sources of food or used to support subsistence livelihoods of local residents.

Almost identical teams examined differences in land and plant use between neighbouring upland and lowland villages. In the upland village the forest was the most important source of food and other materials, while in the lowland village the wide variety of plants in the paddy fields were more important. They concluded that "relationship between humans and plants at this study site was flexible and influenced mainly by topography and land-use and partly by socio-economic conditions and invasion of naturalized species." [10] Other researchers in the same region examined the effects of shading on rice yields, concluding the effects were not significant.[11]

As noted by other researchers (e.g. Watanabe et al 2014) tree location and density in paddy fields is changing over time; intertemporal data on this is scarce

---

9 Matsusita, Y., Hoshikawa, Miyagawa, S. Kosaka, Y. " Geographical Distribution of Tree-rice system in Paddy Fields at Vientiane Plains - Case of Study in Dong Khuai Village of Laos." (in Japanese) Environmental Science annual report, 33 pp.89 - 97, 2011-03-31, Shinshu University Environmental Science Research Group.

10 Kosaka, Y., Takeda, S., Sithirajvongsa, S. Xaydala, K. "Land-use patterns and plant use in Lao villages, Savannakhet Province, Laos." Tropics, Vol. 15 (2006c) No. 1 P 51-63, doi.org/10.3759/tropics.15.51.

11 Miyagawa, S., Seko, M., Harada, M., Sivilay, S. " Yields from Rice Plants Cultivated under Tree Canopies in Rainfed Paddy Fields on the Central Plain of Laos " Plant Prod. Sci. 16(4): 325—334 (2013).

for Laos. Kosaka (2006c) reports the majority of surviving trees are to be found on levies or termite mounds on levies, termite mounds on the paddy floor, with only a small minority on the paddy floor; however, there are wide variations between species. Table 1 illustrates these differences.

Table 1 - Characteristics of Trees in Paddy Fields in Nakhou and Bak Villages

	Paddy floor	Paddy Levies	Both	Total
Wild species				
No. of families	17	37	22	47
No. of genera	23	78	42	116
No. of species	25	97	62	184
Cultivated species				
No. of families	7	6	0	13
No. of genera	10	7	0	17
No. of species	10	7	0	17

Source Kosaka 2006b

In terms of tree density (trees/ha) in one of the older villages (Bak) there were no trees in the paddy fields, with the highest density in Dongmakngeo, the most recently established village, and an intermediate density in Nakhou

6.2. Southern Laos

In southern Laos the same spatial and temporal patterns observed in northern Laos and NE Thailand were also present: older paddy fields have fewer trees, but a greater proportion were used for fruit and fuelwood, while in newer fields the remnants of the forest were mainly used for timber.[12] The second paper provides more detail on the wide range of tree species found and their uses.[13]

Natuhara et al (2009) visited four villages in Champassak to explore the extent of and changes in trees in paddy fields. Their information was derived from discussions with villagers and non-systematic field observations.

In Ban Kok Dua, they noted 19 species of trees, in Ban Sivilay 30 species, in Ban Lak 30 45 species, but Ban Thompsok had small paddy fields and only 9 tree species. According to local people most trees were useful, and said shading (people, cattle) was the main reason for allowing them to grow. They also obtained construction materials, fuel, food (fruits, vegetables, nuts, herbs), medicines, dyes, resins, and many other products from the forests; fertilisation by leaf litter was another benefit mentioned.

The same authors made a more thorough analysis of their information in a later publication, especially with respect to uses of trees found in paddy fields (see Table 2 below). They recorded 61 tree species in or adjacent to the paddy fields

[12] Natuhara, Y., Imanishi, A., Kanzaki, M., A., Southavong, S., Duangvongsa, I. "Uses of trees in paddy fields in Champasak Province, Southern Lao PDR." Landscape and Ecological Engineering 8:115-122 January 2011

[13] Natuhara, Y., Imanishi, A., Mukai, Y., Fukamachi, K., Miki, Y., Southavong, S., Phomvongsa, B., Razkhanty, K., Duangvongsa, I. "Landscape, biodiversity and ecosystem service of paddy fields in Champasack Province, Lao PDR." 2009 Kyoto University and Champasack Universities.

in three villages. Species composition varied widely between villages, with only eight species common to all three villages.

Table 2 - Uses of Trees - Champassak (based on Natuhara et al 2009)

Use of Trees in Paddy	Lak 30	Sivilay	Kok Deau	Total
Fibre	0 (0)	2 (1)	2 (1)	1 (1)
Firewood	11 (4)	17 (7)	19 (8)	15 (12)
Flower	2 (1)	5 (2)	2 (1)	2 (2)
Fruit/seed	27 (10)	17 (7)	28 (12)	27 (21)
Timber/furniture/housing	22 (8)	12 (5)	14 (6)	14 (11)
Medicine	11 (4)	17 (7)	19 (8)	16 (13)
Pole	5 (2)	2 (1)	2 (1)	3 (3)
Resin	5 (2)	2 (1)	2 (1)	3 (3)
Shading	2 (1)	0 (0)	0 (0)	1 (1)
Tea	0 (0)	5 (2)	0 (0)	2 (2)
Vegetable	11 (4)	15 (6)	9 (4)	10 (8)
Total	100 (36)	100 (39)	100 (42)	100 (77)

Source: Natuhara et al (2011), Table 1. Note: First figure in each column is percentage of trees used for each purpose, the second figure in brackets is the number of trees used for that purpose.

6.3. Summary

The nine papers reviewed for Laos are observational and analytic in character and do not attempt to formulate any recommendations for practice or policy. They provide for the first time detailed documentation on the broad range of tree species associated with paddy fields and their many uses by farming communities. They illustrate the continuing social, economic and biological importance of trees in rice landscapes.

It is fairly clear the same processes that are have occurred in NE Thailand - steady loss of trees in paddy fields - are taking place in Laos and following more or less the same spatial patterns. However, it is not clear if the parallel process - trees preferentially being preserved and/or planted on levies - is occurring in Laos. It is reasonable, but possibly optimistic, to assume it is occurring and will continue.

The benefits of trees for providing a habitat for conserving the existing range of wildlife species - mammalian, aquatic, avian, insect, reptile - and nutrient fixing and recycling, i.e. co-dependent biodiversity - growing in paddy fields is well established. This suggests that an FFS module assisting farmers, especially younger farmers, gain a better understanding of the benefits of conserving and planting selected tree species may be a practical and worthwhile approach.

7. Rice Landscapes and Biodiversity

A number of studies of rice landscape biodiversity in Laos (and NE Thailand) have been conducted in recent years, among them FAO's own contributions.[14] These all document an amazing range of species living in and adjacent to ricefields, and some also document the uses made by communities of many species for food. What follows is a brief summary of some of the more important findings and their implications, with an emphasis on the actual and potential role of trees in biodiversity conservation in rice landscapes.

Because such a large proportion of the species live in aquatic habitats, these are considered especially important. The rice-fish systems used by farmers in Laos are among these, as these provide communities with a wide range of edible species (Other Aquatic Organisms = OAA) in addition to fish. Farmers have developed a range of methods for ensuring their survival through the long dry season, and facilitating their breeding and reproduction at the beginning of the rainy season, when surface water begins to flow and ricefields are again flooded.

In 2009 IUCN sponsored the production of a comprehensive bilingual guide to what they termed 'farmscape' biodiversity in Laos aimed at stimulating further research.[15] At about the same time Halwart (2008) made a region assessment of the importance of biodiversity for nutrition and livelihoods in several SE Asian countries including Laos.[16] More recently Garaway et al (2013) showed aquatic biodiversity, which is in decline, was of critical important for household food security throughout Laos.[17]

Rice-field ecosystems are a major source of high protein and high energy foods, minerals and vital micronutrients. Local people, including those in Lao PDR, utilise some 145 fish, 15 mollusk, 13 reptile, 11 amphibian and 37 plant species from rice-field ecosystems.[18] A figure from Halwart & Bartley's study on six families in Savannakhet provides an insight into how important the rice field ecology and landscape is in terms of farm families' diets (Figure 4).

Garaway et al's (op cit) studies are the most recent and detailed: a survey of 240 households in four districts in each of three provinces (Champassak, Savannakhet, Xieng Khouang), spanning 13 months of 24-hour recall data on family food intake, some 90% of which was caught and consumed by families themselves. The range of species included fish, amphibians, mollusks, crustations and aquatic insects.

---

14 "Aquatic biodiversity in Rice-based Ecosystems - Studies and reports from Indonesia, Lao PDR and the Philippines." - FAO, 2014

15 Nieman, A.L. and and Kamp, K. "Guide to Biodiversity in the Farmscapes of Lao PDR." IUCN 2009.

16 Halwart, M. "Biodiversity, nutrition and livelihoods in aquatic rice-based ecosystems." Biodiversity, Volume 9, Numbers 1 & 2 2008

17 Garaway, K., Photitay, Roger, Khamsivilay, Halwart, M "Biodiversity and Nutrition in Rice-Based Ecosystems - the Case of Lao PDR." Human Ecology (2013) 41:547–562, DOI 10.1007/s10745-013-9602-z

18 Halwart, M., and Bartley, D. M. (2005). Aquatic Biodiversity in Rice-Based Ecosystems. Studies and Reports from Cambodia, China, Lao People's Democratic Republic and Vietnam. FAO CDRom, Rome.

The study compared catches from 'within' and 'outside' ricefield habitats: 'within' included: ricefields, ricefield streams and canals; trap ponds; small natural ponds or swamps contained within the rice-field area; 'outside' included lakes/reservoirs; natural ponds; private ponds; rivers and streams; forest. Overall the great bulk of fish and OAA are harvested from 'within' the ricefield habitat. However there are also significant variations between locations and seasons, in some places and seasons harvests from 'outside' the ricefield habitat are greater than those from 'inside'.

For our purposes - i.e. trees in rice landscapes - all these sub-habitats are relevant. Many of them are connected by watercourses, belts of trees and/or perennial vegetation; belts of trees and woodlands contain the largest amount of above and below ground biomass in rice landscapes. These constitute mosaics of interconnected habitats for a wide range of terrestrial, avian, insect and aquatic organisms that are vital for ecosystem functioning, human wellbeing and for its own sake, whose conservation requires an integrated, landscape approach.

From the two habitats 'within' and 'outside' rice fields the average harvest of all aquatic species (fish and OAA) was ~51 kg /AUE/yr (range 36.3 to 76.9 kg/AEU/yr),[19] although with wide seasonal variations in amounts and species composition. This is equivalent to roughly one kg/household/week of aquatic-sourced protein, fats, and scarce minerals (especially calcium, iron and zinc) and micronutrients from rice landscapes; this is in addition to a wide range of other essential products harvested from these landscapes.

Figure 4 provides another perspective on the range of species harvested from rice landscapes, showing that aquatic animals (OAA) are about as important as fish and plants from the landscape in contributing to families' diets.

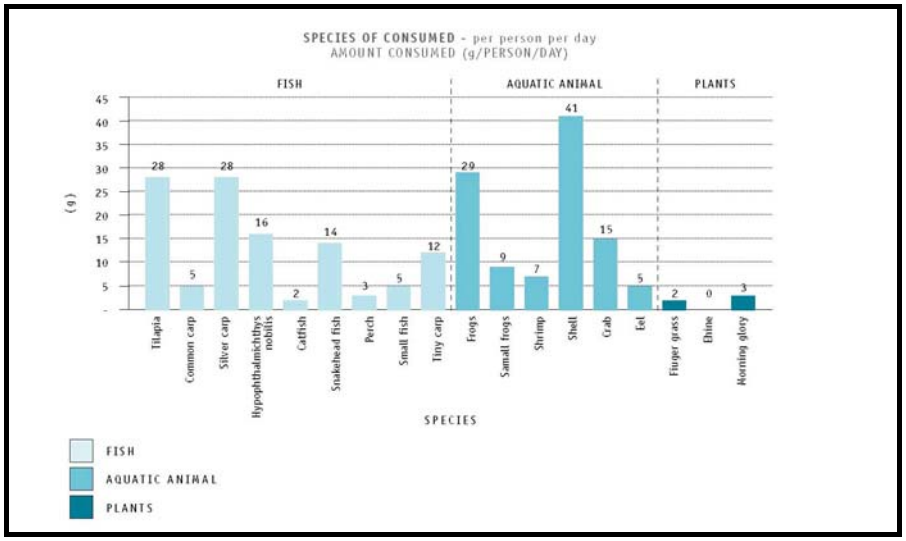


Figure 4 - Range and Amount of Fish, Aquatic Animals and Plants Consumed per Day (Halwart & Bartley 2005:75)

[19] Adult Equivalent Units (AEU).

Sherr et al (2012) identified the five essential elements of integrated agricultural landscape management. All are relevant to management of rice landscapes, with their mosaic of included and surrounding trees and woodlands.

- Landscape interventions need to be designed to achieve multiple objectives, including human well-being, food and fiber production, climate change mitigation, and conservation of biodiversity and ecosystem services;
- Ecological, social and economic interactions among different parts of the landscape managed to seek positive synergies among interests and actors or reduce negative trade offs;
- The key role of local communities and households as both producers and land stewards is acknowledged;
- A long-term perspective is taken for sustainable development, adapting strategies as need to address dynamic social and economic changes; and
- Participatory processes of social learning and multi-stakeholder negotiation are institutionalized, including efforts to involve all parts of the community and ensure the livelihoods of the most vulnerable people and groups are protected or enhanced. [20]

8. Farmers, Trees and Livelihoods

Throughout the literature on trees in paddy fields the multiple products and uses trees represent for farmers, their families and communities is frequently noted - it is a long list and quite consistent across a number of landscapes. However, the actual social and economic value of trees to farmers is no more than sketched in - it is nowhere assessed in substantive social or economic terms, nor is the possible loss or decline in the number and variety of trees and associated habitats discussed, except in the most general terms. It is also unknown to what degree farmers appreciate the role trees play in conserving biodiversity, in addition to providing a range of more obvious and tangible benefits. There are also medium-term issues related to the role of trees and ricefield woodlands in increasing resilience to climate change in the Mekong region.

As noted, it currently appears that trees in paddy fields are only present in significant numbers in central and southern Laos and NE Thailand (e.g. NE Thailand is larger in area than Cambodia). These are important staple crop production regions in Laos with significant levels of poverty and malnutrition among farm communities. Identifying practical means for increasing incomes and wellbeing, in which trees might play a role, are important issues to address.

In the context of S&G and RRI it is vital for governments and FAO understand more about farmer's attitudes and motivations regarding conserving trees and using their products. If farmers value the benefits trees provide - whether subsistence, ecological and/or cash benefits - identifying policies and practical

[20] "From climate-smart agriculture to climate-smart landscapes." Sara J Scherr, Seth Shames and Rachel Friedman, Agriculture & Food Security 2012, 1:12, http://www.agricultureandfoodsecurity.com/content/1/1/12

ways of encouraging farmers to plant and steward useful trees will facilitate achieving S&G's broader aims; biodiversity conservation will be an important co-benefit.

There is no opportunity in the current context to thoroughly explore farmer's attitudes and motivations to the trees growing in their ricefield landscapes. However asking farmers several basic questions can provide initial insights into how important trees may be, if farmers are interested in protecting the trees they have, if they want to plant more trees and how this might be achieved. This is briefly explored below in the summary of fieldwork results. Most importantly, if conserving trees in paddy fields is recognised as important for farmer's and ecosystem wellbeing, and they are alert to this, then this needs to be taken into account when planning future FFS curricula.

9. Farmer's Attitudes and Motivations

A good understanding of farmer's attitudes and motivations is essential if agricultural extension activities such as FFS are to be effective. In part this can be derived from experience of working with farmers in a region, it can also be deepened by what extension staff learn when conducting FFS, and curricula can be revised as necessary. However, when the topic is (relatively) novel, such as rice-tree systems, it is advisable to devote attention to learning as much as possible prior to FFS curricula being prepared and commencing work. Currently, knowledge of farmer's attitudes and motivations regarding rice-tree systems in Laos (or NE Thailand) is scant and shallow.

The great majority of the literature on tree-rice systems concerns NE Thailand's ricefield ecology and the processes of change occurring there. From the limited literature on Laos it is clear similar processes are occurring in central and southern Laos, albeit later and possibly more slowly. This is not surprising, as social and economic factors - increasing population, agricultural modernisation and commercialisation - related to these processes are similar and agroecological and climatic environments all but identical.

The changing patterns of trees in rice landscapes in Laos and NE Thailand are clear but quite varied. The secular trend over the last few decades is for there to be fewer trees, for species to be selected for specific purposes and for trees to be preferentially located on paddy levies. However, almost all literature reviewed for Laos and NE Thailand is technical and quantitative, the steps in the process of charge are described (e.g. Grandstaff et al's four steps) but there is only very limited information on farmer's attitudes or the social and cultural importance of rice-tree systems.

This suggests that to be effective:

- the FFS trainers will most probably require a (brief) training course on rice-tree systems, ideally a detailed briefing with supporting materials;
- the first round of FFS rice-tree training will best be regarded as a pilot activity;

- trainer's experience and insights will need to be systematically collected and documented; and
- if feasible, provision made to revise the curriculum prior to a second round of FFS commencing.

A recent paper by Watanabe et al (2014)[21] - based on Watanabe's doctoral research - employs statistical analyses of recent satellite imagery to explore the processes of change in rice landscapes in NE Thailand. The authors identify five co-varying factors affecting tree density, these are important enough with respect to Laos to be cited in full here:

- history of land development, with more recently developed paddy fields having higher densities;
- topography, with fields located at higher topographical positions having a higher mean density of trees;
- access to natural forest resources, with fields in areas located close to natural forests having higher densities;
- amount of annual rainfall, with fields in areas with higher average annual rainfall having higher tree densities; and
- landholding size, with fields in areas with larger-sized landholdings having more trees. (op cit)

In Laos a number of researchers (e.g. Kosaka 2006, Kosaka et al 2006, Matsusita et al 2011, and Natuhara et al 2009 and 2011 - all op cit) have reached similar conclusions based on local area studies in central and southern Laos. The value of Watanabe et al's paper is that it shows where in NE Thailand the changes are occurring and introduces detailed climatic and topographic variables into the analysis. In brief, assuming a roughly identical level of forest cover and tree density in NE Thailand before deforestation commenced - the changes are least, i.e. tree densities are highest, closer to the Mekong River adjacent to central and southern Laos and greatest in the northern central parts of NE Thailand adjacent to Vientiane. These differences are illustrated in the map below.

[21] Watanabe, M., Vityakon, P., Rambo, T. "Can't See the Forest for the Rice: Factors Influencing Spatial Variations in the Density of Trees in Paddy Fields in Northeast Thailand." Environmental Management (2014) 53:343–356, DOI 10.1007/s00267-013-0206-6

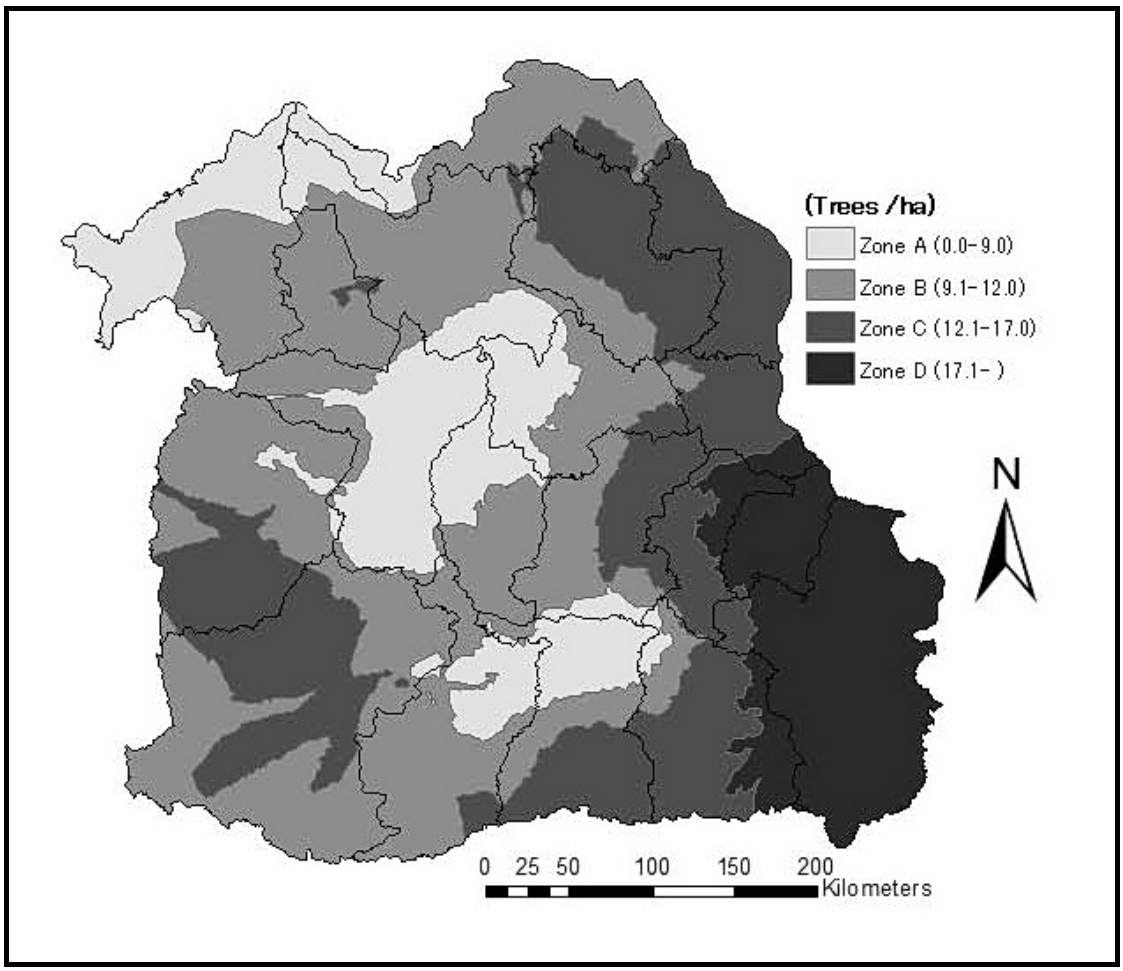


Figure 5 - Density of Trees in Paddy Fields in NE Thailand (Watanabe et al 2014)

There are higher tree density on the eastern side of NE Thailand (Zones C and D) - which face the 'Mekong Corridor' in the previous figure - while the somewhat lower tree density in the north is comparable with that found on the eastern part of Vientiane Plain in that diagram; noting, as satellite imagery confirms, there are fewer trees in paddy fields in the western part of the Mekong plain.

10. Field Surveys in Central and Southern Laos

It was regarded as essential to determine from first-hand data how important trees growing in rice fields in Laos are for famers and, by implication, for village economies. If, for example, trees are important, then including modules on Trees in Rice Fields in FFS (as an element of FAO's Trees Outside Forest - TOF - initiative) could make a valuable contribution to their livelihoods and would be worthwhile; and vice versa.

Early in the study, because farmers do not allow trees to grow in ricefields north of about Vientiane, it was agreed as a result of internal discussions that there would be limited value in trying to change farmer's approach or attitudes, e.g. via including an FFS module on Trees in Rice Fields, for northern Laos which, in part, might encouraged them to plant more trees in their ricefields. On the other

hand, it was clear from observation and the literature that trees were a common feature in rice fields in central and southern Laos. More generally, trees along watercourses and woodland adjacent to rice fields are common throughout Laos.

Given this, two brief field surveys were undertaken in locations where FFS are being conducted in Champassak and Savannakhet; in each of the two provinces three FFS are being conducted. Group interviews and discussions with participants in these FFS were used to quickly collect basic, quantified information about which tree species grew in their rice fields, where they were growing (paddy floor, dykes, watercourses and/or adjacent woodlands), whether the trees were planted or growing naturally, and approximately how many of each species were growing and the uses made by farm families of each species.

In both Champassak and Savannakhet the landscapes are undulating river plains. The rice fields are rainfed and only one crop of rice is harvested late each year; soils are generally sandy, and smaller watercourses ephemeral for most of the year.

Separate Annex #1 reports on the approach, methodology and detailed results, including satellite imagery, of the field surveys conducted in both provinces. The results of the fieldwork are summarised below.

The results of the field surveys can be summarised as follows:

- In central and southern Laos trees commonly grow within the rice fields on paddy floors and dykes, in addition to growing along watercourses and woodlands adjacent to rice landscapes;
- The pattern of trees in rice landscapes is very similar to that found on the western side of the Mekong river in NE Thailand (Isaan);
- North of Vientiane (17°N) there are very few trees growing within rice landscapes, except on hillocks, in gullies or along watercourses;
- FFS participants in all six locations reported significant numbers of a economic/popular trees planted in rice landscapes (12-25 species);
- Preliminary estimates indicate that the number of trees in rice landscapes may amount to about 5-15,000 per village in central and southern Laos;
- All of the trees species grown have multiple uses and some are sold, e.g. for firewood or building materials;
- Overall, it appears there is a trend to planting/nurturing trees preferentially along watercourses and/or in the adjacent woodlands;
- FFS participants want to plant more economic trees, and identified preferred species and locations: watercourses and adjacent woodlands, plus dykes; and
- Trees provide habitats for many species of wildlife, especially aquatic species along watercourses; these habitats are important sources of food and nutrition.

This suggests that finding ways to encourage farmers to plant more economic trees in suitable locations offers a means of both stabilising availability of important subsistence foods, other goods and services and increasing incomes. Providing secure habitats will also contribute to biodiversity conservation. In the FFS context, this requires integrating teaching on the economic and biological importance and potential of trees in TOT courses and FFS curricula. This may best be done by including two or three 'Special Topics' sessions focusing on planting and stewardship of trees in and adjacent to ricefields, and linking this to biodiversity conservation and strengthening food security.

Annexes

Annex 1
Satellite Imagery

The geographical coordinates of the places visited were accurately recorded. This will allow FAO RRI to begin preparing Google Earth-based imagery and maps illustrating the land cover at specific locations and could extend to recording types of farming and project activities.

Once under way this will offer the possibility of making greater use of social media for selectively providing information to a wide range of participants and, more importantly, offering a means for farmers and local officials to share information, including technical and market information.

At the end of the report there are Google Earth images of paddy fields and surroundings in Muang Khun, Ban Thoum (FFS), Ban Phoungman (FFS) and an overview image showing these locations and the central Xieng Khouang area.

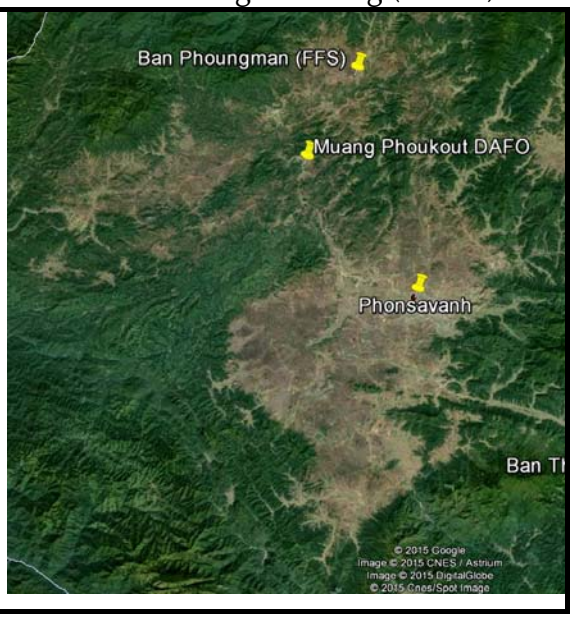
Location	Latitude (N)	Longitude (E)	Altitude (m)
Muang Khun DAFO	19.327078	103.372795	1026
Ban Thoum (FFS)	19.316125	103.405841	1037
Muang Phoukout DAFO	19.568299	103.085682	1071
Ban Phoungman (FFS)	19.640707	103.129820	1096

Muang Khun (Mar13)

Ban Thoum (FFS) (Mar13)

Ban Phoungman (FFS) (Mar13)

Central Xieng Khouang (Oct13)



Annex 2
Tree Species in Paddy Fields in Laos & NE Thailand

Over the past few decades a number of researchers in Laos and NE Thailand (Isaan) investigated and identified the range of tree species growing in rice landscapes. In many cases they have helpfully compiled lists of tree species they found using local (Lao or Thai), English and scientific names. In many cases they also identified the uses to which the trees are put, and in some cases the locations where the species is usually allowed to grow or is planted.

There are overlaps between the lists prepared by different researchers, and also differences between the lists in terms of scientific (systematic) and local names. There is no easy means for resolving these differences.

Most of the research was conducted by scholars from Japanese Universities, many of them working in association with colleagues from the National University of Laos or Khon Kaen University, Thailand.

Major Plant Species Used in Bak village, Savannakhet - based on Kosaka et al (2006)

Scientific Name	Lao Name	Habitat		I	Use	Note
Diptererocarpus alatus Roxb. ex G. Don	Mai nyang	W	DEF	3	T, O	Formerly, oleoresin was main income source.
Nephelium hypoleucum Kurz	Mak ngeo	W	DEF	3	Fo, T, C	Fruits eaten raw.
Syzygium gratum (Wight) S. N. Mitra var. gratum	Phak samek	W	DEF, SWF	3	Fo	Essential vegetable for popular Lao dish.
Tinospora crispa (L.) Hook. f. & Th.	Kheua khao ho	T	DEF, Home	3	M	Medicine for lumbago. Transplanted to homesteads.
Amomum villosum Lour.	Mak neng	W	PTF	3	M	Medicine for stomachaches. Thai traders came to buy.
Baccaurea ramiflora Lour.	Mak fai	W	PTF	3	Fo	Fruits eaten raw.
Cratoxylum formosum (Jack) Dyer	Phak tiu	W	PTF	3	Fo	Essential vegetable for popular Lao dish.
Dialium cochinchinense Pierre	Mai kheng	W	PTF	3	Fo, T	Fruits eaten raw. Producing high quality timber.
Irvingia malayana Oliv. ex Benn.	Mai bok	W	PTF	3	C, Fo, T	Seeds eaten raw. Best quality charcoal.
Peltophorum dasyrrhachis (Miq.) Kurz	Kok aran (safang)	W	PTF	2	T, C	Fast growing pioneer tree.
Tiliacora triandra (Colebr.) Diels	Kheua ya nang	W	PTF	3	Fo	Essential ingredient for popular Lao dish.
Dendrocalamus strictus (Roxb.) Nees	Mai sang phai	C	PTF	3	Fo, H, O	Planted in forest as living fence. Shoots edible.
Calamus sp.	Waai	W	PTF	3	Fo, H	Shoots cooked as vegetable. Fruits eaten raw.
Ananas comosus (L.) Merr.	Mak nat	C	Field	3	Fo	Fruits eaten raw.
Morus alba L.	Kok moon	C	Field, Home	3	Fe	Leaves used for sericulture.
Imperata cylindrica (L.) Beauv. var. major (Nees) Hubb.	Nya kha	W	Grass	3	O	Used for roofing.
Thysanolaena maxima (Roxb.) O. Ktze.	Kok khem	W	Grass	2	H	Spikes used as material for broom.
Nelumbo nucifera Gaertn.	Dok boua	W	Dam	3	Fo	Young seeds eaten raw.
Pandanus sp.	Kok teuy	T	Dam, Marsh	2	O	Transplanted from marsh for dam protection.
Neptunia oleracea Lour.	Phak kaset	W	Marsh	3	Fo	Cooked as vegetable.
Limnophila geoffrayi Bonati	Phak ka nyeng	W	Paddy	3	Fo	Essential herb for popular Lao dish.
Lygodium sp.	Phak kout kapon	W	Paddy	2	Fo, O	Edible fern. Stems used as string.
Marsilea crenata Presl	Phak ven	W	Paddy	3	Fo	Eaten raw as vegetable.
Mentha aquatica L.	Phak suumlao	C	Paddy	3	Fo	Cultivated in paddy levees. Important herb.
Ocimum basilicum L.	Phak i tou	C	Paddy	3	Fo	Cultivated in paddy levees. Important herb.
Oryza sativa L.	Khao	C	Paddy, Field	3	Fo, Fe	Staple diet. Straw and husk was feed for livestock.
Annona squamosa L.	Mak khiap	C	Home	3	Fo	Fruits eaten raw.
Chrysophyllum cainito L.	Mak nam nom	C	Home	3	Fo	Fruits eaten raw.
Pentace burmanica Kurz	Kok si siet	T	Home, DEF	3	O	Used for betel chewing. Transplanted to homesteads

Source: Kosaka Y., Takeda S., Prixar S., Sithirajvongsa S., Xaydala K. (2006, Table 2a). "Species Composition, Distribution and Management of Trees in Rice Paddy Fields in Central Lao, PDR." Notes: The last named species (Pentace burmanica Kurz) was not recorded in Nkahou village. Habitat: C: Cultivated, E: Cultivated and escaped, W: Wild, T: Transplanted, DEF: Dry evergreen forest, PTF: Peltophorum dominant forest, SWF: Swamp forest, Field: Shifting cultivation field, Grass: Grassland, Home: Homestead, Paddy: Paddy field. I: Importance: 3: Essential for daily livelihood or source of cash income, 2: Sometimes self-consumed but not essential, 1: Recognized as useful but rarely used at present); Use: C: Charcoal, Fe: Feed, Fo: Food, Fr: firewood, H: Handcraft, M: Medicine, O: Other uses, T: Timber.

Major plant species used in Nakhou village, Savannakhet - based on Kosaka et al (2006)

Diptererocarpus alatus Roxb. ex G. Don	Mai nyang	W	DEF	3	T, O	Formerly, oleoresin was main income source.
Nephelium hypoleucum Kurz	Mak ngeo	W	DEF	3	Fo, T, C	Fruits eaten raw.
Syzygium gratum (Wight) S. N. Mitra var. gratum	Phak samek	W	DEF, SWF	3	Fo	Essential vegetable for popular Lao dish.
Tinospora crispa (L.) Hook. f. & Th.	Kheua khao ho	T	DEF, Home	3	M	Medicine for lumbago. Transplanted to homesteads.
Amomum villosum Lour.	Mak neng	W	PTF	3	M	Medicine for stomachaches. Thai traders came to buy.
Baccaurea ramiflora Lour.	Mak fai	W	PTF	3	Fo	Fruits eaten raw.
Cratoxylum formosum (Jack) Dyer	Phak tiu	W	PTF	3	Fo	Essential vegetable for popular Lao dish.
Dialium cochinchinense Pierre	Mai kheng	W	PTF	3	Fo, T	Fruits eaten raw. Producing high quality timber.
Irvingia malayana Oliv. ex Benn.	Mai bok	W	PTF	3	C, Fo, T	Seeds eaten raw. Best quality charcoal.
Peltophorum dasyrrhachis (Miq.) Kurz	Kok aran (safang)	W	PTF	2	T, C	Fast growing pioneer tree.
Tiliacora triandra (Colebr.) Diels	Kheua ya nang	W	PTF	3	Fo	Essential ingredient for popular Lao dish.
Dendrocalamus strictus (Roxb.) Nees	Mai sang phai	C	PTF	3	Fo, H, O	Planted in forest as living fence. Shoots edible.
Calamus sp.	Waai	W	PTF	3	Fo, H	Shoots cooked as vegetable. Fruits eaten raw.
Ananas comosus (L.) Merr.	Mak nat	C	Field	3	Fo	Fruits eaten raw.
Morus alba L.	Kok moon	C	Field, Home	3	Fe	Leaves used for sericulture.
Imperata cylindrica (L.) Beauv. var. major (Nees) Hubb.	Nya kha	W	Grass	3	O	Used for roofing.
Thysanolaena maxima (Roxb.) O. Ktze.	Kok khem	W	Grass	2	H	Spikes used as material for broom.
Nelumbo nucifera Gaertn.	Dok boua	W	Dam	3	Fo	Young seeds eaten raw.
Pandanus sp.	Kok teuy	T	Dam, Marsh	2	O	Transplanted from marsh for dam protection.
Neptunia oleracea Lour.	Phak kaset	W	Marsh	3	Fo	Cooked as vegetable.
Limnophila geoffrayi Bonati	Phak ka nyeng	W	Paddy	3	Fo	Essential herb for popular Lao dish.
Lygodium sp.	Phak kout kapon	W	Paddy	2	Fo, O	Edible fern. Stems used as string.
Marsilea crenata Presl	Phak ven	W	Paddy	3	Fo	Eaten raw as vegetable.
Mentha aquatica L.	Phak suumlao	C	Paddy	3	Fo	Cultivated in paddy levees. Important herb.
Ocimum basilicum L.	Phak i tou	C	Paddy	3	Fo	Cultivated in paddy levees. Important herb.
Oryza sativa L.	Khao	C	Paddy, Field	3	Fo, Fe	Staple diet. Straw and husk was feed for livestock.
Annona squamosa L.	Mak khiap	C	Home	3	Fo	Fruits eaten raw.
Chrysophyllum cainito L.	Mak nam nom	C	Home	3	Fo	Fruits eaten raw.
Pentace burmanica Kurz	Kok si siet	T	Home, DEF	3	O	Used for betel chewing. Transplanted to homesteads.

Source: Kosaka et al (2006) Table 2b. Local: Local name; Habitat (C: Cultivated, E: Cultivated and escaped, W: Wild, T: Transplanted, DEF: Dry evergreen forest, PTF: Peltophorum dominant forest, SWF: Swamp forest, Field: Shifting cultivation field, Grass: Grassland, Home: Homestead, Paddy: Paddy field); I: Importance (3: Essential for daily livelihood or source of cash income, 2: Sometimes self-consumed but not essential, 1: Recognized as useful but rarely used at present); Use (C: Charcoal, Fe: Feed, Fo: Food, Fr: firewood, H: Material for handicraft, M: Medicine, O: Other uses, T: Timber).

Tree Species and their Uses in Dong Khuai village, Vientiane, Laos - baserd on Pham et al (2015)

Scientific name	Local name	Charcoal	Firewood	Timber	Food	Furniture	Medicine	Other Uses
Irvingia malayana	Kok bok	x	x	x	x			stain for fishing net
Butea monosperma	Kok chan	x	x		x			leaves for wrapping cak
Shorea obtusa	Kok chik	x	x	x		x		grow edible mushroom
Xylia xylocarpa	Kok deng	x	x	x	x	x	x	
Pterocarpus macrocarpus	Kok dou	x	x	x		x	x	stain for fishing net
Ficus sp.	Kok hai	x	x	x	x			sticky resin to catch cicada
Shorea siamensis	Kok hang	x	x	x		x		mushroom, resin
Lagerstroemia macarpa var. macrocarpa	Kok kalao	x		x		x	x	roadside tree
Ziziphus mauritiana	Kok kathan	x	x		x		x	
Diospyros mollis	Kok kua	x	x	x			x	
Tamarindus indica	Kok kham	x	x	x	x		x	chopping board
Albizia sp.1	Kok khanhoung	x	x	x	x			
Schleichera oleosa	Kok kho	x	x	x	x			
Dipterocarpus tuberculatus	Kok koung	x	x	x				leaves for wall material, wrapping salt basket
Mangifera indica	Kok mouang	x	x	x	x	x		grow edible mushroom
Ceiba pentandra	Kok ngiou				x			mushroom, filling in pillow
Dipterocarpus alatus	Kok nyang	x	x	x		x		resin for making torch
Morinda tomentosa	Kok nyo	x	x	x	x			
Bambusa blumeana	Kok phaiban				x			Handwork making

Scientific name	Local name	Charcoal	Firewood	Timber	Food	Furniture	Medicine	Other Uses
Bambusa bambos	Kok phaipaa				x			fence, hand craft, strings andtapes
Ficus religiosa	Kok pho	x	x		x		x	sticky resin to catch cicada
Dipterocarpus intricatus	Kok sabeng	x	x	x		x		resin for making torch
Peltophorum dasyrrhachis	Kok sakham	x	x	x	x	x		
Samanea saman	Kok samsa	x	x	x		x		
Dipterocarpus obtusifolius	Kok sat	x	x	x		x	x	
Terminalia alata	Kok suak	x	x	x			x	stain for fishing net
Streblus asper	Kok sompho					x		roadside tree
Salacia chinensis	Kok takai	x	x		x		x	
Borassus flabellifer	Kok tan			x	x			sugar, base of rice box
Afzelia xylocarpa	Kok tekha	x	x	x	x	x		
Sindora siamensis var. siamensis	Kok tenam	x	x	x		x		
Albizia sp.2	Kok thon	x	x	x	x			
Annonaceae sp.3	Kok teng seng	x	x	x				
Eucalyptus sp.	Kok vik	x	x	x		x	x	paper
Syzygium sp.	Kok waa	x	x	x	x			

Source: Pham, H. T., Miyagawa, S., Kosaka, Y. "Distribution patterns of trees in paddy field landscapes in relation to agro-ecological settings in northeast Thailand." Agriculture, Ecosystems and Environment 202 (2015) 42-47, doi.org/10.1016/.

Ten Most Dominant Tree Species in Paddy Fields in NE Thailand - based on Prachaiyo (2000, Table 66)

Scientific Name	Thai	Lao	Uses
Dipterocarpus obtusifolius	hiang		T, R, L
Dipterocarpus alatus	yang na		T, L
Dolichandrone spathacea	khae na		F, M
Parinari anamense	maphok	maiohok	T, O
Irvingia malayana	kabok		T, F, S O
Terminalia tomentosa	rokfa		T, S, E
Pterocarpus macrocarpus	pradu	maidu	T, S
Dipterocarpus intricatus	sabaeng	maisabaeng	T, R
Lagerstroemia calyculata	tabaek yai		T, E
Dalbergia nigrescens	chanuan		T, S

Source: Prachaiyo, B. " Farmers and Forests: A Changing Phase in Northeast Thailand ." Southeast Asian Studies, Vo1.38, No.3, December 2000. Notes: T = timber; R. = resin; F. = food; M. = medicine; S. = soil improvement; E. = aglicultural equipment; L. = latex; and O. = seed oil.

Trees in Paddy Fields in NE Thailand - based on Prachaiyo (2000, Table 69)

Scientific Name	Thai	Lao
Dalbergia cochinchinensis	phayung	maiyang
Dalbergia nigrescens	chanuan	
Dipterocarpus intricatus	sabaeng	xmaisabaeng
Albizia siamensis	kang hung	
Azadirachta indica var. siamensis	sadao	xmaikhadao
Dipterocarpus alatus	yang na	maiyang
Hopea odorata	takhian thong	maikhaen
Dipterocarpus obtusifolius	hiang	
Parinari anamense	maphok	
Terminalia tomentosa	rokfa	
Shorea roxburghii	phayom	x
Tamarindus indica	makham	makham
Irvingia malayana	kabok	
Dipterocarpus tuberculatus	phluang	
Shorea obtusa	teng	
Pterocarpus macrocarpus	pradu	maidu
Xylia xylocarpa	daeng	maideng
Sindora siamensis	makha tae	maitae
Lagerstroemia calyculata	tabaekyai	
Adina cordifolia	khwao	
Ajzelia xylocarpa	makha mong	
Peltophorum dasyrachis	nonsi	
Dolichandrone spathacea	khae na	mai
Diospyros rhodocalyx	tako na	
Combretum quadrangulare	sakae na	maikae
Acacia siamensis	kathin phiman	kathin
Mitragyna javanica var. microphylla	kathum na	
Butea monosperma	*chan*	

Prachaiyo (2000, Table 69)

Scientific Name	Thai	Lao	Uses
Dipterocarpus obtusi/olius	hiang		T,L
Dipterocarpus alatus	yang na		T , L
Dolichandrone spathachae	khae na		F ,M
Parinari anamense	maphok		T ,D
Irvingia malayana	kabok		T ,D ,S
Terminalia tomentosa	rok/a		T ,E ,S
Pterocarpus macrocarpus	pradu		T ,D ,S
Dipterocarpus intricatus	sabaeng		T , R , L
Lagerstroemia calyculata	tabaekyai		T ,E
Dalbergia nigrescens	chanuan		T, S
Shorea obtusa	teng		T , R
Diospyros rhodocalyx	tako		F ,M ,Y
Xylia xylocarpa	daeng		T
Sindora siamensis	makha tae		T
Adina cordi/olia	khwao		T
Shorea roxburghii	phayom		T, M , D , R
Acacia siamensis	khatin phiman		T ,M
Mitragyna javanica var. microphylla	kathum na		T, F
Tamarindus indica	makham		T , F , S
Ajzelia xylocarpa	makha mong		T ,S
Butea monosperma	chan		T
Peltophorum desyrachis	nonsi		T
Dipterocarpus tuberculatus	phluang		T , R , L , W
Hopea odorata	takhian thong		T
Azadirachta indica var. siamensis	sadao		T ,M ,F
Dalbergia cochinchinensis	phayung		T ,S
Dalbergia siamensis	kanghung		T ,S
Combretum quadrangulare	sakae na		T,M

Notes: T=timber, L=latex, F=food, M=medicine, O=seed oil, S=soil improvement, E=equipment, D=fodder, R=resin, Y=dying, W=wrapping

Uses and characteristics of trees in paddy fields in NE Thailand - Based on Pham et al (2015, Table 4)

Scientific Name	Family	Local name	Use	Status	Farmers' perception
Mangifera indica L.	Anacardiaceae	Ma muang	Fo*	P	Soil fertilization by leaf litter Yield reduction by shading
Elaeis guineensis Jacq.	Arecaceae	Tan	Ol*	P	
Dolichandrone spathacea (L.f.) Baillon ex Schumann	Bignoniaceae	Khae na	Fo, T	P/W	
Parinari anamensis Hance	Chrysobalanaceae	Phok	S, T	W	
Combretum quadrangulare Kurz	Combretaceae	Sakae na	C	W	
Dipterocarpus alatus Roxb. ex G.Don	Dipterocarpaceae	Yang na	S, T	P/W	Soil fertilization by leaf litter Yield reduction by shading
Dipterocarpus intricatus Dyer	Dipterocarpaceae	Sabaeng	C, T	W	Soil fertilization by leaf litter Yield reduction by shading
Dipterocarpus tuberculatus Roxb.	Dipterocarpaceae	Phluang	Fu	W	
Shorea obtusa Wall. ex Bl.	Dipterocarpaceae	Teng	C, Fu, T	W	
Shorea siamensis Miq.	Dipterocarpaceae	Rang	C, Fu, T	W	Soil fertilization by leaf litter
Shorea roxburghii G. Don	Dipterocarpaceae	Phayom	C, T*	W	Soil fertilization by leaf litter
Diospyros rhodocalyx Kurz	Ebenaceae	Tako	S	P/W	Soil fertilization by leaf litter Yield reduction by shading
Afzelia xylocarpa (Kurz) Craib	Fabaceae	Makha mong	T	W	
Butea monosperma (Lmk.) Taub.	Fabaceae	Chan	C,	W	
Dalbergia sp.	Fabaceae	Pha yung	T*	W	
Pterocarpus macrocarpus Kurz	Fabaceae	Pradu	Fu, T*	W	Soil fertilization by leaf litter Yield reduction by shading
Samanea saman (Jacq.) Merr.	Fabaceae	Cham churi	S	W	
Senna siamea (Lmk.) Irwin & Barn	Fabaceae	Khilek	Fo	P/W	Soil fertilization by leaf litter
Sindora siamensis Teysm. ex Miq. var. siamensis	Fabaceae	Makha tae	T	W	Soil fertilization by leaf litter Yield reduction by shading
Tamarindus indica L.	Fabaceae	Ma kham	Fo*	P	Soil fertilization by leaf litter
Xylia xylocarpa (Roxb.) Taub. var. kerrii (Craib & Hutch.) Niels	Fabaceae	Daeng	T	W	
Irvingia malayana Oliv. ex Benn.	Irvingiaceae	Kra bok	T	W	Soil fertilization by leaf litter
Tectona grandis L.f.	Lamiaceae	Sak	T*	P	

Scientific Name	Family	Local name	Use	Status	Farmers' perception
Careya arborea Roxb.	Lecythidaceae	Ka don	Fo	W	
Lagerstroemia macrocarpa Kurz var. macrocarpa	Lythraceae	Kalao	Or	W	
Lagerstroemia sp.	Lythraceae	Puay	C, Fu	W	
Michelia champaca L. var. champaca	Magnoliaceae	Champa	T	W	
Azadirachta indica A. Juss. var. siamensis Valeton	Meliaceae	Sadao	C, Fo, T	W	Soil fertilization and pest control by leaf litter
Ficus religiosa L.	Moraceae	Pho	Or*	W	
Eucalyptus camaldulensis Dehnh.	Myrtaceae	Yuka	P*, S, T*	P	Soil fertilization by leaf litter
					Competing with rice for nutrition and water
					Yield reduction by shading and leaf litter
Syzygium cumini (L.) Skeels	Myrtaceae	Waa	T	W	Soil fertilization by leaf litter
					Yield reduction by shading
Bambusa sp.	Poaceae	Phai	Fo, T	W	Competing with rice for nutrition and water
Mitragyna diversifolia (G.Don) Havil.	Rubiaceae	Krathum	C, Fu	W	

Source: Pham, H. T., Miyagawa, S., Kosaka, Y. "Distribution patterns of trees in paddy field landscapes in relation to agro-ecological settings in northeast Thailand." Agriculture, Ecosystems and Environment 202 (2015) 42-47, doi.org/10.1016/. Notes: Uses: C, Charcoal; Fo, Food; Fu, Fuelwood; Ol, Oil; Or, Ornamental; P, Pulp; S, Shade; T, Timber; *, sale for cash income. Status: P, Planted; W, Wild.