วารสารการจัดการป่าไม้

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Strategies for Sustainable Mangrove Management and Conservation

Ong Jin Eong[1]

ABSTRACT

The rapid and widespread worldwide loss of mangroves has made it necessary to consider strategies for its sustainable use management and conservation. The main strategies discussed include the evaluation of assets and establishing inventories, determining the best ecologic and socio-economic use the system can be put to, and development of comprehensive management plans. Two case studies are cited: (i) the Matang mangroves in Malaysia and (ii) the mangroves of the Andaman Coast of Thailand.

The 40,000-hectare Matang mangroves are arguably the best managed mangroves in the world with a century long history. Patches (annual coupe of a thousand hectares) of 30-year old mangroves are clear-felled (for making charcoal) each year with thinnings at 15 and 20 years. Enrichment planting is then carried out, where necessary. The preference of *Rhizophora apiculata* timber has resulted in a significant drop in species diversity (one of the two major drawbacks of the management system). It is also economically unsustainable although this has been ameliorated by a recent doubling of royalties.

Severe flooding in Southern Thailand resulted in a total ban of logging in 1989. Although the ban was generally not considered effective (due to widespread illegal logging), a notable exception was the mangrove forests on the Andaman coast. Patches of some old and majestic stands still exist and extensive replanting (mainly *R. apiculata*) has resulted in extensive stands of new mangroves.

One lesson learned from the Andaman coast study, was thatthe success has been due to importance of scientifically competent and politically influential leaders as well as effective implementing agencies with dedicated mangrove scientists. To move forward, there is an urgent need to develop a comprehensive integrated multidisciplinary Management Plan (based on the Matang experience) for Thailand's Andaman coast mangroves. Community based development is important but there isno substitution for the hard science that is still sorely needed.

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INTRODUCTION

The rapid and widespread worldwide loss of mangroves (e.g. Spalding *et al*., 2010) has made it necessary to consider strategies for its sustainable use management and conservation. At the local level, Haywood *et al*. (2001) has presented time-series data that suggests that the Merbok mangroves in Malaysia may be completely depleted by around 2020 (when Malaysia aspires to become a developed nation) if the present trend is left unchecked (Figure 1). A similar trend is seen for the loss of mangroves in Penang, Malaysia (Ong, 2007).

One of the main problems with mangrove conservation is that from the economic stand point, it is a market failure. The usual remedy is for governments to provide the necessary equity. Unfortunately most mangroves exist in developing countries where the governments are usually too poor to provide this solution. For instance, Ong *et al*. (2001) and Dodd & Ong (2008) have contended that, essentially, posterity requires a modicum of prosperity.

The emphasis of this paper is not so much management per se but rather the exploration of the strategies needed for the "sustainable use" management of mangrove ecosystems. Essentially, to manage sustainably, it is vital to know the best use that a particular mangrove ecosystem can be put to.

Two case studies; one on the Matang Mangroves (with its century old history of sustainable timber use management) and the other, on the Mangroves of the Andaman Coast of Thailand are presented, compared and the lessons learned are discussed.

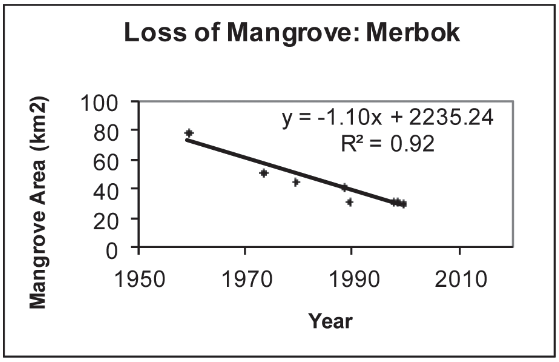

Figure 1 Time-series data showing the loss of mangrove in the Sungai Merbok Mangroves, Kedah, Malaysia. [From: Haywood *et al*., (2001)]

STRATEGIC NEEDS

The main strategies discussed include the evaluation of assets and establishing inventories, determining the best use the system can be put to, and development of comprehensive management plans (after appropriate scientific and socio-economic studies).

Assets/Inventories

These should include the size (area) of the ecosystem as well as basic geo-morphological and meteorological characteristics. Data on human population within the mangroves as well as in the immediate surrounding areas are also basic data requirements. It would also be useful to know the occupation of the human population (especially if they depend directly or indirectly on the mangroves). The composition (biodiversity) of at least the plant species (preferably also the main species of animals as well) should be determined. It would also be useful to know the structure and the demography of the mangroves (e.g. as seen in Ong *et al.*, 1995 and Gong & Ong, 1995). If the mangroves are to be used for timber production, it would be necessary to have a good handle of its productivity (e.g. see Ong *et al.*, 1995 and Clough *et al.*, 1997).

Uses & Users

It is now evident that different mangroves provide different goods and services (Ewel *et al.*, 1997); so it is important to determine what particular use or uses a particular mangrove can be used on a sustainable basis. Values of mangroves based on the goods provided (e.g. timber) are relatively easy to determine (since they have market values) but valuing services will always be contentious (e.g. Dodd & Ong, 2008). Still, it would be useful to have as much data on the value of a particular mangrove in order to determine the best use it can be put to.

Management Plans

These are also referred to as "working plans" and much of the information just stated above, like the inventory of natural assets, history of human occupation/use and local community needs must already be available before a working plan can be written. There is also a need for an integrated multidisciplinary approach so that the needs of multiple direct or indirect users (or stakeholders) can be satisfied. Data is never complete to write a working plan (especially the first one) so it is necessary to point out the data gaps and to suggest the types of scientific and socio-economic research that would be needed for future plans. It would also be useful if such plans are discussed with stakeholders and the public at large before they are finally published and implemented. Since we live in a changing world, it is also essential to regularly revise implemented working plans.

State of Health of the Ecosystem

One of the most important thing for any manager of an ecosystem (whether it is for conservation, as a park or sustainable extraction of goods or services) is its state of health. Unfortunately, determining the state of health of an ecosystem is not an easy thing to do and is more often than not, not monitored. Monitoring growth is one way. Monitoring changes in community structure is another. Monitoring changes in sensitive indicator species (unfortunately, most of the time we do not know which are the indicator species that are sensitive to adverse change) is yet another. A scientific research unit as part of the management staff would go a long way to solving this major problem. There is no substitute for on the ground hard science.

CASE STUDIES

Two case studies are considered: one of the Matang mangroves in Malaysia and the other of the Andaman Coast of Thailand. The reason for this choice is that the well-known Matang mangroves, with its century of history, are arguably the best example of a sustainably managed (essentially for timber use) mangrove ecosystem. On the other hand, there is little documentation on the mangroves of the Andaman Coast of Thailand. Yet, its last three decades of history is a success story that needs to be told.

THE MATANG MANGROVES, MALAYSIA

With a century history, the 40,000-hectare Matang mangroves are arguably the best managed mangroves in the world. The management practice is based essentially on rule of thumb developed by British foresters in the early part of the last century (Watson, 1928). Apparently (see Noakes, 1952), the first "working plan" was written by Durant in 1930 but was not in a published document that is generally available to the public, so the first working plan for the Matang Mangroves is considered to be that of Noakes (1952). There had since been four revisions, with the latest by Azahar Muda & Nik Mohd. Shah (2003). The original use for the timber was as fuel for steam locomotives that transported tin ore on the first railway line in Malaya, from Taiping to Port Weld. It was clear what the use was and it was never a case of a product looking for a use. When the tin ore ran out there was enough demand for firewood and charcoal. The present use is mainly as charcoal (a significant amount being exported to Japan and Korea) and poles (mainly used as piling in the building construction industry).

A brief description of the management system can be found in Ong (1982) and in Chan (2001). Essentially, on a thirty-year rotation, patches mangroves (annual coupe of a thousand hectares) are clear-felled each year with thinnings (for the production of poles) at 15 and 20 years. Enrichment planting is carried out, where necessary, soon after clear-fell. Some fifty percent of clear-felled areas presently require enrichment planting.

How Sustainable?

Essentially this mangrove has been managed for the sustainable production of timber. It has basically undergone three 30-year timber harvest rotations and there is apparently no discernible drop in timber production. There is thus little to argue that the management for sustainable use for mangrove timber has been very largely successful. However, in order not to lose sight of the forest for the trees (= timber), it is important to ask how other aspects of the overall health of the forests has been affected. It is also necessary to look at the socio-economic aspects.

Ecological sustainability (Biological Diversity)

The preference for *Rhizophora apiculata* in the production of charcoal has meant that almost all of the production areas had been converted to a mono-culture. Whilst mangroves naturally grow in almost pure single-species stands in a particular tidal inundation zone (e.g .Watson, 1928), having plantations of *R. apiculata* is in two of the five inundation zone of Watson (1928) would be deemed reasonable practice (see Figure 2 for Watson's tidal inundation classes). However, under the present practice almost all of Watson's Inundation

Classes 3, 4 and 5are under *R. apiculata*. Inundation Class 1 is generally non-vegetated (apart from the occasional R. mucronata). The only zone not heavily planted with *R. apiculata* is Inundation Class 2 where pioneering species of *Avicennia alba, A. marina* and *Sonneratia alba* are left undisturbed. There has thus been a very visible and significant drop in mangrove tree species diversity in the Matang Mangroves. Thus one of the major criticisms of the Matang Mangrove management system is this very significant loss in biodiversity.

Two possible solutions to this problem are suggested here:

One possible solution (or partial solution) is to be less aggressive with the planting of *R. apiculata*. Perhaps, reducing the reducing the annual harvest coupe by some 10%, particularly in areas that have planting problems (e.g crab predation of *R. apiculata* propagules) and in Inundation Class 5 (the zone with the highest tree biodiversity), would go a long way in solving the biodiversity problem.

The other solution is to permanently set aside a portion of the 10,000 hectares that is now used essentially as a buffer for production purposes. There biodiversity areas must cover different vegetation zones (e.g. see Ong, 1995).

Of course, eventually, especially if the production of timber is only marginally economical or non-economical, then it may be prudent to consider adopting the system formerly practiced in the Merbok Mangroves of minimal intervention (i.e. relying entirely on natural

WATSON'S (1928) FIVE
TIDAL INUNDATION CLASSES

1. **All High Tides** Barren mudflat / occasional *Rhizophora mucronata*
2. **Medium High Tides** *Avicennia alba / Rhizophora mucronata*
3. **Normal High Tides** *Rhizophoras, Bruguieras, most species*
4. **Spring Tides** *Bruguiera cylindrica, B. parviflora, Xylocarpus*
5. **Equinoctial / Abnormal Tides** *Intsia bijuga, Excoecaria agallocha , Phoenix pelidosa*

Figure 2 Watson's (1928) five tidal inundation classes with their dominant mangrove plant species.

Note that the mangrove plant distribution may be site specific and in this case represents the situation in the Matang mangroves.

Economic sustainability

Generally, as a result of low returns from mangrove goods, the value of mangrove is low and most mangroves are considered economic market failures. This means that governments have to provide equity. Thus in developed countries where mangroves occur (e.g. Australia, Japan and the USA) mangroves are given legal protection from degradation and destruction. Most of the world's mangroves are unfortunately located in developing countries and most of these governments (Thailand being a recent rare exception) cannot afford to protect their mangrove (see Ong *et al.*, 2001 and Dodd & Ong, 2008).

The latest working plan for the Matang Mangroves showed that the revenues from royalties and premiums was just enough to cover the operational running costs of the Matang Mangroves (Azahar & Nik Mohd. Shah, 2003). Staff emoluments and infrastructural costs are not part of the running costs and when these are added, it is clear that the Matang mangroves were not economically sustainable. The Malaysian Government has thus been providing equity for the market failure of the Matang Mangroves.

It is very heartening to note that in November 2008, the Perak Forestry Department (who are responsible for the management of the Matang Mangroves) took the bold step of doubling the royalties for charcoal and other timber products produced by the Matang Mangroves. This means that the Matang Mangroves is now closer to economic sustainability, and just as importantly showed that the managers of the Matang Mangroves have a handle of the economic aspects of their management.

One question to consider is: Even if the Matang Mangroves is not economically sustainable, would it be still worth it to continue with the system? One important consideration is that despite the financial loss from the forestry management, the Matang Mangrove remains an extremely rare example of "zero loss" in a real extent.

MANGROVES OF THE ANDAMAN COAST OF THAILAND

Severe floods in Southern Thailand resulted in a total ban of logging in 1989. Although the ban was generally not considered effective (due to widespread illegal logging), the mangrove forests (at least on the Andaman coast) have been well preserved. Patches of some old (and majestic) stands still exist and extensive replanting has resulted in extensive stands of new mangroves. Although there has been a considerable number of studies (mostly in the Ranong UNESCO Mangrove Biosphere Reserve), from a UNESCO initiated Regional Project and joint Thai-Japanese research projects), these studies were not sustained.

Total Logging Ban in Thailand

After very severe floods in Southern Thailand in 1989, the Thai Government took the bold step to ban logging in all of Thailand's forests (with the exception of mangrove forests). The aim of this exercise was to have 40% of Thailand under forest cover so that 25% of Thailand would be under conservation forest and 15% under production forests. This is a noble aim but, unfortunately this logging ban has been generally ineffectively due to illegal logging (a Google search resulted in a number of sites, including an FAO site, reporting on this).

My recent forays to the mangroves of the Andaman Coast of Thailand (from Satun in the south to Ranong in the north) strongly suggested that whilst the logging ban may have been ineffective in most of Thailand's forests, this is not the case with the mangroves (despite mangrove forests being exempted from the total logging ban) of the Andaman Coasts.

Mangroves of the Andaman Coast of Thailand

It is lucky that at around the time of the total logging ban, some 80% of Thailand's mangroves are on the Andaman Coast. This amounts to just under 200,000 hectares of mangroves. At a rough estimate, this means that some 100,000 hectares of mangroves is now available in the Andaman coasts as conservation forests and some 70,000 hectares, as production forests. What is more heartening is that there remain some very majestic patches of "old growth" mangroves (e.g. in the District of Trang) on this coast. Another piece of good news is that there has been extensive replanting in many of the mangroves that had been degrade prior to the 1989 logging ban and most of these "new growth" mangroves are in good shape (i.e. like what healthy stands of around twenty-year old mangroves in this part of the world should look like).

Ranong UNESCO Biosphere Reserve

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Ranong UNESCO Biosphere Reserve

This conservation area of just under 26,000 hectares of mangroves (with some 19,100 ha forming the core mangrove area) was established before the 1989 total logging ban. It also has 4,300 ha of non-mangrove "transition zone".

Despite its UNESCO Biosphere Reserve status, much of the 24,000 ha was degraded mangroves (tin mining being a major degrading driver), in the mid-1970s. There were however good patches of mangroves, including a small but very impressive stand of very big (around 40 metres tall) and old *Rhizophora apiculata* forest. With an annual rainfall of 4 to 5,000 mm these mangroves receive the highest precipitation anywhere in the world and their productivity is expected to be amongst the highest (as seen from the very impressive old *R. apiculata* stand).

The Thai Royal Forestry Department has since the 1980s done some exemplary rehabilitation work and all the forest is now covered in 20-30 year-old mangroves. Unfortunately most of these are *R. apiculata*. However, the mangrove arboretum at nearby Le Un (although not part of the biosphere reserve) partly makes up for this.

There is a Mangrove Research Centre, occupying some 2,000 ha of mangroves and some "transitional" areas. This was established around 1980, not long after a UNESCO Regional Mangrove Project was initiated and the start of a Joint Thai-Japanese Mangrove Research Project in 1982. The height of research activity at this Centre was seen during the UNESCO

Multi-disciplinary Research Project in the mid-1980s (see Aksornkoae, *et al.*, 1991) but, unfortunately, research activities have slowed considerably since, and appear unsustainable.

Local community participation

It is a stroke of good fortune for the mangroves that around the time of the logging ban there were a number of NGOs interested in local community participation. An excellent example is the locally run NGO, Yadfon Association, based in Trang. Their "Community Mangrove Forest Project", for instance, was designed to give the local communities livelihood utilising mangroves. Just as important was giving a sense of belonging and participation: thus most of the local communities looked after their mangroves.

The Phuket Marine Biological Centre has also (for even a longer period) been very actively involved in promulgating marine environmental education and awareness programmes to local communities for many decades.

LESSONS LEARNED AND THE WAY FORWARD

Matang Mangroves

Only two main points here will be highlighted here:

Management or Working Plans

One of the biggest lessons that can be learned from the Matang mangrove management system is the availability of Management or Working Plans. These mangroves were gazetted as early as 1904 and a "Working Plan" was prepared by Wells (unpublished) immediately after. This was followed by a number of revisions such that enough relevant data and observations had been acquired for a detailed description of the structure, functioning and sustainable timber harvesting of the forest: in the form of Watson's (1928) publication which remains a mangrove classic to this day. This essentially constitutes the first published Working Plan since the Working Plan of Durant (1930) and its revision by Robertson (1940), were unpublished. The first complete Working Plan was considered to be that of Noakes (1952). Thus the latest Working Plan revision by Azahar & Nik Mohd. Shah (2003) is considered as the "fifth revision", after those of Dixon (1959), Mohd. Darus (1969), Haron (1981) and Gan (1995). The Working Plans are now revised about every ten years and constitute a major management activity. These revisions are extremely useful as they allow the Forestry Department to keep tabs on any changes in their forest so that necessary changes may be put in place. It also makes the management process transparent to stake holders and the public, who may then be able to make critical comments and suggestions.

It cannot be over emphasised that a Management or Working Plan is a vitally essential part of any sustainable ecosystem management system. The managers of the Matang Mangroves have done an exemplary job here that mangers of other mangrove ecosystems can very profitably learn from their considerable experiences.

Research Unit

There are many day to day management problems that can only be solved by proper scientific investigations and to do this, there has to be a scientific team or research unit that is based at the site. There is presently no such facility at the Matang Mangroves. I have personally made this suggestion before and the then management was receptive to the idea. I suspect that the reason for not implementing this may be one of policy. Forestry research in Peninsular Malaysia is the purview of the Forest Research Institute and State Forestry Departments may not be allowed to establish forestry research units. Of course, there are ways and means to overcome this but this issue is a political one and it is not for me to be involved in any way other than to point out that, from a scientific aspect, this research unit is a necessary and integral part of any sustainable forestry management system. This is very much a part of "the way forward".

Thai Andaman Coast Mangroves

As with the first Case Study, I will confine to highlighting only two main points: the need for an overall Management Plan for the Andaman Coast Mangroves and the need to unlock the potential of carbon trading. Finally, I will try to fathom why the 1989 total logging ban (generally considered a failure as a result of illegal logging) has been a success story for the Andaman Coast mangroves.

Management Plan?

There is a need to prepare a Management Plan for the Mangroves of the Andaman Coast of Thailand, if the mangroves there are to be managed on a sustainable basis. This will be a major exercise and the Thai Royal Forestry Department (TRFD) will need to deploy personnel and resources for this.

I am not aware if there is already a Management Plan for the Ranong UNESCO Reserve. If not, this will be an urgent requirement. This will not be too difficult to do as much of the needed data is already available.

Unlocking the Potential of Carbon Trading (under CDM and REDD)

After some twenty years of effective rehabilitation, most of the mangroves will be eligible for carbon credits under the Clean Development Mechanism (CDM) of the Kyoto Protocol. These regrowth mangrove forests as well as all the other mangrove forests in the Andaman Coast will be eligible for carbon credits the Reducing Emissions from Deforestation and Degradation (REDD) scheme. The potential is huge and the TRFD should form a team of suitably qualified mangrove scientists to look into unlocking this potential source of funds that are sorely needed to sustainably manage these forests.

Reason for the success

It is hard to determine what it is, but a chain of fortuitous events starting around the mid-1970s has resulted in what can be considered to be good tidings for the mangroves of the Andaman Coast of Thailand. First, there was the UNESCO Regional Mangrove Programme and there were a few scientists in academia, the TRFD and one of the ministries. UNESCO's selection of the Ranong Mangroves for it Multidisciplinary Mangrove Research Project and the eventual establishment of the Ranong Mangroves as a UNESCO Biosphere Reserve. Other joint scientific programmes, with external funding followed: from the Joint Thai-Japanese Research Project to the ASEAN-Australia Project.

Unfortunately scientific research vanned at the end of these joint projects. Fortuitously the huge floods in Southern Thailand resulted in the total logging ban. The ban was only implemented because there were mangrove scientists in position who were already primed for this drastic action and who were influential enough to convince the Government of the day. After the ban, enough had also been done (e.g. in environmental education such that NGOs and local communities had become aware of the need to protect the environment. This is likely the reason that whilst there was rampant illegal logging in the other forests, mangrove forests on the Andaman Coast were spared.

We could just put down this chain of happenings to mere coincidence, good luck or just serendipity, but is it?

One lesson learned was that success may be due to having a hierarchy of influential mangrove scientists present in the relevant ministries, universities, research institutions and implementing agencies at the time of the logging ban. It is this depth of Thai mangrove scientific competence that is perhaps critical in saving the mangroves of the Andaman coast of Thailand. It would appear that if international funding for mangrove research is not sustained, Thailand may be in danger of losing its depth of mangrove scientists. Unfortunately the present trend appears to be that international funding agencies are moving away from supporting hard science.

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Community Participation Approach for Mangrove Conservation in Vietnam

Mai Sy Tuan[1] Pham Hong Tinh[2]

ABSTRACT

Vietnam is underway in economical transition, facing a great problem which is to maintain mangrove conservation in the context of rapid economical growth for sustainable development. This paper introduces a general view of mangrove in Vietnam and the need of getting community involved in exploitation of forest products and sharing of mangrove protection and rehabilitation. The principles and activities for improving community's knowledge of mangroves are also briefly mentioned.

A case study in the specific situation in Ramsar Site of Xuan Thuy, Nam Dinh province belonging to the Red River Delta showed that in the presence of community participation in mangrove conservation, the benefit from fishery (value of the crab, shrimp, fish and other aquatic products) and beekeeping as well as value of the protection function of mangroves increased significantly. The study also indicated that mangrove conservation will produce good results if local communities realize that an income for their livelihood is closely linked with mangrove conservation.

Though community participation in mangrove conservation in Vietnam has brought about certain results, we have still faced great challenges. For further effectiveness of community activities, deeper research should be conducted.

Key Words: mangrove, conservation, community participation, Vietnam

INTRODUCTION

Mangroves of Vietnam

Vietnam's 3,260 km long coast and a dense river system with abundant alluvia potentially support a substantial area of mangroves (Figure 1). Before the revolution (1945), it was estimated that mangrove forests in Vietnam covered an area of 408,500 ha (Maurand, 1943), 290,000 ha of which were in the south (NAS, 1974). The densest mangroves concentrated in Ca Mau peninsula with the total area of 149,982 ha. The extent of mangroves

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depends upon the climatic conditions as well as on the physical properties of the coastal topography and has changed greatly since then (1945) (Tuan, 2005).

According to the national forest inventory done by the Forest Inventory and Planning Institute (FIPI) (2001), Vietnam has an estimate of 156,608 ha of mangroves, 96,876 ha of which are planted and 59,732 ha are natural ones (Table 1).

Various climatic, hydrographic and topographic factors of the coastal area have strongly influenced the distribution of the mangrove vegetation in Vietnam. Basing on the differences in those natural conditions, Phan Nguyen Hong (1991) divided the mangrove vegetation in Vietnam into four zones as follows.

- *The northeast zone* (Quang Ninh Province) has physical conditions which are suitable for the growth of mangroves. However northeast monsoon in winter creates a sudden drop in temperature which affects tree growth and some species that cannot adapt to it. A list of 34 species is recorded including 15 species of true mangroves and 19 species of associate mangroves (Hong & San, 1993).

Provinces	Mangroves area (ha)
Quang Ninh	13,294
Hai Phong	3,382
Thai Binh	4,200
Nam Dinh	4,000
Ninh Binh	400
Thanh Hoa	700
Nghe An	600
Ha Tinh	645
Quang Binh	100
Quang Tri	0
Thua Thien Hue	10
Quang Nam-Da Nang	30
Quang Ngai	205
Binh Dinh	10
Phu Yen	n/a
Khanh Hoa	n/a
Ninh Thuan	n/a
Binh Thuan	n/a
Ba Ria-Vung Tau	10,042
Ho Chi Minh City	40,000
Tien Giang	4,000
Kien Giang	3,080
Ben Tre	6,126
Tra Vinh	5,591
Soc Trang	3,058
Bac Lieu	n/a

200 km

Figure 1 Mangroves distribution in Vietnam

Table 1 Changes in mangrove area in four regions of Vietnam (Unit: ha)

Coastal area	1982	1999
North-east	39,400	22,969
Northern delta	7,000	20,842
Central	14,300	3,000
Southern delta	191,800	109,797
Total	**252,500**	**156,608**

Sources: FIPI, 2001

- *The northern delta zone* (Red River Delta) is accreted by Thai Binh River and Red River. Though the mud flats are large and rich in alluvium and fresh water, this zone is subject to strong winds, storms and waves. In winter, the temperature is rather low so the mangrove stands are not extensive and the trees are relatively small. The mangrove communities consist of brackish water species, dominated by *Sonneratia caseolaris, Kandelia obovata* and *Aegiceras corniculatum*.

- *The central zone:* The seacoast here is parallel to the Truong Son Range. Most of the rivers that rise from the mountains limit the supply of fresh water and suspended matters. In addition, the coastline is rocky surrounded by deep sea and is influenced by strong water action. Due to the above reasons, there are no mangroves along the seashore. Narrow strips of brackish water mangroves can be seen along the riverbanks. Twenty six species of true mangroves and 24 associate mangrove species are recorded.

- *The coast of southern Vietnam:* This zone is created by two river systems: Dong Nai River and Mekong River. The ecological conditions are favorable for the extensive development of mangroves. Moreover, this zone is located near the Indonesian and Malaysian archipelagos the places of origin for mangroves species. Due to the warm streams and the southwest winds which carry seeds and propagules to this zone, the composition is rich including 32 species of true mangroves and 42 species of associate mangroves, and the tree sizes are the largest in the country.

Roles of mangrove conservation in Vietnam

Mangroves play a very important role in economic development in coastal zones, especially in the two largest plains of Vietnam – the Red River Delta and Mekong River Delta. Mangrove ecosystem supports a variety of economic activities, being likely to bring about direct economic values such as exploitation of wood and fuel-wood from mangrove trees; exploitation of shrimp, crabs and other valuable products such as honey. These direct values have contributed to stabilizing and improving the life of coastal communities, and therefore, improving agricultural quantity and quality.

Vietnam has been facing impacts of climate changes and prone to environmental incidents which have been occurring and will possibly occur. Hence, environmental values of mangrove ecosystems are closely linked to economic development. The role of mangrove ecosystems toward the environment is seen through wave buffering, wind reduction, coastal protection for erosion control, soil restoration, improvement of water quality, absorption of pollutants and preventing them from entering into the sea, and supply of nutrients for faunal and floral populations. They are of vital significance to economic development.

In addition to economic and environmental values, mangrove ecosystems are places for storing genetic sources of great importance, contributing to enhancing biodiversity of fauna and flora. The diverse and natural features of mangrove ecosystems probably attract more species and thereby increase the diversity of the mangrove ecosystem itself and reduce risks and threats to various faunal species which are hunted and over exploited. Mangrove protection and biodiversity conservation is not only of ecological significance but also of economic value to local community through ecotourism development, relaxation activities, research and training.

However, chemical war (1962-1971) devastated a large area of mangroves in coastal Vietnam, especially in Southern where the best grown mangroves and the most species could be observed. A typical example is Can Gio Mangrove Forest, Ho Chi Minh City. After the war, indiscriminate mangrove exploitation and felling for construction of urban area and ports, agricultural production and especially for shrimp farming has been a major threat to not only the mangroves but also to the environment.

As a result, the preservation and restoration of mangrove is an urgent need. Nevertheless, such work could not be fulfilled or be successful with the participation of only a few people engaged in forest caring, and protection. One effective solution that has been applied is to get community involved in exploitation of forest products and sharing of mangrove protection and rehabilitation.

CHALLENGES OF COMMUNITY PARTICIPATION IN MANGROVE CONSERVATION

Though community participation in mangrove protection and restoration has brought about certain results, we have still faced great challenges not only linked to community awareness but also policies, ways of activity implementation or problems arising from the mangrove ecosystem itself. Those challenges probably include:

• Economic and population pressures have greatly placed on restoration and protection of mangrove ecosystems in Vietnam. In recent years, population has not been of major concern; however, the problem is economic pressures worsened by by-any-means economic development purposes of some people even including illegal mangrove deforestation for farming of shrimp, fish and other marine species.

• Overexploitation and conversion of mangroves into agricultural land, salt pans, and especially shrimp ponds and recent intensively developed meretrix farming area in coastal zones of Vietnam has narrowed mangrove forests and degraded functions of mangrove ecosystems. Extensive shrimp farming and meretrix farming have been determined to be a great challenge to mangrove ecosystem in Vietnam as this practice has brought about high economic value.

• Most of the land suitable for mangrove planting has been used for shrimp farming. The remaining is mostly inundated by tide and too deep, making it difficult for the newly planted seedlings to photosynthesize. Moreover, barnacle attack is also a reason for the slow growth of newly planted mangroves. So far, effective technical measures for barnacles control have not yet been worked out.

• One rule that occurs in mangrove ecosystem itself is the older the mangrove forests the higher ground elevation. Nevertheless, when ground elevation is elevated, the mangroves will get degraded. This is clearly observed in 25-30 year old mangrove forests. However, if these mangroves are converted into fish or shrimp ponds, decomposition of organic products will be enhanced and a high quantity of CO_2 will be released into the environment. Therefore, a more long-term and effective forest resource management strategy is required.

A CASE STUDY OF COMMUNITY PARTICIPATION IN MANGROVE CONSERVATION AT RAMSAR SITE OF XUAN THUY, VIETNAM

The Ramsar Site in Xuan Thuy District

Community participation in conservation of mangrove ecosystem has been seen in many areas of coastal Vietnam. This section introduces an example of community participation in management and conservation of mangroves in a Ramsar Site of Xuan Thuy, Vietnam.

The coastal area of Xuan Thuy is located in Northern Vietnam (Figure 2) with a huge alluvial quantity creates the mudflats about 200 ha/year toward sea, forming a large tidal wetland area of 10,000 ha. The area of the reserve is about 65,000 ha. Its altitude is from 1 to 3m above sea level. The salinity changes from 5 to 30‰ (NaCl) depending on the distance to river mouth and on the tide. pH is about 8 to 8.4 depending on the tidal flooding level and season. The water temperature in summer is about 23 to 27°C and slightly lower in winter. The difference of water temperature between the surface and bottom layers is about 1°C.

The population of Xuan Thuy district up to 2002 was about 370,421 people with the natural birth rate of 1.79%. Consequently the population density is 1040 people per km^2 (Tuan, 2010). It is said that 89,645 households with 167,576 agricultural laborers are pressurizing the exploitation and sustainable use of natural resources of which an important part belongs to mangroves.

Materials and methods

In this study, we conducted the direct observation and interview with constructed questionnaire in 4 communes closed to the study site (Giao Thien, Giao Xuan, Giao Lac and Giao An). The questionnaire contained both closed- and open-ended questions and composed of basic information about socio-economics, uses of mangrove, attitude toward mangrove conservation and participation in mangrove conservation. The method of cost benefit analysis was also used in this study to evaluate the benefit of community participation in mangrove conservation.

Figure 2 Location map of Ramsar Site in Xuan Thuy District, Vietnam

Major pressure in the use of natural resources

Pressure of population growth is considered to be most important impact on resource management. In 1989 the population of 4 communes of Giao Thien, Giao Xuan, Giao Lac and Giao An were 7,387, 7,317, 7,329 and 7,191, respectively, in 2010 the number of people increased up to 8,468, 8,331, 8,446 and 8,506. The annual average growth is about 200 people. The percentage of natural population growth is from 2.4% to 2.9%.

It was estimated that the total food production in rice equivalent increased only from 2,025 tones (1994) up to 4,052 (2000), or the annual growth is about 400 tons while the population growth is fast as mentioned above. Consequently the production is not able to supply food needed. Moreover, there are a lot of requirements on energy (firewood, wood) domestic needs which are gradually increasing to create a pressure on the exploitation of natural resources.

The expansion of aquacultural area (shrimp, fish ponds) has increased. The area of shrimp and fish ponds has increased from 837 ha (in 1989) to 1,926 ha (in 1994) (Thu, 1994) and 1,890 ha (in 2010). This expansion has been related to dike construction and mangrove destruction for building ponds. Attention should be paid to the fact that the production is unstable although the aquacultural area increased.

Approaches of community participation in managing the resources

In the natural reserve area, local people from 4 surrounding communes (Giao Thien, Giao Xuan, Giao Lac, Giao An) are allowed to go catching fish and shellfish without destruction of mangroves. The interview result shows that many people from Giao Thien, Giao An communes have gone there to catch crab and snail by hands and hooks and the others coming from Giao Lac, Giao Xuan communes come to catch mainly shellfish or mollusks. The distance from their houses to catching sites is about 4-7 km. Besides there are some people from far away communes like Binh Hoa, Giao Thanh and Giao Yen (12 km) who have gone there to catch terdinidae. Catching fish, shellfish, and crab is mainly done by hand and other tools like trap, net, hook, etc.

On the average, every day there are about 280-300 people coming Xuan Thuy Mangrove to collect aquatic catching-products. The average daily production of the people is about 0.25 kg of small crab or crab and 0.1 kg small fish, adding up to about 1 USD. For those who work with bamboo trap for catching, they have a production of about 10 kg shrimps and other small fish per day and a little higher production when using bamboo tube traps, i.e. about 12-13 kg shrimps and fishes per day. The people catching shellfish and mollusks including snails have lower income of about 2 USD per day. The number of such people is rather large (170 people per day in average).

Although the income is not much, the pressure due to material and spirit needs of local people on resources has reduced mainly because they realize that these resources are their own. In recent years, those who have been being allowed to catch fish, shrimp crab and shellfish have responsibility and volunteer to replant mangroves and to protect them from illegal cutting by others. Some people have joined into groups to prevent those who use high-voltage electricity, dynamite in fishing causing total destruction of aquatic resources directly affecting their life.

In buffer and surrounding areas it should be realized that if environmental protection is well done, the living standard of local people will be improved. The planning and land allocation to local people for construction of shrimp and fish ponds should be closely attached with responsibility in planting and protecting mangroves.

The land allocation for local people to construct shrimp ponds should be limited to the buffer zone by legal contracts. It could be allowed for a group of people to participate in planting, culturing as well as managing the reserve.

At present, there are about 50 ponds with the area of from 2 to 50 ha. There are a lot of ponds keeping mangrove trees inside and gaining a rather stable productivity. For example, a 4 ha shrimp pond owned by Mr. Ngo Van Toai was used from 1994 to 2010 with annual stable productivity of 100 kg shrimp with the export standard and 45 kg of crab, 90 kg of small fish, and 150 kg of other aquatic products as part of the total harvest. It is estimated 200,000 USD was the total income. Expenditures included charge, adding seed or larvae fees, protection and harvest hire fee and other miscellaneous expenditures; the net benefit would be about 150,000 USD.

It is clear that this is not much of an income but it is sustainable and mangrove has been preserved because water change has been regularly done. These households are mainly involved in agriculture activities and one or two people are hired to take care and protect the ponds and mangroves.

Besides, bee keeping is one of the activities supporting both economic benefits and good mangrove protection. It is estimated that every year there are 700 bee-troops brought here to profit mangrove flowers. The production is about 22 kg honey per troop with a price of 1.5 USD/kg. After the flowering season these troops have been transported to other sites in mountainous provinces. Local people have a good idea of mangrove species flowering regimes around the year and include planting of litchi, longan in gardens situated behind mangroves to profit bees. There is room for investment in this regard.

Meretrix has been cultured for exportation and it has become major resource which is closely related to mangrove existence. There are now 53 households having culture grounds of 200 ha in this area. It has a high productivity and annual production is up to 500 tons. Following profits from the resource, the role and responsibility of local people to mangrove protection has been improved because the mangroves serve well for meretrix as well as other shellfish culture. Consequently they participate eagerly in mangrove protection.

The pressure on wetland reserve area has been significantly reduced by regulation in allowing local community to share benefits as well as protection responsibility of mangroves which are the shelter and feeding around of endangered migratory birds not only in Xuan Thuy but also those Southeast Asian regions.

Although there are still a lot of problems such as the ponds cover a large area (40-50 ha) leading to much difficulties in water changing and management, inadequate aquaculture productivity, unharmonized land allocation regulations, the community participation in sustainable use and protection of resources has created an initial success.

Principles for community participation of mangrove conservation

The principles for community participation in mangrove protection and restoration have been proposed basing on the results and experiences from the study mentioned above, some of which are summarized as follows:

• *Voluntary spirit:* being aware of the value of mangroves as well as the role of mangrove protection and restoration in protection of their livelihood, local community voluntarily take part in mangrove protection in coordination with competent organizations and agencies.

• *Benefit sharing:* individuals in community have the same right in sustainable exploitation of mangrove products.

• *Reconciliation with the benefits of the community, locality and whole nation:* mangrove protection and restoration activities ought to be sufficient for the common benefits of the whole community and locality.

• *Sustainability:* mangrove protection and restoration have to be conducted regularly and for a long period, ensuring sustainable development of mangrove forests.

• Way of implementation has to be in line with culture, tradition and customs of local people and legislations of the country.

Improving awareness about the need to protect the coastal environment and the natural resources as well as mangrove forests is a matter of necessity for governments of all levels, communities, and individuals. Therefore, many activities have been being carried out to make coastal local communities aware of the importance of mangrove forest and remind people that mangrove forests are a common property managed by the State. People, therefore, are not allowed to destroy mangroves. Mangroves need to be protected and used sustainably. Some of those activities are as follows:

• Propagation and education

- Introduction to the role of mangrove through slide films
- Video films on show
- Pictures of mangrove forests
- Students' painting works
- Comic pictures and posters
- Poems and songs
- Game: ranking pictures and photos, quick picture tear and paste, or picking flowers and answering questions with the theme "Understanding mangroves and our surroundings"

• Organization of "Mangrove forest clubs"

• Contests about mangroves and mangrove conservation

• Development of the internal magazines on mangroves

• Exchange meeting program held for club members

• Visiting to mangroves

CONCLUSIONS AND RECOMMENDATIONS

Community participation in management and protection of resources is not new to us and community participation in sharing of benefits from forest exploitation and responsibilities for mangrove protection and restoration has witnessed initial effectiveness in Vietnam. However, for further effectiveness of community activities, deeper research should be conducted.

Interests of each individual, group or the whole community obtained from mangrove protection and restoration should be closely associated with strict management policies so that they can understand the benefits/interests they get from their participation in forest management and protection.

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Sustainability of Mangrove Forest Management by Local People in Thailand

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ABSTRACT

A social survey was conducted in Yeesarn, Samut Songkram province, central Thailand on community-based mangrove conservation measures. A census on socio-economics and involvement of the local stakeholders was investigated. Interviews were made with 3 different target groups, consisting of 50 mangrove plantation owners; 8 charcoal kilns owners; and 12 charcoal producers who rent the use of kilns owned by others. In addition, direct observation and in-depth interview with 2 persons from each group were conducted.

The investigation revealed that the majority of respondents were locals and who had inherited mangrove planting and charcoal production knowledge and skills from their relatives. Local wisdom in mangrove planting and charcoal production has been accumulated and passed on from generation to generation within the community. The average land holding of 9.28 ha per household was insufficient for mangrove wood production to run annual rotational harvesting and planting, which would bring a steady annual income. Therefore, it was necessary to engage in other income-generation activities. However, most of the mangrove wood producers stated that problems and obstacles in mangrove planting were at an acceptable and manageable level. The charcoal producers encountered much difficulty in finding sufficient labour to carry out wood harvesting, this was especially the case among the group of smallholder charcoal producers who rented kilns. This problem discouraged them and may result in their giving up charcoal production in the near future. In terms of factors affecting mangrove plantation' sustainability, biophysical factors were found to be the most important. The physical conditions pertaining to soil and tide water were suitable for mangrove planting but were a constraint for growing other kinds of plants. Most mangrove wood producers found it economically worthwhile to invest in mangrove planting. Although incomes from

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mangrove plantations were only a small part of total household income, it was regarded as family savings and was better than not using the land at all. On the other hand, mangrove wood producers had to earn enough income from selling wood or other occupations while waiting for the next rotation to be harvested, which took around 12-15 years. The inheritance of mangrove planting knowledge and skills from generation to generation has caused the occupation of mangrove planting to remain in Yeesarn community (p=0.004).

Key words: community-based management, mangrove forest, *Rhizophora apiculata*, plantation

INTRODUCTION

The area of mangrove forest at Samut Songkhram province decreased rapidly after 1975 (Vibulsreth, et al., 1975; RFD, 2004) due to conversion of the mangroves for shrimp farming, which was common in many coastal zones within Thailand. However, many villagers in Yeesarn community continue to maintain their local knowledge on mangrove conservation, this knowledge has been within the community for almost a century as villagers initiated mangrove *Rhizophora apiculata* plantations in 1907. These mangrove plantations were the first to be planted in Thailand. *Rhizophora apiculata* wood has been used mainly for a raw material for charcoal making and as construction materials for decades. The mangrove forest area of the province was recently estimated at about 1,276 ha (RFD 2004) including of 1,352 ha R. apiculata plantations (Hassan 2006). The remainder is distributed along the coastal line of the province. The most fertile and thick mangroves along the coast occur near the river mouths of Klongkhon (Figure 1).

Though the number of villagers who are willing to plant and manage mangrove plantations and produce charcoal has gradually decreased here are still individuals who deliberately carry on this local business which they have inherited from their relatives. Current interest in sustainable economies which include social and environmental sustainability has lead to a renewed interest in community-based mangrove forest conservation measures in this area.

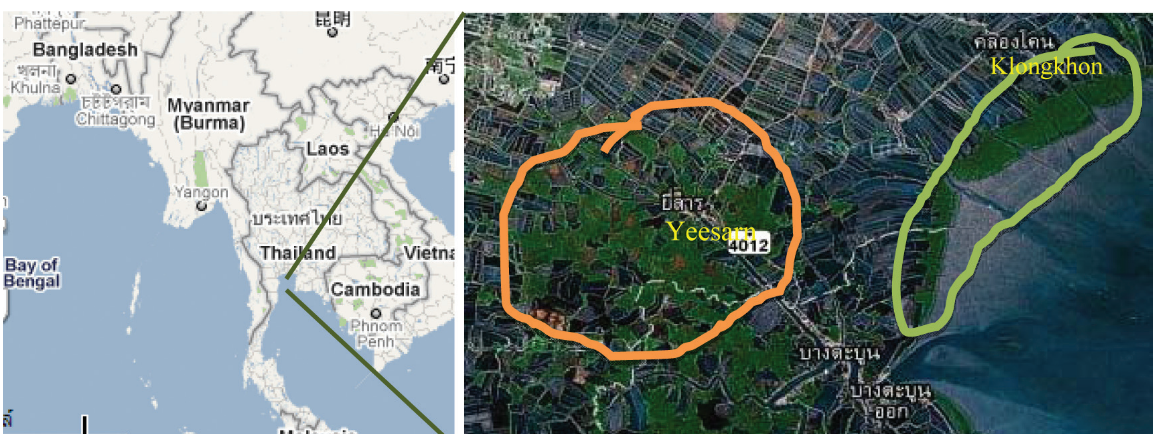


Figure 1 Mangrove area in Samut Songkram province, central Thailand

OBJECTIVE

The objective of our study was to investigate socio-economic conditions of local stakeholders involved in the mangrove conservation with emphasis on *R. apiculata* plantation for charcoal production. Factors affecting sustainable management of mangrove plantation at Yeesarn community were studied. Three major approaches under the sustainable development concept (Russell 2003) namely, economic viability, socially just, and ecosystem equilibrium were applied.

METHODS

The methods for this study consisted of structured interviews and rapid rural appraisal (RRA) techniques' e.g. direct observation, in-depth interview, etc. The respondents were divided into 3 groups. The first were mangrove tree planters, the second were charcoal kiln owners, and the last group were charcoal producers who rented the kilns. A simple random sampling was used for the selection of 50 samples from the first group (Scott, 1985). For the other groups, all individuals were interviewed including 8 charcoal kiln owners and 12 charcoal kiln renters . In addition, two respondents from each group were selected for in-depth interview. Data was analyzed and described with a simple statistics such as percentage and average values. Chi-square was calculated for testing the influence of the variables.

RESULTS AND DISCUSSIONS

Socio-economic conditions

Social

More males than females were involved in mangrove plantation and charcoal production. Particularly for those who rented kilns, over three-quarters were male. Most of the individuals involved with charcoal production were born in Yeesarn community and only a few had moved from adjacent areas. The owners of the mangrove plantations and charcoal kilns tended to be elderly people, mostly over 60 years old, who had inherited the business from their parents or relatives. The age of individuals who rented charcoal kilns tended to be younger, they were mostly between 45 to 60 years old. From the in-depth interviews, we discovered that charcoal production from mangrove trees is an extremely hard and complicated job. There were so many management processes from wood material searching, wood harvesting, charcoal processing and marketing of the production (Table 1). Thus, most give up the job when they become the elder.

Table 1 Management processes for mangrove charcoal production.

Steps	Activities	Local knowledge base
1 Search wood source	Purchase aged-*Rhizophora* plantation	Forest inventory and valuation
2 Harvest wood product	Hire workers/boats to cut/carry wood	Logging and transportation
3 Combustion wood log	Charcoal kiln operation	Combustion process
4 Marketing of charcoal	Hire workers to pack and weight	Packaging and marketing

All of the owners of the mangrove plantations had completed primary school; nevertheless, through learning by doing they have become professional managers in such a difficult business. Local wisdom in mangrove planting and charcoal production has been accumulated and passed on from generation to generation in the household and at the community levels.

Economics

Both the mangrove plantation owners and the charcoal producers gained their income from a variety of sources. More than half of the plantation owners gained one third of their total income from mangrove plantations. Thus, for only one-third of the plantation owners were the mangrove plantation management their main occupation, whereas, for the remainder plantation management was a minor or supplementary occupation. Important factors forced plantation owners to find other sources of income were the size of land owned and rotation requirements of *R. apiculata* trees. The other jobs they simultaneously or sequentially worked included charcoal production, aquaculture, employment, officer, merchant and other private jobs.

The costs for mangrove plantation consisted of *R. apiculata* viviparous seedlings (c 0.77 US$ per 100 hypocotyls) and hiring workers (at a minimum wage of 5.43 US$ per man-day). The price of the plantation depended on the wood production and the distance from the charcoals' mill. Based on the recent value of *R. apiculata* plantation (1,250-2,083 US$ per ha) and the planting cost of about 350 US$ per ha, their average annual income of 10 US$ per ha from commercial wood was about viable.

Half of the charcoal producers who owned the kilns also planted mangrove trees as their main occupation. One-third of them produced charcoal as their main occupation, the others produced charcoal as a minor occupation. Those who owned many kilns and could not manage to produce the charcoal to utilize the kilns fully, thus, they hired some kilns to other producers. Some kiln owners even hired all their kilns out.

All rental kiln charcoal producers stated that they produced charcoal as their main occupation. However, only one-third relieved exclusively upon charcoal production for their income. Half gained two-thirds, and the rest gained a half of their total income from charcoal production. Therefore, the majority of rental kiln charcoal producers generated income from other sources such as planting *R. apiculata*, through hired work, renting abandoned shrimp ponds, and fishing. Most had hired charcoal kilns for a long time. Interestingly, the charcoal producers and the owners of charcoal kilns were somewhat dependent upon each other. For instance, the kiln's owner advanced investment costs to charcoal producers, who were then expected to sell their products to the kiln's owner.

The charcoal producers who owned both the kiln and the plantation generated sufficient income from charcoal production and hired out some of the kilns. A rental fee of a charcoal kiln was about 1,000-1,160 US$/year (about 10 combustion cycles). That included the cost for hired workers to look after the charcoal kiln as well. The production was about 7 ton charcoal per kiln per cycle. The annual income from one charcoal kiln was estimated at about 23,300 US$.

Land and land use

Land ownership of the respondents was on average 9.28 ha, but mostly less than 8 ha with only a few that hold more than 16 ha. A large area of the land was used for a traditional natural aquaculture. Many villagers had sold their land to private companies or wealthy persons. Some charcoal producers intended to hire their land for planting mangrove trees. Therefore, wood production can be sustained for the production of charcoal.

Respondents with less than 8 ha of land perceived that they had insufficient land to allow rotational harvesting of their mangrove plantations. This land shortage resulted in them generating insufficient income for their livelihoods. Of the land owners with 8-16 ha, 6% of mangrove plantation owners and 37.5% of charcoal producer perceived that their land was sufficient for their needs (Table 2). Some explained that they planted mangrove tree for subsistence rather than commercial needs, some wanted to maintain their family tradition of managing mangrove plantations. In addition, the site quality of the land was only suitable for mangrove species and not for other terrestrial tree species.

Table 2 Attitudes of the respondents on land size for investment mangrove *R. apiculata* plantation.

	Plantation owner (n=50)			Charcoal producer (N=20)					
				Kiln owner (N=8)			Kiln tenant (N=12)		
	Sufficient (%)	Insufficient (%)	Total (%)	Sufficient (%)	Insufficient (%)	Total (%)	Sufficient (%)	Insufficient (%)	Total (%)
<8	16.0	68.0	84.0	-	50.0	50.0	-	100.0	100.0
8-16	6.0	8.0	14.0	37.5	-	37.5	-	-	-
>16	2.0	-	2.0	12.5	-	12.5	-	-	-
All	24.0	76.0	100.0	50.0	50.0	100.0	-	100.0	100.0

On the other hand, 8% of the plantation owners indicated that 8-16 ha of land was insufficient for mangrove plantation investment. First, the benefit from plantations was not able to cover various expenses during the waiting of wood production. Second, they have to support their children to go school. Thus, they needed to do traditional aquaculture to generate income quickly to meet their living expenses.

All the respondents who owned more than 16 ha perceived that it was a sufficient land size to manage mangrove plantation sustainably. This was support by informal interviews when the most of the villagers in the study area agreed on the statement. Normally, it takes about 12-15 years to rotate the felling cycle of *R. apiculata* plantation. Thus, they can divide their land into a small patches of approximately 1 ha for an annual planting area. This was greatly differ from the Matang mangrove management in Malaysia where the rotation of *R. apiculata* was set at 30 years, patches mangroves (annual coupe of a thousand hectares) are clear-felled each year with thinnings (for the production of poles) at 15 and 20 years (Ong, 1982; and Chan, 2001).

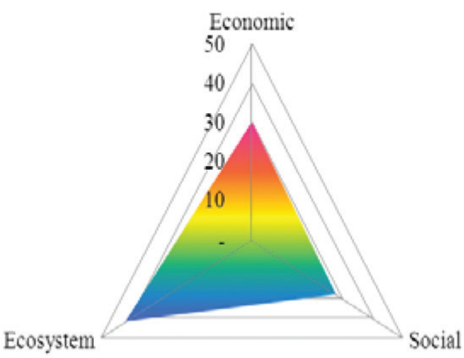
Mangrove plantation and charcoal production problems

Apart from the limitation of land, there were some problems related to mangrove conservation in the study area. The lack of capital and labour, low production levels, poor market, low price of wood, and thieving of wood were among problems listed by respondents. However, the plantation owners stated that the problems were not serious and were manageable. Small land holders (<8 ha) planted the *R. apiculata* trees instead of leaving the land unused. When plantation trees reach a harvestable size, charcoal producers will contact plantation owners for wood purchase. Afterward the buyer will be responsible for all logging and transporting costs. Clear felling in a specific area was used for logging. Wood billets length of 1.4 m were logged, debarked and transported by boat to the mill. Small canals were dug if necessary for wood transportation. Plantation owners usually leave the felling site one or two years before reforestation. The fallow period was useful both for site and seedlings preparation; and also looking for labourers to carry out seedling planting. The small land holders replanted their forest by themselves. Plantation owners perceived that their wood production was decreasing. The attitude was confirmed by comparing the plantation yields estimated by Wechakit (1987) and by Hassan (2006). The average yield of a 12-15 years old plantation was estimated by Wechakit (1987) as 193.86 cu m per ha. Whereas, the yield estimated by Hassan (2006) was only 112.5 cu m per ha. That means the yield decreased by 41.94% over 19 years. The change of mangrove land use for aquaculture was attributed to be one of the major causes leading to a decline in productivity. Inundation of tide water to the planting site was obstructed by the sedimentation of waste materials discharged from the aquaculture ponds. Planting areas were not inundated regularly by sea water which resulted in the slow growth rate of *R. apiculata* trees.

The charcoal producers faced moderate problems concerning investments. Firstly, they needed lump sums for wood purchasing. In order to purchase the wood they have to pay for a unit area of plantation for instance 1,250-2,083 US$ per ha. Many charcoal producers, who hired the kiln, have to ask for loans from the kiln owners. In such cases, they must sell the charcoal products to owner of the kiln at a fixed price. The second problem was the lack of labour in mangrove tree logging. Few workers accepted this job because it is so hard and dirty. They have to cut the tree into 1.4 m logs, debark the logs, and transport them to the mill. For a hundred of billets landed at the mill site they will get 3.33 US$. A team of ax-men usually composed of 2-3 workers with a boat and necessary equipment's for logging. In order to sustain raw materials for charcoal production, the producers had contracted with several teams of ax-men. They have to pay for labour costs not only on a fixed wage, but also some other incentives as well.

Factors affecting sustainability of mangrove forest plantation

Findings from the interviews revealed that most of the mangrove plantation owners (86%) expressed their willingness to continue their business. Based on sustainable development concept, we classified their possible incentives into 3 aspects namely economic, social and ecosystem. Forty-two per cent of them valued the ecosystem as the most important priority for mangrove plantations, whereas, 44% valued the ecosystem as a second priority (Figure 2). The area was suitable for mangroves, so-called species/site matching. The substrate was muddy and regularly inundated by sea water which enhances the growth of mangrove species without requiring any additional inputs. Some stated that they lacked of alternatives for agriculture. The detailed perception of plantation owners on the values of *R. apiculata* plantation is shown in Table 3.



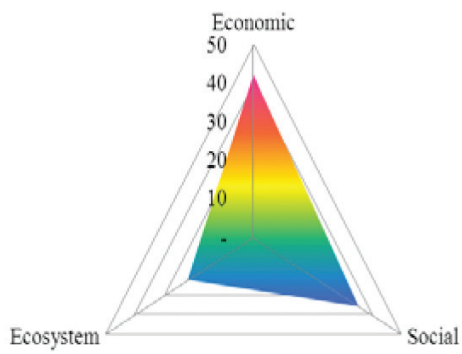


Figure 2 Perception of plantation owners on the values of *R. apiculata* plantation (left: value for the first priority; and right: value for the second priority)

Table 3 Detail perception of plantation owners on the values of *R. apiculata* plantation (n=43).

Application of the sustainable development concepts	Perceptions of the respondents (n=43)	
	First priority*	Second priority**
Economic viability	30.23	42.22
Satisfy the benefit/cost ratio	23.25	31.11
Enough income/saving while waiting for wood harvest	6.98	6.67
Indirect benefits from the plantation i.e. aqua-animals	-	4.44
Social just	27.91	35.56
Inherited occupation from ancestors	25.58	17.78
Support from state enterprise (CDM?)	2.33	-
Capability/skill to do the job		13.33
Close up with family, no need to migrate	-	4.44
Ecosystem equilibrium	41.86	22.22
Suitability of land use (soils and tidal water inundation)	39.53	22.22
A measure for mangrove conservation	2.33	-
* Each respondent answered 1 choise only		
** Each respondent answered 1 choise or more		

Remark: Applied sustainable development concept from Russell (2003)

There were some plantation owners (14%) who wanted to give up mangrove planting. The main reason was economic aspects. It takes more than 10 years to get the benefit from mangrove plantation and they could not wait that long. Some wanted to change all their land use for shrimp farming so that they can gain income continuously. Some do not have successors. They wanted to sell their land if the price was satisfactory. Some individuals with a very small land area stated they wanted to build new houses for their children.

Table 4 shows the result of analysis of socio-economic conditions and decision making of the respondents regarding continuing mangrove plantations. Availability of successors was the only factor that influenced on the decision significantly. All of those who have a successor will continue their inherited mangrove plantations ($p < 0.01$).

Table 4 Analysis of socio-economics and decisions of the mangrove plantation owners.
Socio-economic conditions of plantation owners Decisions of plantation owners (n=50)

Socio-economic conditions of plantation owners	Decisions of plantation owners (n=50)		
	Continue (%)	Not continue (%)	Sig.
Sex			.506
Male	50.00	10.00	
Female	36.00	4.00	
Age (year)			.324
<45	2.00	2.00	
45-60	30.00	4.00	
> 60	54.00	8.00	
Education level			.626
Primary school	72.00	12.00	
High school	4.00	-	
College	6.00	-	
University	4.00	2.00	
Purpose of planting			.183
Main occupation	34.00	2.00	
Minor occupation	50.00	10.00	
Supplement occupation	2.00	2.00	
Land tenure (ha)			.461
< 8	70.00	14.00	
8-16	14.00	-	
> 16	2.00	-	
Average for the continued group 9.8 ha			
Average for not continued group 5.9 ha			
Income gained from the plantation			.530
Less than 1/3 of the total household income	50.00	12.00	
About 1/3 of the total household income	18.00	-	
About ½ of the total household income	6.00	-	
About 2/3 of the total household income	8.00	2.00	
100% of the total household income	4.00	-	
Availability of successor			.004**
Available	50.00	-	
Not available	36.00	14.00	

Conclusions

The *R. apiculata* plantation in Yeesarn is a good example of community-based mangrove conservation in Thailand. The villagers have sustained their inherited local knowledge regarding wood and charcoal production for nearly a century. From generation to generation they continuously improved skills and techniques within their households and the community. However, most of them were elders and foresaw that their successors would be fewer in the near future.

Wood producers, the owner of *R. apiculata* plantations, were mostly local people. Each owned approximately 9.28 ha of land. Their concerns regarding the size of land was that it was not sufficient to sustainably manage for timber forest products. Thus, mangrove plantations are only a minor or supplementary occupation for them. Problems related to mangrove tree planting were fewer and manageable.

Some charcoal producers, mostly of middle-age, rented the use of the kilns from their neighbors to make charcoal. Based on community knowledge which they had implemented continuously, they had no serious difficulty in carry out this hard and complicated work. Both wood producers and charcoal makers were dependent on each other. A major problem concerning mangrove charcoal production was shortage of labour. This problem strongly impacted to the producers who rent the kilns from the others. They said that they may give up this business in the future if the problem remains unsolved.

There were various factors influencing community-based mangrove forest conservation in Yeesarn. Sustainability of mangrove plantation was affected mainly by biophysical factors. The physical conditions pertaining to soil and water tide were suitable for mangrove planting but were a constraint for growing other terrestrial plants. Besides, most mangrove wood producers found it economically worthwhile to invest in R. apiculata planting. Although incomes from the plantations were only a small part of total household income, it was regarded of family savings and was better than not using the land at all. On the other hand, mangrove wood producers had to earn enough income from selling wood or other occupations while waiting for the next rotation to be harvested, which took around 12-15 years. In addition, inheriting mangrove planting and management knowledge and skills from generation to generation has remarkably caused the occupation in mangrove planting to remain within the Yeesarn community

Current information from an officer at the Yeesarn Tambol Administration Organization (personal communication) revealed that about 8,550 cu m of mangrove *R. apiculata* wood were used annually for charcoal production. Based on an average volume of the plantation, aged between 12-15 years, of 112.5 cu m per ha; approximately 76 ha of the plantation are needed in order to maintain wood supply for charcoal making. According to Hassan (2006), *R. apiculata* plantation in the area was estimated at 1,352 ha. So, the community-based mangrove forest management in Yeesarn shall be secured for wood utilization and charcoal production at least 17 years more.

Acknowledgement

First of all, we would like to thank the people of Yeesarn in providing valuable information on their livelihood concerning the community-based mangrove ecosystem conservation. Thanks are given for students from Department of Forest Management, Faculty of Forestry and the Sustainable Land Use and Natural Resource Management of Kasetsart University (KU-SLUSE) for their hard work in field data collection. We also would like to thank for partial support of the Graduate School of Asian and African Area Studies, Kyoto University and the Research Project E-092 by the Global Environment Research Fund, Ministry of the Environment, Japan. This paper was reviewed from a previous version published in the Journal of Agroforestry and Environment. A special thank isare given to Dr. Catherine H. Traynor for valuable comments and English correction.

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A Review of Mangrove Conservation and Management in Myanmar

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ABSTRACT

In Myanmar, mangrove forests are mainly found in three geographical regions, Rakhine, Taninthayi, and the largest area is within the Ayeyarwady delta. Mangrove forests are important not only for the livelihoods of coastal people but also for environmental services. Mangrove coverage is rapidly declining because of direct and indirect causes, primarily population growth. Owing to the expansion of agriculture and excessive cutting for fuelwood, the 382,023ha of mangrove forests at the beginning of the 1990s was halved by 2002. In the Ayeyarwady delta, mangrove forests are decreasing because of overexploitation for fuelwood collection, charcoal production, illegal logging, and encroachment of paddy cultivation especially during the period 1965–1990, when average annual fuelwood removal peaked at 93,812 tons (Kyi, 1992). Mangrove forests have been managed by the Forest Department, via the establishment of reversed forests and protected areas. Since the 1980s, the Forest Department has established many mangrove plantations in the delta to meet the fuelwood deficiency. Community forestry was initiated in the delta in 1998. Meanwhile, non-governmental organizations have also been involved in implementing rehabilitation programs.

Key words: Mangrove, overexploitation, rehabilitation, Ayeyarwady delta

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INTRODUCTION

Myanmar has a total land area of 676,577 square kilometers (sq.km), with a continental shelf of 225,000 sq.km. Tidal forests, beach and dune forests, and swamp forests account for 4% of the country's total forest area (Han, 1992b). The coastal zone of Myanmar covers three regions, Rakhine (formerly Arakan), the Ayeyarwady (formerly Irrawaddy) delta, and Taninthayi (formerly Tenasserim), with a coastline of approximately 2,832 kilometers along the Bay of Bengal and Andaman Sea. The population of the coastal and delta areas grew from 9.6 million in 1983 to 12.7 million in 1997 (27% of the country's 1997 population, and a population density of 583 people/sq.km), and continued population increase has affected land use and coastal resources (Oo, 2002). Like tropical rainforests, the mangroves of Myanmar have been rapidly denuded and deforested by human activities. The most rapid deforestation occurred in the Ayeyarwady delta, where mangrove forests have been cleared for charcoal and shrimp production. Cyclone Nargis struck eastward across the delta in early May 2008, with winds reaching 212 km/hour. The cyclone and accompanying heavy rainfall (up to 600 mm), inundated more than 14,402sq.km of the delta, causing catastrophic damage and loss of life in the region, and has increased the vulnerability of the delta during storms owing to the reduced density of mangroves (Hedley *et al.*, 2010). This study aims to assess the extent of mangroves and to quantify the past development and present activities of mangrove conservation and management in Myanmar. We review this study through the working plans of the Forest Department, several papers, and academic books of mangrove ecosystems.

DISTRIBUTIONS OF MANGROVES IN MYANMAR

Mangroves are situated within tidal limits, on alluvial flats in the delta, and on sheltered muddy coastal areas, and are vertically stratified depending on tidal influence (FAO, 2005). Mangroves extend beyond the tropics, both northward in Asia, and southward in Africa, Australia, and New Zealand (Macnae, 1968). The mangroves of Myanmar extend along the coastline, from latitude 10°N and 20°N, and longitude 94°E and 98°E (Figure 1), a range of more than 1600 km (Ohn, 1992). Mangroves are also found on the region's offshore islands. The largest mangrove areas, in the Ayeyarwady delta, are reported to be being heavily degraded, with only 235 sq.km of undisturbed mangroves in the country by 1983 (Spalding *et al.*, 1997). Mangroves have largely disappeared from the eastern parts of the Ayeyarwady delta. Several forest reserves in the western areas retain scrubby mangrove forests, although these are heavily utilized as a source of fuelwood and charcoal for Yangon (Spalding *et al.*, 1997). Unlike the delta area, Rakhine state is not heavily populated. However, Rakhine mangroves were also heavily exploited to produce charcoal for the Ayeyarwady Division and Yangon, the major market centers of firewood and charcoal in Myanmar. In Taninthayi, mangroves are much better in floristic composition and denser in stock, given the relatively low population, and the fact that the coastal formation is better sheltered, particularly from cyclonic impacts (Han, 1992b).

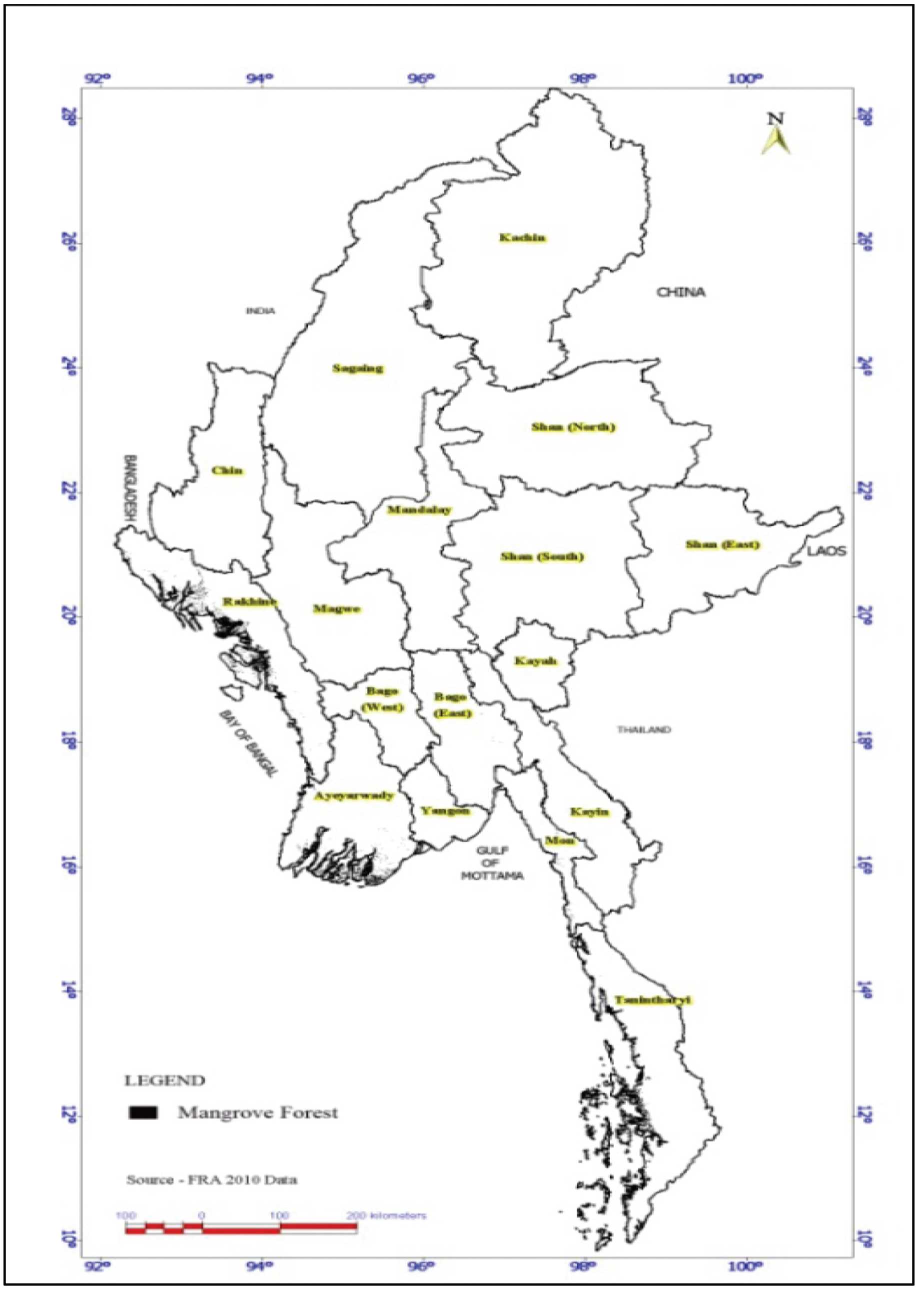

Figure 1 Map of Mangrove Forests Distribution in Myanmar
Source: Remote Sensing and GIS section, Forest Department

According to Spalding *et al*. (2010), Myanmar traverses the biogeographic transition between the South-East Asian and the Indo-Andaman floral communities, and it has 32 true mangroves species, including representatives from both communities. All three regions show the same species composition (Han, 1992b). In the Ayeyarwady delta, there are 29 mangroves and associated species, representing one of the most complex mangrove systems in Asia (Tomlinson, 1986). The first aerial survey of the Ayeyarwady delta, in 1924, found Kanazo (*Heritiera fomes* Buch.-Ham.) forests with large, isolated kambala (*Sonneratia apetala* Buch.-Ham.), and *thinbaung (Phoenix paludosa* Roxb.) (Stamp, 1925). Macnae (1968) reported that some areas along the west coast of peninsular Thailand, south of Myanmar, were occupied by extensive forests of *Sonneratia apetala* Buch.-Ham.), and others of *R. mucronata* Lamk. In Rakhine and Taninthayi, *R. apiculata* B1- and R. mucronata Lamk. are the predominant species, in association with *Heritiera fomes* Buch.-Ham., *Bruguiera gymnorrhiza* (L.) Lamk., *Avicennia* spp., *Sonneratia* spp., and *Xylocarpus* spp.

ROLE OF MANGROVES IN ECOLOGY

Mangrove forest ecosystems contribute a wide range of goods and services from which local communities benefit. These goods include food, medicine, tannins, fuel and construction materials. Mangrove services include acting as a buffer against wave-erosion and storm surges for inland areas; their dense roots systems absorb storm energy and protect inland silts while stabilizing the shoreline. Mangrove species are highly productive, and can absorb pollutants, thus improving commercial fisheries. Mangroves provide shelter and nursery grounds for fish and many marine organisms.

Mangroves are a key element in the evolution of tropical deltas such as the Ayeyarwady, acting as sediment traps, primary colonizers of shallow submerged sand bars (Osti *et al.*, 2009). Based on the late-nineteenth to early-twentieth century period of British involvement in the region, Stamp (1925) commented that *"very little damage to mangrove damage is caused by wind, and cyclones are unknown"* (Hedley *et al.*, 2010).

DEFORESTATION OF MANGROVES

Mangrove forests once covered more than 200,000 sq.km of sheltered tropical and subtropical coastlines, and are disappearing worldwide at a rate of 1% to 2% per year. It is estimated that nearly 40% of the remaining mangroves of tropical Continental Asia are degraded (Blasco *et al.*, 2001). In Myanmar, mangrove forests are very much depleted because of their close proximity to populated areas. Most are converted into paddy fields under the pressure of increasing population. The rate of decrease was found to be 0.2% to 0.3% during the period 1924–1973 (Thein, 1989). The rate of mangrove deforestation in the Ayeyarwady delta from 1984 to 1991 was 7,775 ha per year (Bo, 1992). In the mid-1950s, the tidal or delta forests of the Bassein Division (the Ayeyarwady delta) contained large areas of

Heritiera fomes Buch.-Ham.; today, these forest have almost disappeared (Blasco *et al.*, 2001). In Rakhine, mangrove coverage declined from 101,980 ha to 64,749 ha between 1958 and 1983, because of overexploitation. Deforestation is proceeding in mangrove ecosystems in Myanmar between Zigaing and Taungup (Rakhine coast) (Blasco *et al.*, 2001). In Taninthayi, mangrove coverage declined from 186,155 ha in 1958 to 140,021ha in 1988 (Pe Thein, 1989).

It is estimated that 98% (293,035 ha) of mangrove deforestation in Myanmar during the period 1975–2005 resulted from agricultural expansion (Giri *et al.*, 2007). The policy framework may also contribute to both the exploitation and conservation of mangroves, for example through policy initiatives to increase fish production (Saenger *et al.*, 1983). The delta mangroves are the major supplier of fuelwood for the needs of the Ayeyarwady Division and Yangon City.

Delta mangroves were overexploited during the 25- year period from 1965 to 1990. Owing to overexploitation of mangroves, the delta mangroves can no longer supply Yangon's growing fuelwood demand. Marine turtles and crocodiles in the Ayeyarwady delta and Rakhine are rapidly declining because of the depletion of mangrove ecosystems. Wild elephants in the Ayeyarwady delta and Rakhine mangroves are threatened by deforestation of mangroves, mainly caused by human settlements and agricultural encroachment (Han, 1992b). According to the Post Nargis Joint Assessment (PONJA, 2008), about 16,800 ha of natural forests and 21,000 ha of forest plantations were damaged in the Ayeyarwady delta by cyclone Nargis, during May 2008.

Table 1 provides some information on mangroves in Myanmar. However, information on the extent of mangrove vegetation is very limited because of financial constraints, and estimates differ within the literature.

Table 1 Mangrove areas in Myanmar

Year	Area extent (ha) in three regions			Total (ha)
	Rakhine state	Ayeyarwady division	Taninthayi division	
1972	101,842	n.a	186,322	288,164
1980	167,860	275,002	262,266	705,128
1989	64,750	177,252	140,021	382,023
2002	63,974	138,344	82,390	284,708

Source: Thein (1989), Han (1992b), Planning and Statistics Division, Forest Department

MANAGEMENT AND CONSERVATION OF MANGROVES

Historical management

Management of Myanmar mangroves started in 1900. The reservation of the Ayeyarwady delta mangroves began in 1895 and expanded until 1904 (Oo, 2002). There was no comprehensive management plan for the Ayeyarwady delta until 1924, when the first working plan (1924–1925 to 1933–1934) for the tidal forests of the delta was drawn up by Moodie. Using a control system based on forest area and tree size, mangrove forests were harvested sustainably on an annual basis. Carapiett produced the second working plan (1957–1958 to 1969–1970) for the delta forest division (Hoe, 1952), which included three working circles: the Delta, Kyauk kone, and Le pyauk. Working plans could not be drawn in the forest management strategy after 1972; owing to the uncontrolled extraction of preferred biofuel species, the entire area had changed, not only in species composition but also in land uses (Han, 1992a).

Silvicultural management

The tidal forests of the Ayeyarwady delta have long been a valuable source of timber and fuel for the towns and villages of the rice-growing regions of the delta. The most valuable tree species is the Kanazo (*Heritiera fomes* Buch.-Ham.), which may reach a height of 45 m. In order to protect Kanazo from unregulated exploitation and destruction, the more important of the tidal forests were formed into Government Forest Reserves between 1895 and 1901 (Stamp, 1925). From 1924 to 1970, the Ayeyarwady delta mangroves were managed via forest working plans that prescribed silvicultural treatment, harvesting time, utilization, and other relevant measures. The 1924 working plan initially specified girth limits for *Heritiera fomes* Buch.-Ham. of 213cm girth at 262cm above ground level. The prescribed girth was subsequently reduced to 121cm gbh (girth at breast height) in the reserves by 1929. Three years later, in 1932, gbh was increased to 140cm and 152 cm. The size-limit selection system was applied in the management of mangrove forests in Myanmar. The annual allowable cut was determined by dividing the area in the felling series by the duration of the felling cycle, which varied from 30 to 40 years. Macnae (1968) calculated that a forty-year rotation cycle would provide trees of a size suitable for the demands of the charcoal burners. Firewood and charcoal were the main products extracted from the delta working circle. Heritiera fomes Buch.-Ham. was the preferred species for firewood, but extraction declined because of a scarcity of exploitable sizes (Han, 1992b). Firewood was mainly obtained from Rhizophora (Byu) species, while posts and poles were produced from Ceriops decandra (Griff.) Ding Hou and Heritiera fomes Buch.-Ham. Species trials were initiated to restock the degraded Ayeyarwady delta mangroves, and a “coppice with standards” system was tried in place of the selective felling system (FAO, 1994).

Present conservation and management of mangroves

Mangroves in the Ayeyarwady delta have been major sources of charcoal production for many years. Meinmahla Kyun was designated as a Forest Reservation, in 1895, and there were five Reserved Forests designated in the Ayeyarwady delta by 1901. In 1992, Saw Han reported a total of 13 reserves in the delta, covering an area of 2859 sq.km. In 1993, the government strictly prohibited charcoal and firewood production from the Ayeyarwady delta mangroves. Meinmahla Kyun Reserve, an area of 136sq.km, was designated as a wildlife sanctuary in 1994. Protected mangrove forests are being established in the coastal areas to protect endangered fauna, and to conserve mangroves and coastal resources. Starting in 1996, the Forest Department formulated new management units (management plan) throughout the country, including the coastal mangrove areas. Mangrove plantation activities, focused on conservation, began on a small scale in the 1980s, expanding in the second half of the 1990s in the Ayeyarwady delta, to cover an area of around 14,000 ha. In the Ayeyarwady delta, 60 hectares of natural stands have been regenerated annually by means of tending operations. The most important mangrove species for reforestation is the native Avicennia officinalis L., which accounts for 50% of the reforestation area in the Ayeyarwady delta (Webb & Than, 2000). Some mangrove species were planted on experimental plots. A regeneration-improvement felling (RIF) strategy has been adopted to encourage natural regeneration and improvement of stands within the degraded mangrove forests. Since the mid-1990s, the UNDP/FAO project, under the Human Development Initiative Programme (HDI), has conducted a feasibility study on mangrove projects in Laputta and Bogalay Townships in the delta; from 1980-81 to 2004-05, this established approximately 14,140 ha of mangrove plantations in those Townships (FD, 2008). The Forest Department has implemented rehabilitation activities in Rakhine, Ayeyarwady and Taninthayi in cooperation with UNDP/FAO, JICA (Japan International Cooperation Agency), and local NGOs such as FREDA (Forest Resources and Environment Development Association). However, mangrove plantations in Rakhine and Taninthayi are still at a trial stage. A large-scale annual planting program was implemented in degraded mangroves and abandoned paddy fields. Community forestry plantations and private mangrove plantations were established in degraded and abandoned mangrove areas particularly within the Ayeyarwady delta.

CONCLUSION

There is limited data on the status and extent of mangrove forests in Myanmar. Mangrove forests within Reserved Forests are rapidly disappearing, and land outside the Reserved Forests has been converted to agricultural uses. Mangrove losses reduce biodiversity and adversely affect adjacent coastal habitats. Reduced mangrove coverage eliminates the major source of fuelwood and other products for the local communities that are rely on mangroves. Within the revised forest management plans, the Forest Department has managed mangrove forests in line with modern forestry concepts. The present plans focus on the production of timber and non-timber forest products (NTFPs), conservation of fauna and flora species, and the social wellbeing of local communities. The Forest Department has been responsible in managing mangrove forests through reservation, restoration, and rehabilitation activities.

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Transformation of Mangrove Charcoal Production in Batam, Indonesia

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ABSTRACT

In this paper, we describe how mangrove charcoal production activities continue alongside or despite industrial development on Batam Island, Indonesia. Five villages and two colonies of households producing charcoal were selected as investigation sites. From 2009 to 2011, interviews were conducted with local residents and local government staff. Even before the 1930s, mangrove charcoal was produced in kilns owned by Chinese Indonesians who lived in urban areas of Batam. In the early 1930s, local residents started to develop their own kilns to produce charcoal which they sold to urban areas. Later, the Batam prefectural government began to issue mangrove harvesting permits. The oldest permit possessed by an interviewed household was issued in 1971. In total, 59 kilns were identified within the selected study sites. One charcoal kiln has been producing mangrove charcoal since 1936, although most of the other kilns were established after 2005. The recent increase in charcoal production was prompted by the increase in overseas demand (against a reduction in local demand), which kept charcoal production profitable. The local government stopped issuing harvesting permits in 2007 thereby making current charcoal production illegal. About 20 years ago, mangrove wood and charcoal were the main fuels used in all the studied villages. Now, use of these fuels is limited to households producing charcoal. Most of the charcoal produced is exported overseas. Industrial development in Batam has been favorable to charcoal production as it has improved access to raw materials as well as overseas markets. Although charcoal production is often expected to have negative impacts on mangroves, the transformation of mangrove charcoal production in Batam may help ensure preservation and regeneration under continued use.

Key Words: charcoal production, industrial development, mangrove, preservation under continued use.

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INTRODUCTION

In Southeast Asia, charcoal is used as a daily fuel and charcoal production is an important livelihood for some rural residents (Ajiki, 1999). Mangrove wood is highly dense, making it and its charcoal excellent fuels (Baharudin, 1987; Ya Min, 2011). The rapid economic development of Southeast Asia since the 1980s, however, has led to the conversion of mangrove forests into various land uses such as industrial parks, agriculture, and aquaculture. It has also led to changes in occupation patterns of rural mangrove communities and to a reduction in the demand for charcoal partly because of the easier availability of fossil fuels (Cavalcante, 2009). As a result, charcoal production has generally been declining and has even ceased in some urban areas.

The rapid declines in mangrove forests and charcoal production might also reflect the fact that most of the countries with mangrove forests are developing countries, where large numbers of people depend on natural resource-based occupations (Glaser, 2003; Ruitenbeek, 1994). With increasing populations and greater integration with global markets, exploitation of natural resources including mangroves has accelerated (Torigai, 2004; Miyamoto K, 2010). In addition, after mangroves are converted into industrial and urban areas, the land is further degraded through the discharge of toxic effluents into rivers and estuaries (Rivelino, 2009). These problems have long been recognized and efforts have been made to conserve mangrove resources, including the declaration of some mangrove forests as protected areas. This prohibitive solution by law, however, is not necessarily the best solution to preserve the environment. Although some mangrove areas have escaped overexploitation because of legal protection, many cases have also been reported in which complete prohibition of economic activities in mangrove areas is not possible and the conventional utilization of forest and land could be more sustainable (Komiyama, 1992; Inoue, 2003; Walters, 2004). As Nakamura (1996) also pointed out in his study of Thailand, charcoal production may cause deforestation and degradation due to clear-cutting, over-harvesting, or illegal logging, but as long as the soil, which is crucial for mangrove existence, is maintained in its natural state, the mangrove forests can regenerate.

This study presents charcoal production in the context of its overall management strategy. Almost all previous studies of mangrove charcoal production were conducted outside urban areas and reported the drawbacks of management strategies. However, exploitation does not always result in destruction. In this study, we describe how traditional charcoal production on Batam Island, Indonesia, has transformed and still continues “sustainably” in spite of rapid industrialization and more open trade with neighboring countries.

RESEARCH SITE AND METHOD

The villages we selected as investigation sites are located on Batam Island, Riau Province, Indonesia. Batam is located in the Strait of Malacca about 20 km southeast of Singapore. The island has an international airport and harbors. Spurred by development in nearby Singapore, industrial development started in the area in the 1970s under the guidance of the Batam Industrial Development Authority (BIDA). BIDA was established under the direct control of the president in 1971, and all of Batam Island was designated as a bonded warehouse zone in 1978. Full-scale development began in the late 1980s when restrictions on foreign capital were relaxed. Export industries were particularly attracted to the island. Moreover, in 2000, Batam Island was made exempt from export-import and customs taxes making the island a free-trade zone. Batam Island is considered to be one of the centers of globalization in Indonesia due to its advantageous location for the Asian market along international sea routes. Its proximity to the more advanced Singapore continues to substantially influence its development. Batam now has an airport, 9 harbors, 21 industrial parks, and 128 multinational companies, as well as well-maintained roads that ease inland transportation and import and export shipping (BIFZA, 2010). In spite of these developments, mangrove forests are still found in the southern coastal areas (Balai Pengelolaan das Kepelauan Riau, 2006).

We collected statistical information about mangrove forests from forestry and fishery officials and local public officials, and data on development from BIDA. From August 2009 to August 2011, we also interviewed local residents about mangrove utilization. Several villages (A, B, D, E, F, and G) producing charcoal and a village (C) that did not produce charcoal now were selected as research sites (Figure 1). The names of the research sites are based on Harada's study (2012). The charcoal kilns of A, B, F, and G were located inside the villages, whereas those of D and E were established outside the villages at sites used only for charcoal production. Here, we refer to research sites A, B, C, F, and G as "villages" and research sites D and E as "colonies" (Harada, 2012). At each research site, we interviewed the charcoal producers, asking about the number of charcoal kilns and the method of charcoal production. We also asked about household information, methods of mangrove utilization, and household fuels used. To select households for interviews, we conducted random sampling among the households belonging to two RT (a RT is a sub-village administrative unit) located on the shore. Colony D had only three households, and thus all were targeted. In total, we sampled 175 households.

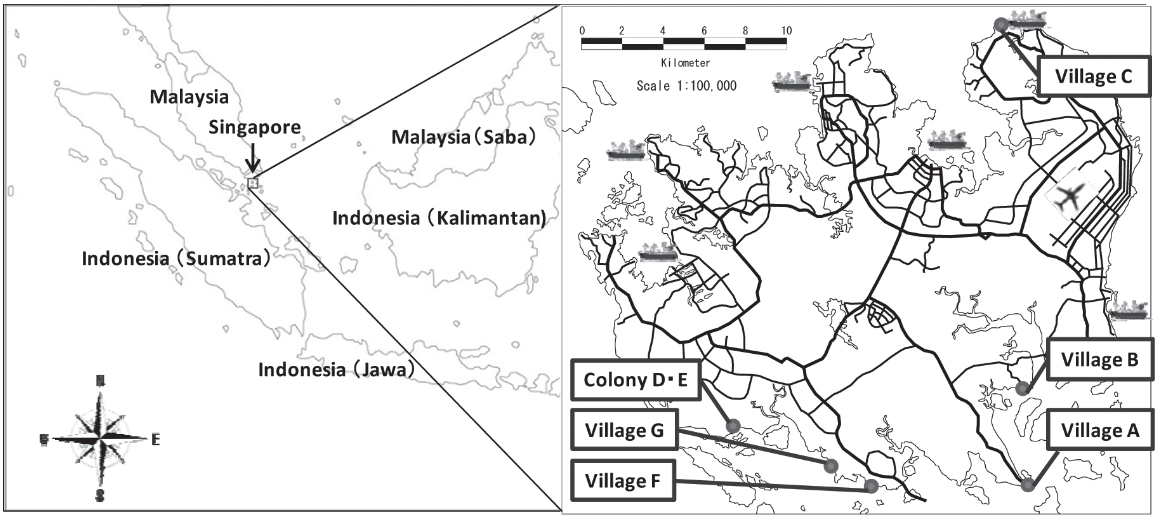

Figure 1 Research site ✻ The map was made from Google Earth by author
The right map includes main roads, international airport and port

RESULT

1. History of charcoal production

Use of mangrove forests has differed among the main islands of Indonesia. In Java, mangrove forests have been mainly converted into brackish water aquaculture ponds. In Sumatra and Kalimantan, mangroves have been cut for their timber or converted to farmland (Ajiki, 1996). Batam is part of the Sumatra region and thus the conversion of mangrove forests into fish farms, one of the typical effects of globalization, has generally not occurred in Batam. Moreover, as mentioned above, Batam's location has helped it become one of the busiest industrial zones in Indonesia (Miyamoto, 2000). Instead of land conversion, there has been a long history of mangrove charcoal production and exportation to Singapore and Malaysia (Burbridge, 1982), which has continued until present (Badan Pusat Statistik, 2000-2009).

According to our interviewees, mangrove charcoal was produced in Batam even before the 1930s. Early charcoal kilns were then owned by Chinese Indonesians living in urban areas. In the early 1930s, local residents started to establish their own charcoal kilns and produce charcoal by themselves, selling it to city dwellers. Early on, mangrove harvesting was regulated. According to the chief of Village F, the government began issuing permits to charcoal producers to harvest mangrove in the 1930s. The oldest permit possessed by an interviewed household (Village F) was issued in 1971. The local government stopped issuing permits in 2007; nevertheless, charcoal production continues (Pemerintah Kota Batam, 2008). Moreover, although the issuing of cutting permits ended in 2007, a presidential decree issued in 1995 had already prohibited the cutting of natural mangrove forests in Indonesia.

2. Status of mangrove forest management

In 2008, there were approximately 400 charcoal kilns and 857 people engaged in charcoal production in the whole of Batam prefecture (Pemerintah Kota Batam, 2008). Local government officials and the general public were aware that mangrove forests were still being harvested for charcoal production despite the legal prohibition. The local government's "blind-eye" policy toward charcoal producers could be due to the lack of other employment opportunities for people involved in charcoal production. Although industrial parks and factories are supposed to bring employment opportunities to local residents, Batam also attracts migrants who often are more qualified and competitive than some locals, including those engaged in charcoal production. As a consequence, there is a large disparity between existing regulations for mangrove cutting and the realities of charcoal production.

The change in the number of charcoal kilns per village is presented in Table 1. Although data are lacking prior to 2005, the number of charcoal producers has been increasingly since that year. Only Village F has possessed a harvesting permit and has continuously produced charcoal since before industrial development began in the 1970s. The table also shows that the number of charcoal kilns has increased even since 2007, when charcoal production was prohibited by the Batam local government. Of the 59 kilns identified within the selected study sites, 29 kilns were inside villages (Villages A, B, F, and G) and 30 were outside villages (in charcoal production spots, the colonies of D and E). The two colonies were used exclusively for charcoal production.

Table 1 Number of charcoal kilns per village

Years	1936	1937～2004 (unknown)	2005	2006	2007	2008	2009	2010	2011
Village A	0	4	0	0	0	0	2	5	5
Village B	0	0	0	0	0	1	5	6	12
Village C	0	uknown	0	0	0	0	0	0	0
Colony D	-	-	-	3	3	3	3	3	1
Colony E	-	-	5	unknown	unknown	unknown	unknown	29	29
Village F	2	2	2	2	1	1	1	1	1
Village G	0	2	0	11	11	11	11	11	11
Total	2	7	2	16	15	16	22	26	59

In a way, the transformation of Batam into industrial parks with well-managed infrastructures has made it easier for people to engage in charcoal production. For example, one person in village B said that he started making charcoal in 2011, even though in 2009 he had complained about smoke coming from a neighbor's charcoal kilns. He finally got into charcoal production himself after finding it profitable. The colony E was established mainly by immigrants from Sumatra who have been there since 2005. 29 kilns were operating in colony E in August 2011. The charcoal producers mentioned that the site has the advantage of a "better maintained infrastructure than the other areas making it easier to ship raw materials and charcoal products." Thus, charcoal production is an important occupation for people in the non-industrial sector.

3. Charcoal production

Materials

The type of charcoal kiln, materials, and building methods have not changed over time, which means that the original process of making charcoal is still followed. First, to make a kiln, an approximately 30 cm deep by 20 cm wide trench is dug marking the perimeter of the kiln. Bricks are placed into the trench and shaped into a dome that is affixed with soil mixed with water. The size of a kiln depends on its intended capacity but usually, for a 5-ton capacity kiln, the diameter would be approximately 5 m and the height approximately 2.5 m. Over the kiln, a simple roof is built using wooden poles. The roof is usually made of *Nypa fruticans*, but recently galvanized iron sheet roofs have also been used. The mangrove species used for charcoal production are *Rhizophora apiculata* and *Rhizophora mucronata*. These species have long been used in charcoal production in Southeast Asia. Both are dominant species of mangrove forests and have high wood density that results in high-quality charcoal (Nakamura, 1996). These mangroves are found in various parts of Indonesia (Burbridge, 1982) including the Riau Islands (Choong, 1990). Currently, *Rhizophora* sp. is also being made into charcoal in Batam.

Methods

The harvesting sites are usually near the charcoal production site. At the sites studied here, charcoal producers typically choose *Rhizophora apiculata* larger than 10 cm in diameter. Rowboats are usually used to carry out wood from the mangrove forests. After being transported, the branches are cut into pieces approximately 50 cm long and dried, usually by stacking them near the kilns. Finished charcoal is cut into 15-cm pieces and classified according to quality before being packed into sacks. Finally, the charcoal is sold to dealers in the cities. The value of mangrove charcoal ranges from Rp. 1500–2500/kg (Rp. 9,045 = US $1 in Feb 2012). At all our research sites, charcoal producers engage in every step of production, from harvesting to packing. However, no villagers engage in trading charcoal. Shipping is also conducted by people from outside these villages. All processes are conducted by hand without machines. Chainsaws are commonly used in other parts of Indonesia, but in Batam saws and hatchets are used and charcoal producers practice selective cutting, harvesting only trees that are suitable for charcoal production in terms of species and diameter.

According to interviews in the colony D, 25 tons of wood makes approximately 5 tons of charcoal, with an additional 3 tons of wood required for each production run. Thus, it is estimated that 28 tons of wood are needed for one production run in a 5-ton kiln. Furthermore, it is estimated that one-time wood harvesting was approximately 300 kg, and an average of 1 ton of wood is harvested in a day. Thus, a producer would have to harvest wood for one month to fill a 5-ton kiln to full capacity. The amount of time required for producing charcoal is as follows: one month harvesting, one month drying, two weeks stacking the dried wood and firing the kiln, and one week cooling. Packaging the charcoal takes only one or two days. If a household has multiple kilns, members can harvest for a kiln while another kiln is firing.

4. Transformation of charcoal production
Demand on and off Batam

Full-scale industrial development started in Batam in the 1980s, which is probably also when the use of mangrove forests started to change. We asked respondents in each village about mangrove forest use when they were children (Table 2). Before industrial development in Batam, most villages already utilized mangroves for fuel, as wood or charcoal. Today, alternative sources of fuel, particularly oil and gas, are being used (Table 3). Urban residents are the main users of gas for daily fuel, whereas rural residents often use oil, which is easier to supply than gas in rural areas.

Table 2 Utilization of mangrove forest in the past, 1975-1980 (%)

	Number of Sample Households	Fishery	Building Materials	Sale	Mangrove Wood	Mangrove Charcoal
Village A	43	12	14	21	70	67
Village B	28	0	14	36	39	46
Village C	15	7	33	53	13	93
Village D	3	0	0	33	66	100
Village F	24	-	-	0	0	100

* Includes Overlapping Answer

Table 3 Main source of fuel by households, September 2009(%)

	Number of Sample Households	Gas	Oil	Wood	Mangrove Wood	Mangrove Charcoal
Village A	55	2	95	16	0	4
Village B	52	3	90	21	17	14
Village C	41	51	95	24	0	0
Village D	3	0	100	100	0	100
Village F	24	0	42	8	33	92

*Includes Overlapping Answer

In the colony D and Village F, however, all households use mangrove wood or charcoal as their main fuel. They use these fuels because they are free, not necessarily because they are convenient. This especially true in Village F where excess charcoal pieces are often left after shipments and picked up by all households including those who do not engage in charcoal production. In Villages A, B, and C, the households that reported using mangrove wood or charcoal were mainly charcoal producers. Most of the mangrove charcoal produced in these villages is sold outside the villages and even outside Batam. The stable and even increasing foreign demand for charcoal encourages continuous production even since the end of the harvesting permit system in 2007. As of 2010, approximately 90% of charcoal exported was from Batam to Singapore (BIFZA, 2010; Badan Pusat Statistik, 2000-2009), from where it is shipped to other countries (Murai, 2007). Mangrove wood was used at all charcoal kilns in our study areas: thus, we assumed that the charcoal sold for export was produced using mangrove wood. Charcoal production is now an important source of income especially in rural areas of Batam.

Changing ownership

According to the villagers, Chinese Indonesians living in urban areas of Batam introduced charcoal production to the villages. Villagers engaged in charcoal production under the supervision of the owners. However, the ownership style of the “owner in the urban area and employee in the village” transformed into “village-owners and self-employment.” Today, charcoal production in Batam is generally a small-scale industry involving the whole family as laborers. A good example is Village F. In Village F, before the industrial development in the early 1980s, a Singaporean owned 2 kilns and villagers worked to produce charcoal for the owner. However, in 1963, due to legal problems, ownership was transferred from the Singaporean to the village. Since then, almost all villagers have engaged in charcoal production under the supervision of the village chief.

Size of charcoal kiln

The local government of Batam issued harvesting permits even after the presidential decree in 1995 prohibiting the cutting of mangrove forests. However, although there is almost no enforcement of national and local laws prohibiting mangrove harvesting, stopping the issuance of harvesting permits had an impact on charcoal production. The volume of charcoal kilns is now limited to 6 tons or less. For example, a producer in Village F has a 12 ton kiln but has not used the kiln since 2007. According to both the charcoal producers and local public officials, large-scale charcoal production will overexploit the mangrove forests. The producers themselves are regulating their operations so as not to overharvest the mangrove forests.

DISCUSSION AND CONCLUSION

The case of mangrove charcoal production in Batam Island involves transformation but at the same time continuity. The materials, techniques, and processes used in charcoal production have not changed, and all processes continue to be conducted using non-electrical tools and selective harvesting. Given this, the impact of charcoal production on mangrove forests may be similar to levels in the past. Therefore, it is possible that these continuing aspects of charcoal production in Batam have actually worked over the long term to conserve the mangrove forests.

Transformation occurred to adapt to the present state of industrial development in Batam. To an extent, such transformation has contributed to the continuity of mangrove forest management such as for charcoal production. The industrialization in Batam provided alternative sources of employment to both urban and rural populations and also enabled them to afford alternative sources of fuel (e.g., gas and oil). This industrialization decreased the local demand for mangrove fuel but did not reduce mangrove charcoal production. Instead, industrialization opened the overseas market not just to the factory outputs from the industrial parks in Batam but also to its charcoal. Legal influences have also been important. Mangrove logging is illegal, but there continue to be many charcoal kilns and charcoal producers. Although formal policies are not strictly enforced, policy changes have affected charcoal producers. The law mainly responsible for the transformations also restricted large-scale charcoal production by companies and foreign producers. Meanwhile, management by the villagers themselves and their high dependence on charcoal production motivates self-regulation not to overharvest.

On the other hand, the balance between local people and the tolerance of the local government is one of the reasons for maintaining traditional techniques and exerting spontaneous control. In Batam, the local government had previously issued permits for charcoal production but recently stopped issuing these permits. This change may reflect new and heightened recognition of laws and regulations by both local government and local residents of Batam. If a charcoal producer’s overharvesting were to become visible and obvious from the outside, the local government would have to take action, which could result in all local producers losing their main source of income. In the end, producers would rather reduce their scale of production than face the consequences of further expansion.

In summary, unique features have enabled the transformation as well as the continuity of charcoal production on Batam Island: the improvement of the rural economy that reduced the local usage of mangrove-based fuel, the improvement of infrastructure that enables the export and selling of mangrove charcoal at a relatively high price, and the non-overharvesting partly brought about by self-regulation among the producers as well as their practice of using manual and labor-intensive methods of harvesting mangrove trees. Secondary mangrove forests have been under pressure from both industry and tradition, with industrial pressure surpassing traditional pressure in terms of impact (Komiyama, 1992). Most cases of environmental pressure progress in a negative direction (Ajiki, 1996, 1999; Burbridge, 1982; Cavalcante et al., 2009; Murai, 2007), but modernization is not always directly related. In some ways, industrial development and globalization have helped promote the traditional utilization of mangrove forests in Batam. This case study has important implications for current prohibitive policies and reveals the need and possibility of "preservation and regeneration under continued use" of mangrove forests.

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Tracing a Riparian Area to Objectify Social Capital Dynamics of Local Resource Management : a Case Study in Northeastern Thailand

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ABSTRACT

Thai human and social science studies regarding riparian forests are of a distinctly characteristic type: through action research methods they encourage local villagers to direct natural resource management better. In contrast, the focus of this article is on the broader context, where the development of legislation, institutions, organizations, lineages, and ideologies in this field are examined in conjunction with local resource management dynamics around a riparian area in northeastern Thailand. Here, local resource management history and dynamics are first traced, and then their broader structural backgrounds are plotted. Finally, structural implications with regard to local resource management are suggested as follows: First, any outstanding change that contributed to the formation of the pattern of dynamics at the research site was directly or indirectly catalyzed by legislation, institutions, organizations, lineages, and ideological trends, which were themselves transformed at the state scale. Next, the resource management area of the research site attracted various state-scale agencies; however, such agencies did not necessarily have a consistent system in terms of ideology and operations. Furthermore, some groups embraced conflicting perspectives such as where to place ideological and operational emphases. Finally, within the conflicting dimensions, we see the likely origin of some confusion in the field of Thai local resource management.

Key Words: local resource management, riparian area, community forest, social capital, Thailand.

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INTRODUCTION

In the commonly used academic database "Web of Science," no human and social science studies are listed when the topics of "Riparian forest" and "Southeast Asia" are entered as search criteria (accessed 03/10/2011). However, using terms in a local language such as Thai produces a demonstrably different result. The authors found seven papers, reports, and books dealing with these topics in Thailand.

These works can be divided into three types based on the characteristics of the content and methodology. The first category includes some books and reports that describe local knowledge systems related to riparian resource utilization through action research methods [1)] (Khunurat *et. al.* 2002; Setthachua and Phitthakthepsombat eds. 2005; Caikhammi *ed.* 2005; Yukhong *et. al.* 2007; Samnakngan plat krasuang sapphayakon thammachat lae singwetlom *n.d.*). In the second category, local resource utilization and villagers' desire for adequate management were ascertained through interviews using a questionnaire (Phabu 1997). The third category comprises a master's thesis that used various methods to investigate the relationship between resource management dynamics and natural vegetation change (Boonwan 2007).

Inoue (2002) discussed the interrelationships among five fundamental types of capital (*i.e.*, livelihood assets) that constitute villagers' sustenance in forested areas (Figure 1), including human capital, natural capital, physical capital, financial capital, and social capital. Of these five, social capital can be further divided into bonding social capital and bridging social capital.[2)]) Each arrow in Figure 1 indicates potential outcomes for enlarging each type of capital. Most of the human and social science studies relevant to Thai riparian forests fit into the triangle (Figure 1) formed by social capital, human capital, and natural capital, with the researchers themselves serving as facilitators or catalysts. The exception is Boonwan's study (2007), which viewed the dynamics of the diagram (Figure 1) from an outsider's standpoint.

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1) For their explanations, for instance, see 8th paragraph of the part, *"Two Movements for Robust Foest Management in Communal Lands"* in this article.
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2) Social capital is defined as "social factors that have influences on taking some kinds of concerted actions required for the attainment of the development goal in the interested communities and groups." Also, bonding social capital and bridging social capital are distinguished as "social capital that strengthens the solidarity inside each community" and "social capital that strengthens the linkage with other groups and formal institutions/organizations," respectively (Inoue 2002).

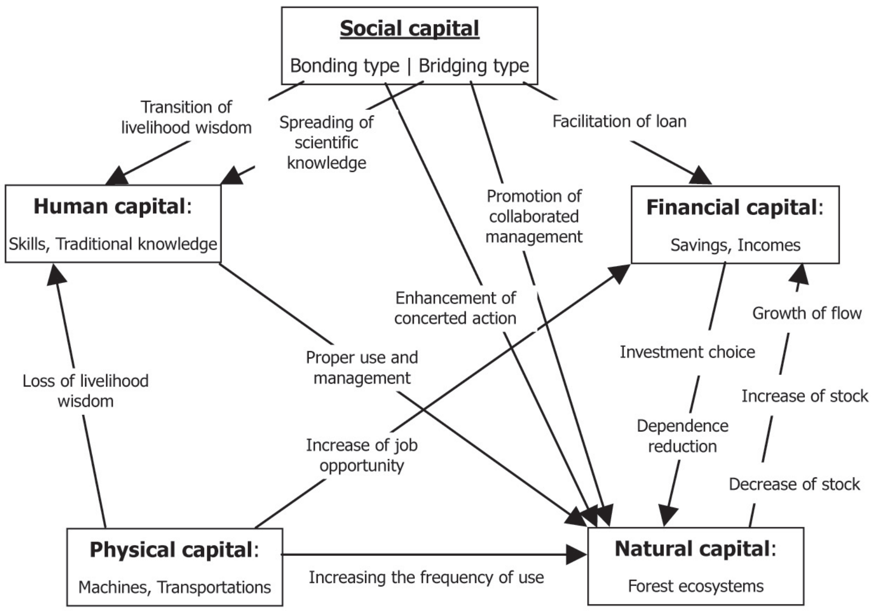

Figure 1 Five fundamental capitals (livelihood assets) and their interrelations, which constitute the villagers' sustenance in forested areas.
Source: Translated from Inoue (2002).

Our study expands Boonwan's (2007) work by focusing on not only the local resource management dynamics but also its origins and contexts, including legislation, institutions, and state-level ideological trends. The reasons for this approach consist of the premises and questions as follows: First, the importance of facilitators or catalysts with high levels of expertise and information is growing in the field of local forest management due to new and complicated value-adding mechanisms such as Pay for Environmental Services (PES) and Reducing Emissions from Deforestation and forest Degradation in developing countries (REDD)-plus. [3)]) At the same time, such a high-value forest resource potentially attracts multiple entities and actually encourages entry into the field of resource management. This means that analyses of local resource management dynamics must consider the roles

[3)] Reducing emissions from deforestation and forest degradation in developing countries (REDD); and the role of conservation, sustainable management of forests, and enhancement of carbon stocks in developing countries (plus). For the specific content, see Toma (2011).

of facilitators or catalysts on the one hand and the objectives of multiple bodies on the other hand to unravel the complex composition of local resource management. Thai riparian areas are a suitable place to assess the emerging research issues in local resource management because we can assume that the diverse natural ecosystem has already stimulated multiple bodies to come into the field using various approaches. Boonwan (2007) concluded that strengthened management by villagers played a role in the restoration of the riparian ecosystem, taking into account that foresters and non-governmental organizations (NGOs) facilitate the improvement of local resource management. Certainly, this is an exceptional and valuable study that analyzed local resource management dynamics including the roles of facilitators or catalysts from an outsider's standpoint. However, the case study does not provide the general reader with the insight to answer further questions. These include whether the phenomenon Boonwan (2007) reported is extraordinary or common in Thailand and whether there are persons or entities other than foresters and NGOs acting as facilitators or catalysts in local resource management dynamics. If there are, what are the styles of facilitating or catalyzing and how did they develop? What encouraged the emergence of foresters who differ from the conventional type characterized by "foresters' syndrome"? [4)]

In this article, the authors attempt to elucidate a broader context, where the development of legislation, institutions, organizations, lineages, and ideologies are examined, in conjunction with local resource management dynamics around a riparian area in northeastern Thailand. Following the introduction of the field research site, local resource management history and dynamics specifically related to communal lands around a riparian area are first traced, and then their broader structural backgrounds are plotted. Finally, structural implications with regard to the local resource management are suggested in the concluding remarks section.

FIELD RESEARCH SITE

In this study, the authors focused on a riparian area along the Sebai River in northeastern Thailand. The Sebai River, a tributary of the Mun River, is 233 km long and is divided into three parts: upper, middle, and lower (Yukhong *et al*. 2000). The field research site is located in Tambon N, Yasothon Province, where it is situated in the middle part of the Sebai River (Figure 2). Within Tambon N, the territory of P Village is particularly targeted for research on local resource management dynamics.

[4)] For example, expressed as "Cherishes trees and dislikes human beings" (Inoue 2002).

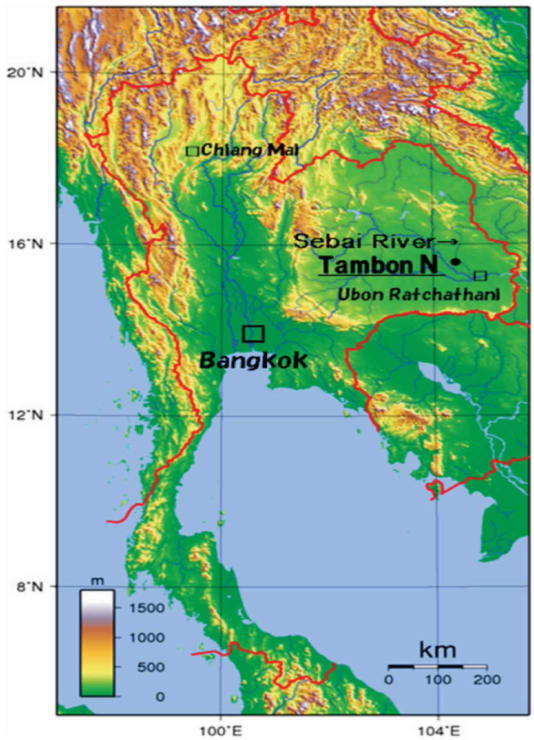

Figure 2 Location of field research site.

The oldest village of Tambon N has evidence that a Buddhist temple already existed there in 1787 (http://www.phrapanakea.com/54/phravat/ phravat.html accessed 14/10/2011). With this knowledge, P Village, the second-oldest village of Tambon N, was probably founded at least 200 years ago, although it moved 1.5 km away from its original location in the late 1930s because of widespread plague.

At present, the populations of P Village and Tambon N include 795 persons (181 households) and 2,845 persons (650 households), respectively (Table 1). Table 2 outlines local land use in 2010. Most of the farmland is rice paddy fields, and more than 90% of household members in P village and 80% of household members in Tambon N engage in agriculture.

Table 1 Population dynamics around field research site.

A.C.	1960	1970	1980	1990	2000	2010[3)]
P Village						
Households	58[1)]	<100[1)]	115	150	188	181
Persons			826	699	727	795
Tambon N						
Households	Not yet established.		416	554	687	650
Persons			3,067	2,504	2,532	2,845
K District						
Households	10,025[2)]		8,859	11,234	13,299	11,434
Persons	58,670[2)]		56,584	46,349	44,396	39,749

Source: 1) Interview from villagers. 2) Department of Local Administration (n.d.) 3) Samnakngan phatthana chumchon Cangwat Yasothon (2011). Others: Samnakngan sathiti heang chat (1980, 1990, 2000).

Table 2 Present outline of land use around field research site.

	Total[1)] (ha)	Farm households (%)	Farmland[2)] (ha)	2)/1) × 100 (%)	Per Farmland Paddy (%)	Per Farmland Others (%)	Communal lands (ha)	Others (ha)
P Village	1,001	96.7	567	56.6	93.4	6.6	429	5
Tambon N	5,980	80.1	2,491	41.7	90.8	9.2	No available.	
K District	63,840	70.0	36,890	57.8	85.2	14.8	No available.	

Source: Counted by Kurashima from data of Samnakngan kase (2011), Samnakngan phatthana chumchon amphoe Khamkhauankeao (2011), KoChoCho 2 Kho. Z2011), etc.

According to the Community Development Office, Yasothon Province (Samnakngan phatthana chumchon cangwat yasothon 2011), average income per villager per year in 2010 was 32,404 baht in P Village and 30,907 baht in Tambon N, respectively. [5)]) Many of the younger generation leave the villages for temporary or permanent jobs. Many villagers under 80 years old have also performed contract or part-time labor in the south and central parts of Thailand and in Bangkok. Most villagers are Buddhist, although the practice is likely different for each individual.

In P Village, communal lands occupy 429 hectares, which is >40% of the total area. Each communal plot of land contains forests, water bodies, grasslands, places for religious practice, and squares with public halls. In the area near the Sebai River, P village has communal lands with national land certificates (Nangsu samkhan samrap thiluang: no.so.lo.) as shown in Figure 3. In addition, two reservoirs and the east side of the largest communal land area belong to communal lands, despite a lack of national land certificates. The total area of P village's communal lands near the Sebai River is about 200 hectares. There is neither national reserved forest area (khet pa sanguan) nor protected forest area (khet pa anurak) within P Village and Tambon N.

In Figure 3, the points marked with stars represent the August 14, 2011 highest stream water levels. That is, they represent the average highest points of the stream water annually. Around P Village in 1964, 1978, 2001, and 2002, great floods overflowed far beyond these highest points.

5) 1 Thai baht = about 0.03249 US dollars on 20/9/2010. The document described average income per villager per year. In actuality, the authors suspect that it was more likely equivalent to the average income per household per year in most cases.

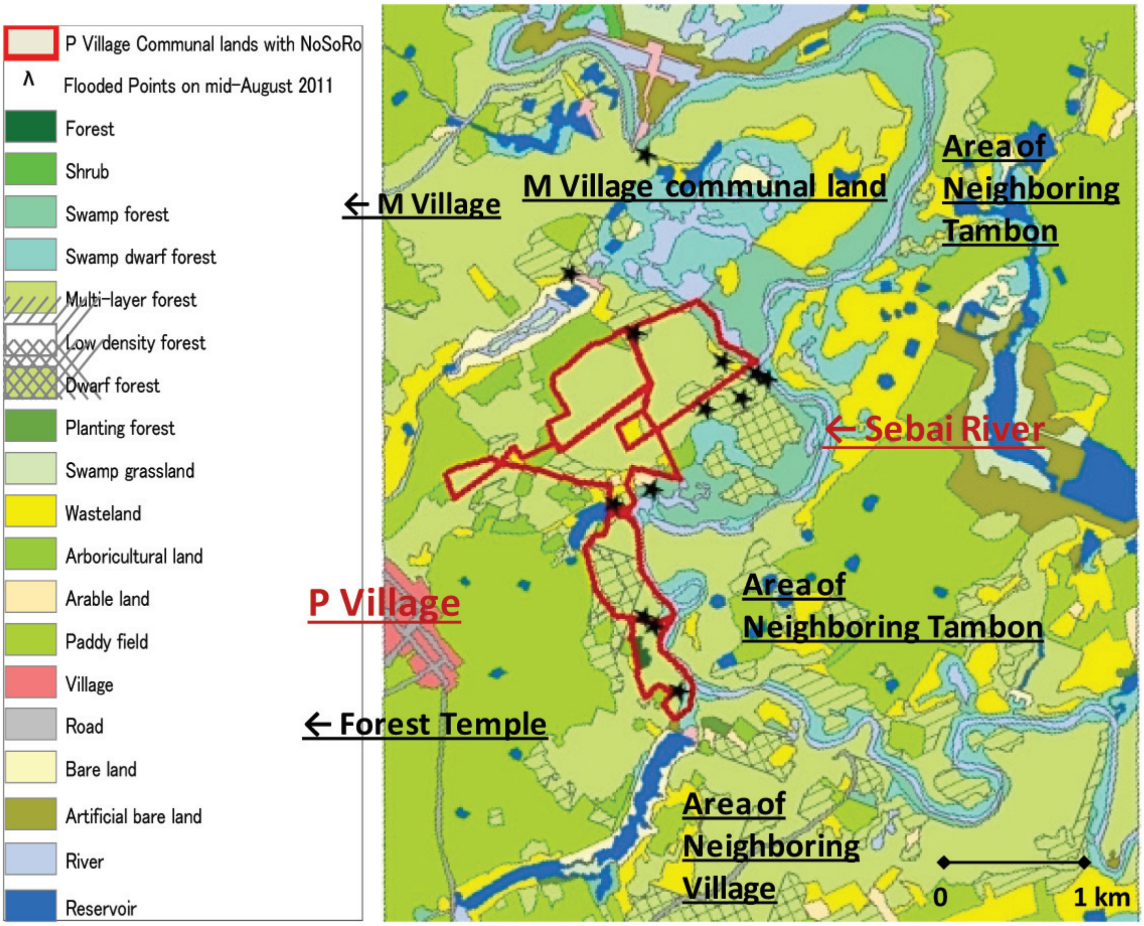

Figure 3 Land use (based on satellite photo in 2008) and location of communal lands with the national land certificates along Sebai River in field research site.

Source: Made from Sano *et. al.* (forthcoming).

LOCAL RESOURCE MANAGEMENT DYNAMICS RELATED TO COMMUNAL LANDS AROUND A RIPARIAN AREA

Since the early 2000s, notice boards have been set up in many areas of P Village and other villages that are part of Tambon N. They inform inhabitants about prohibited matters, penalties, and so on in some communal lands designated as “Community forest to glorify the 72nd birthday of the Queen”. The main regulations announced by the “Voluntary forest guardian citizens’ group, Tambon N”, include a prohibition against felling, illegal cultivation, clearing, possessing forestland, and burning of forest; prohibition of hunting of all kinds of animals in the reserved area or the animal-species conservation area; permission to collect forest products for family consumption appropriately, although the permanent village committee must be informed in advance. As shown by the existence of these regulations and the guardian body, P Village and Tambon N currently have institutions in place for conserving the communal forests around each riparian area. Additionally, some foresters have undertaken action research in the area and have facilitated riparian resource management. In the following section, the authors trace the local resource management dynamics that has developed as described above by dividing it into two phases: first, up to the point where communal lands were informally and formally designated; and second, to the stage where institutions and support for forest conservation were implemented in the established communal lands.

Communal Lands: Establishing the Foundation for Forest Conservation

According to a past head of P Village, even his remotest paddy field in P Village was occupied, and cultivation was started, by his grandfather. He is 60 years old, meaning that almost all land suitable for paddy fields in P Village has been in use for at least half a century. This can be verified by comparison of aerial photos taken during 1954–2008 (Table 3). Apart from the paddy land, however, the circumstances have changed. Land was available for occupation until the beginning of the 1970s, after which time the process of establishing communal lands officially began.

Table 3 Important events related to the managements on riparian area around the field.

AC	Riparian Area in P & M villages	Villages and Tambon	District and larger scale
		Villages, where are situated now, was established.	
	Traders used river boat for transpotation.	Almost rice fields had been made.	
Before	Villagers had taken fishes with traditional gears, while the number was far less than today.		Commercial cotton cultivation.
1954	←(54) Taking arial photos		Kenaf started.
	-1954 Land Act. Owners were requested to declare the rights and got land occupation titles. The declaration period were extended.		
60s			
	Stoped to use river boat for transpotation.	-Upgrading main road in region and small road to P Village .	
	-Massive flood (Water from rivers reached P Village). Villagers fleed to upland around the north part of village.		
	Kenaf started (P).		
	←(67) Taking arial photos		
70s	-Stopped rice cultivation around Thung Mon pond (M).		Cassava started.
	-Tambon leader has a plan to develop for cultivation, but villagers refused it (M).		Kanaf disappered in some places.
	-The extended declaration period for land occupation claims under 1954 Land Act terminated.		
	-Further land occupations were prohibitted. As a result, communal lands area were roughly provided de facto.		
	Kenaf disappered (P).		Commercial cultivation of rice started.
	←(73) Taking arial photos		
	-Made a dam:Tamnop, in the north part of village (P).		
	-Massive flood. -Increased tree cutting (P).		Cassava expanded.
	-Villagers tried dry-season rice cultivation, but it didn't establish because of the bad access (P).	-Establishment of Tambon N. P village divided into two administrative units.	
80s	Tree cutting around communal lands reached a peak (P). Villagers cut valuable trees except *Dipterocarpus alatus* for private uses and sales.		
	←(83) Taking arial photos		
	-Made a rule that outsiders must pay fee for net fishing (other way no permitted) in ponds around Thung Mon (M).	-A forest temple was established (P).	
		-The forest temple made roads to fix the area (P). Tree cutting was prohibitted there.	
90s			Started to expand uses of cultivators.
	-Communal land areas around riverside and upland have fixed with boundary stones and land certificates (P).		Labor-saving agricultural techniques spreaded.
			-Queen visited next tambon. A Royal project for forest conservation started. The villagers were permitted to be a forest protection body officially.
	←(96) Taking arial photos		
	-The northern dam was enlarged. Started to release fishes there and made rules for management ? (P).	-A monk told his wish to strictly conserve the forest around temple to district forestry officers and villagers (P).	-Construction of dam and irrigation system was started at the royal project area.
		-Villagers were trainned by RFD, and established a forest conservation committee with strict management rules. Temple + village leaders wanted to dedicate the forest for Queen. The committee applied to the royal office, but the office rejected the application because the forest area was too small.	
2000s	-A regional forest officer made a berief report on Sebai River riparian forests and highly estimated them.		
	-The committee scaled up the area plussing many communal lands including riverside for the application, and got the acceptance.		
	-Massive flood		
	←(02) Taking arial photos		
			-Books studied by Thai baan researches on riparian forests were published.
	-Regional Forest officers had made action researches with villagers.		-Project for collecting regional biodiversity data were started by the MNRE.
	←(08) Taking satelite photos		
	-A celemony for fish releasing/nursing under the monetary support of Regional Forest Office in southern dam (P). Provincial Govenor joined it.		
		-A company came to roughly estimate carbon quantities in upland forests (P) ?	
	-Construction of irrigation system was started under the budgetary quota of Royal Project Office (P).		

Source: Interviews, Wisut *et. al.* (2000, 2007), Khanakamakan klum rasadon asasamak phithak pa (RoSoThoPo) chumchon chaluem phrakiat 72 phansa (2002), Boonwon (2007), Kono *et. al.* (1992), Ubukata (2008), and so on.

The procedure for the official establishment of most communal lands in P Village was based on the 1954 Land Act. In Section 5, the 1954 Land Act obliged land occupants and owners without proper land title deeds to apply for each right within 180 days from the date when the act was applicable (Wisetso 1970), although the qualifying period for application was extended under the conditions permitted by each governor (Prakhongsi *et al.* 1994). Furthermore, the 1954 Land Act prescribed that persons who did not apply for each right were deemed to relinquish their claims on the properties, and the government had the authority to manage the renounced properties (Wisetso 1970). In short, with this introduction of the 1954 Land Act, the Thai government began the division of land ownership between public and private sectors. The process for officially establishing communal lands in P Village was linked to this procedure and was based on the 1954 Land Act.

In P Village, most communal lands with national land certificates were effectively zoned in the middle of the 1970s, as postponement of land claim applications was terminated by the Revolutionary Committee Order on February 29, 1972 (Table 3). According to a past head of P Village, only householders with adjacent paddy fields were permitted to occupy the newly vacant lands near the riparian area during those years. Meanwhile, some households in other vacant lands located in the hills were permitted to occupy the land with some previously existing households after paying 50 Thai baht. After these processes were implemented by the tambon head at the time, the district land office, etc., the remaining areas were subsequently designated as communal lands, although it was only in the 1990s that each zone was formally set with boundary poles and detailed survey maps (Table 3).

Today a few suspicious households and illegal cultivators can be found around the borders of such communal lands with national land certificates. However, except in these instances, there is no hint of land conflict. Without doubt, the processes described above were of considerable importance as the basis for communal land designation. More than 40 households were able to occupy lands during those years. Additionally, many more households were given the opportunity to occupy lands, even though they needed to pay rather expensive fees.

In addition to the formally designated communal land, P Village has communal land along Sebai River that does not have national land certificates. In the late 1970s, there was a move to open it to villagers for rice cultivation during the dry season. Although many villagers responded positively to this move, cultivation was unsuccessful because of the remoteness of the site from P Village and low water availability.

Two Movements for Robust Forest Management in Communal Lands

Although there are several classifications, communal lands in Thailand can be divided into at least three types: communal forests, water bodies, and public squares (Sutthitham 1999). Their common characteristics have been established for various utilizations. Communal forests have been used for obtaining timber, collecting forest products, and feeding animals. Obviously, obtaining timber had the greatest effect on forests in terms of volume and shape, even though the vegetation can be restored by appropriate management over a certain time period.

P Village went through a peak of tree cutting for local timber demand within communal lands between the late 1970s and the early 1980s. The villagers indicated that the density of the forests within the communal lands, which once had plenty of big trees, was remarkably reduced by this tree-cutting activity. Nevertheless, there were no particular regulations pertaining to forest conservation in communal lands for more than a decade, except in the forest area surrounding a forest temple and for legally restricted trees such as *Dipterocarpus alatus*.

The late 1990s was a turning point for forest management within many communal lands. The catalyst was a forest-dwelling monk who desired more stable and broader forest protection around his temple, which was situated in a hilly area across from Tambon N and the neighboring Tambon D. In 1995, the Queen visited the most famous community forest in northeastern Thailand, Dong Yai Forest, located within the neighboring Tambon H, and Dong Yai Forest was selected as the target for a royal project. This event likely influenced the ideas of the monk and his supporters.

The monk, born and raised in P Village, entered his second priesthood in Nong Paphong Temple at the age of thirty-eight. Nong Paphong Temple, Ubon Ratchathani Province, is a well-known place where a famous charismatic Buddhist master of the Thai forest monk's [6] lineage, Chah Subhaddo, coached enormous numbers of disciples. The monk returned to P Village in about 1980 and built a hermitage near an old cremation ground in the vicinity of the village border. Eventually, a forest monastery developed that currently covers a substantive 160-ha area after incorporating some old swidden cultivation plots.

The forest monk consulted the district forestry office regarding more stable and broader forest protection. The district forestry office subsequently suggested that villagers living around the temple forest should be trained in forest protection methods.

In response to the forest monk's initiative, numerous leaders and villagers from the two tambons formed a "Voluntary forest guardian citizens group," and in 1999, after receiving training that was mainly implemented by the district forestry office, they set up regulations to protect the temple forest (Table 3). Moreover, the monk and the leaders applied to the royal office for authorization over the temple forest and guardian body, requesting the awarding of a blue flag with a royal symbol, two trees, etc., through the Second Regional Office of the Thai Army. The first application, however, was turned down on the grounds that the forest indicated in the application was too small in scale to be worthy of granting such a flag. Consequently, many other communal lands

[6] *Phra pa or Phra thudong* in Thai (Hayashi 1989). To understand those monks, see first paragraph of the part, *"A Thai Religious Tradition and Rural Land Use Changes"* in this article.

within the two tambons were added to the forest around the temple. As a result, the second application passed the screening of an evaluating committee in 2002, and many places, including communal lands around riparian areas, became part of the "Community forest to glorify the 72nd birthday of the Queen".

According to the head of P Village and Tambon N at the time, the regulation introduced in the wake of the forest monk's initiative still functions acceptably for the management of communal lands even now. Nonetheless, the direct activities of the "Voluntary forest guardian citizens" group have halted in the last few years, mainly for budgetary reasons. Instead, different types of forest management efforts and activities have been practiced with the support of regional forestry officers since the mid-2000s (Table 3). In particular, they have focused attention on riparian area utilization and management, targeting M Village, a neighboring village of P Village, and other villages, including part of P Village.

A team led by a senior regional forester conducted action research. Together with villagers, they recorded the wealth of local wisdom, such as information regarding valuable trees for timber and tools, medical and edible plants, fishery resources, and fishing gear and locations (Yukhong *et al.* 2007). The team subsequently held workshops for various villagers, especially younger generations and schoolchildren, to present and transmit the collected local wisdom (*ibid.*). In addition, they planned and carried out study tours with villagers to other riparian areas, encouraging network building among local villagers living in riparian areas and the self-enlightenment of villagers.

Boonwan (2007) indicated that the interest and collaborative actions of forestry officers stimulated local villagers to increase their awareness about the significance of the riparian forest and other resources. The field research site of Boonwan (2007) was located around M Village, the same area where the team of foresters had conducted action research with earnest energy.

MACRO-LEVEL STRUCTURAL BACKGROUND RELATING TO LOCAL MANAGEMENT DYNAMICS OF A RIPARIAN AREA

In addition to the division that focuses on the functions of bonding and bridging, social capital is further categorized by two dimensions: patterns of appearance, and functional scale. The former consist of structural social capital (*e.g.*, institutions, organizations, networks) and cognitive social capital (*e.g.*, trust, norms, values). The latter includes micro social capital and macro social capital. Micro social capital is that which promotes the concerted actions of local villagers within each community or small group. Macro social capital is that which encompasses socio-political circumstances within a wider area or at state level (Sato and Adachi 2002, Grootaert and van Bastelaer 2002). In the following sections, we mainly identify types of structural social capital and their transformations at the macro level in conformity with the dynamics at the micro level traced in the last section.

Around P Village, local forest management dynamics were facilitated or triggered by the institution of Thai communal land, the initiative of the monk belonging to the forest monk lineage, the involvement of the army and royal office as well as the forest administration, and the forestry officers eliminating "foresters' syndrome." These agencies facilitated or triggered each change within the economic and technological contexts, as outlined in Table 3. [7]

Community Forests and Communal Land Institution: Special Focus on the Lands with National Land Certificates

In the mid-1990s, Prakhongsi *et al.* (1994) classified communal land in northeastern Thailand into five groups: 1) water bodies for public use (156,211 ha); 2) uplands and grazing lands (948,913 ha); 3) cremation grounds, ancestor/spirit forests, and public forests (68,152 ha); 4) places for official works and village public halls (44,764 ha); and 5) other uses (379 ha).[8] Of these communal lands, some areas belonging to groups 2) and 3) have been utilized as community forests, although the specific areas are unknown. Additionally, the Royal Forestry Department (RFD) has permitted areas such as those listed in Table 4 to be used as community forests within the territories, based on the 1964 National Reserved Forest Act or the 1941 Forest Act, until the middle of 2011.

Table 4 Outline of community forest project permitted by the RFD during 2000- 2010.

	Total number/area			National reseved forest lands	Lands based on the 1941 Forest Act	Cooperative settlement lands
	Village (villages)	Project (cases)	Area (ha)	(ha)	(ha)	(ha)
Yasothon	223	223	8,291	4,976	3,315	0
N.E. Thailand	3,578	3,119	161,832	96,888	64,944	0
Thailand	8,183	7,515	489,462	371,938	117,002	523

Source: Data within http://web2.forest.go.th/webmis/page (26/10/2011 accessed).

[7] Obviously, economic aspects are important as the background for resource management dynamics around the field research site (cf. Ubukata 2010). Ubukata, a member of our study team, continues to conduct his investigation of economic matters at the present time.

[8] With various data, Prakhongsi *et al.* (1994) estimated the whole area of communal lands in the northeast part as 1,218,401 ha (12,184 km2). The total area of the northeastern part is 168,854 km^2.

Unlike with national reserved forestlands, Thai communal lands, noted by the Civil and Commercial Code, the 1914 Local Administration Act, and the 1954 Land Act, were originally designated by various methods (Wisetso 1970) such as royal decrees, prohibiting orders by municipal chiefs, and prohibiting proclamations of governors and district heads in previous times. Compared with these past methods, areas designated as communal lands with national land certificates are said to be more robust, as the designation processes involve location surveys, signposting, and mapping (*ibid.*). [9)]

Until the proclamation of a revolutionary committee in 1972, Thailand had no particular legislation to promote the issuing of national land certificates (Nilakhet and Phonphaibun 1997). The order in 1972 added a clause to the 1954 Land Act that stated "The Director General [of the Land Department] may issue national land certificates for the purpose of keeping the zones [of communal lands] explicitly" (*ibid.*). The legal position of national land certificates eventually took shape as a consequence, though the actual issuing of certificates did not accelerate until after the mid 1980s (Shigetomi 1997), due in part to the slow pace of the decoupling of private land ownership (Wisetso 1970).

The basic procedure for national land certificates is as follows: a) the official organization, which has jurisdiction over the area, applies to the Land Department for the issuance of a certificate; b) the department screens the application, surveys the area, and announces the plan for designation; c) if other persons claim land rights within a time limit, the claim is examined and judged; d) if the claim is judged to be legitimate, the contested area is excluded from the national land certificate planning zone (Nilakhet and Phonphaibun 1997). Furthermore, the Land Department has implemented revisions of rules related to process b) a few times. [10)] Fundamentally, such revisions of process b) are intended to enhance the commitments of local councils.

The extent of land conflict with respect to each community forest is an important element controlling the quality of local resource management. Serious conflicts over land become the seed of mutual distrust within communities or with the outside world. Such mutual distrust harms the performance of resource management.

Table 5 briefly shows the locations and numbers of persons maintaining their land rights within the Thai government's lands that were registered in 2003 as a part of anti-poverty policy under the Thaksin government. According to this table, Thailand still harbors the seeds of land conflicts, which might harm robust community forest management, even in communal lands, although the number and area of these are smaller than is the case for the national reserved forestlands.

[9)] Correspondingly, the area of communal lands that have national land certificates in the region was 7,075 km^2 in 2010 (Calculated from http://www.dol.go.th/doc/index.php?option=com_ content&task=view&id=521&Itemid=238 accessed 1/11/2011).

[10)] See http://www.local.moi.go.th/law131.pdf (accessed 1/11/2011).

Table 5 Outline related to the holders of Thai government's lands that was registered in 2003 as a part of anti-poverty policy under the Thaksin government.

	Total		National reseved forests		Communal lands		Others	
	(cases)	(ha)	(cases)	(ha)	(cases)	(ha)	(cases)	(ha)
Yasothon	4,928	12,827	1,978	5,644	877	1,738	2,073	5,445
N.E. Thailand	210,469	567,900	78,415	259,826	26,519	47,404	105,535	260,670

Source: Counted by Kurashima from data in Huaprasuet (2006).

A Thai Religious Tradition and Rural Land Use Changes

The forest monks are a type of ascetic monk. They are numerous and widespread over northeastern Thailand, specifically through the beginning of the twentieth century (Hayashi 1989). They wandered in accordance with certain rules, and practiced meditation in natural cremation grounds and mountain caves rather than learning Pali scriptures at monasteries (*ibid.*). In particular, Man Phuurithatto (1871–1949) and his early disciples are famous as the forest monks that revitalized this Buddhist tradition in Thailand. Chah Subhaddo (1918–1992) was a disciple directly connected with Man Phuurithatto. Since the emergence of Man and his early disciples, the forest monk lineage has continued to expand widely and is now managed by subsequent generations (Tiyavanich 1997).

For instance, Tiyavanich positioned Chah as a forest monk over Man's leading nine disciples (ibid.). The genealogy of Chah, which established Nong Paphong Temple as their headquarters, currently has 280 branches across Thailand. [11]

Originally, the forest monks were closely linked to the natural environment by necessity. For ascetic practices, meditation, and enlightenment, they needed mountains, caves, and forests. Essentially, this differs little from the past, regardless of the passage of several generations, because the precepts of Man have been kept unchanged. Meanwhile, the natural environment and land use in rural Thailand have changed remarkably over the generations of the forest monk lineage, despite the expansion of the lineage. This has inevitably prompted different behavior regarding nature and wilderness among different generations.

[11] http://board.palungjit.com/f63/สายป่าธรรมยุติ-หลวงปู่มั่น/ (accessed 10/11/2011), ข้อมูลวัดสาขาวัดหนองป่าพง พระเดชพระคุณท่านพระโพธิญาณเถร (ชา สุภทฺโท). The forest temple in our field research site is the 71st branch of Nong Paphong Temple.

Figure 4 shows patterns of rural environmental change in Thailand, particularly for the northeast area, where the topography is comparatively flat. Man and his first-generation disciples such as Chah performed their practices under the environmental conditions shown in Figure 4A. The later the generation of the forest monk became, however, the more similar the environment of rural Thailand, notably the northeast part, has become to Figure 4B. In short, the wilderness required by the forest monks existed everywhere during the time of Man and his first-generation disciples. In later generations, however, wilderness areas became scarce and their use more competitive, so the forest monks were likely to lose their training space if measures were not taken. Jim Taylor, a religious anthropologist, reported the activities of some northeastern Thai forest monks, which included planting native tree species and building protective walls (Taylor 1993). These actions by the forest monks are possibly related to the drastic environmental and land use changes in rural Thailand, together with the rising environmental awareness that has recently spread across all of Thailand.

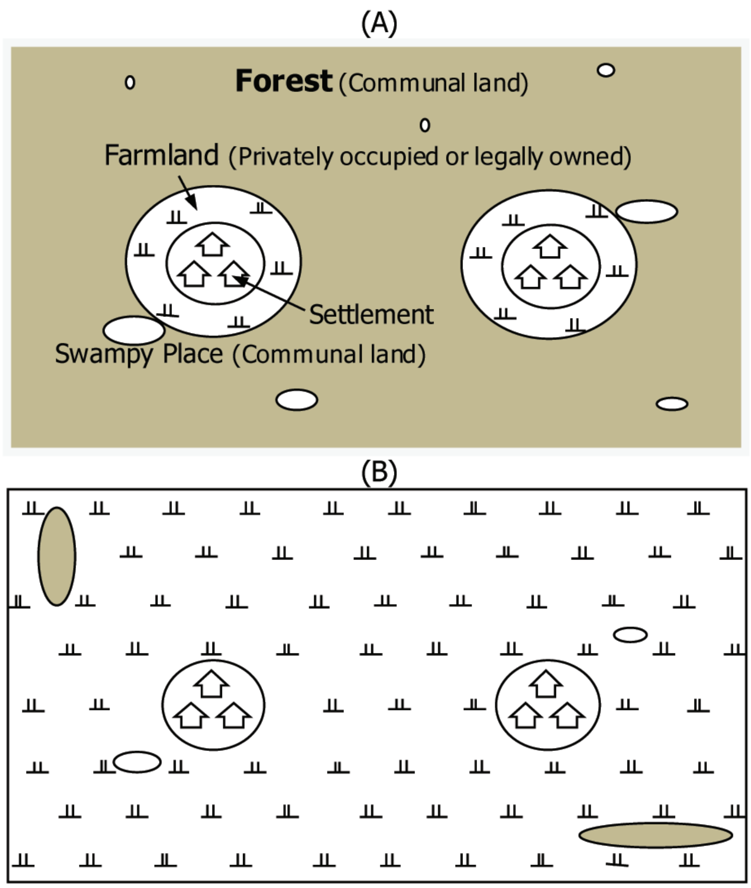

Figure 4 Pattern diagram of land use change in rural Thailand during last a half century.
Source: Translated from Shigetomi (2007).

From Security to Environment: Targeted Transition for Voluntary Guards by the Thai Nation

Currently, the main supervising organization of the "Voluntary forest guardian citizens (*Rasadon asasamak phithak pa: ro.so.tho.po.*)" is the Department of National Parks, Wildlife and Plant Conservation. [12] Originally, however, the institution of "Voluntary forest guardian citizens" began with the deeper involvement of the Thai Army and the Internal Security Operations Command. [13] Why were the security authorities deeply involved in forest conservation? This is related to the early origin of the Thai voluntary guardian institution, launched as an anti-communist operation, and to the topographical characteristic of the civil war between the Thai government and the Communist Party of Thailand (CPT).

During the civil war with the CPT, a great number of anti-communist voluntary guardian bodies were organized by the security authorities (Tinsulanon 1978, Wiriyawat 1977). In particular, the organizing operation was intensely deployed around mountainous and border areas because the CPT established their bases in such remote frontier areas (Kurashima 2007). After the end of the civil war, the remote frontiers with vast areas of forest attracted local villagers and many new settlers, and the forests were extensively destroyed in some places (*ibid.*). At first, the security authorities and forest administration preferentially adopted crackdowns to stop forest destruction and clearing, but this was not sufficiently effective. Under these conditions, the original, similar meanings of "Village scout (Luk sua chaoban)" and "Thai national voluntary guard (*Thai asa pongkan chat*)" were combined in the anti-deforestation policy (http://www.prdnorth.in.th/king60/king_projects05.php accessed 7/8/2011) [14], although the two kinds of voluntary guardian institutions ultimately had different goals.

A document at http://www.m-society.go.th/document/news/news_4870.doc (accessed 14/11/2011) indicates that the number of "Voluntary forest guardian citizens," which launched training in 1994, was 126,744 persons in the 2009 fiscal year. Also, entering the search term "ราษฎรอาสาสมัครพิทักษ์ป่า" ("Voluntary forest guardian citizens" in English) in a Google search produces more than 46,000 hits (accessed 17/11/2011). Furthermore, by checking such information, we know that a certain number of activities for the purposes of training "Voluntary forest guardian citizens" continue today.

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[12] http://www.m-society.go.th/document/news/news_4870.doc (accessed 14/11/2011).

[13] See Cangwat Ubon Rachathani (n.d.), Krom thahan rap chapho kit thi 23 (n.d.), Suncan (1999), and Temdamnan (2006).

[14] For example, see Muecke (1980) and Bowie (1997) to understand "Village scouts" in Thailand.

In advance of organizing each "Voluntary forest guardian citizens" group, lectures for "voluntary citizens" are carried out by the forest administration and military. The content consists of lectures relevant to the situation of the forest, forestry and other laws, the introduction of community forest management, and forestry techniques (Cangwat ubon ratchathani n.d., Krom thahan rap chapho kit thi 23 n.d., Temdamnan 2006).

According to Temdamnan (2006), the purpose of such training is generally to transmit to citizens the determinations and concerns of the King and/or Queen regarding forest conservation; to give citizens proper knowledge and understanding of ecosystem protection and natural resource utilization; to establish a civil organization; to have the established civil organization function as an assistant to bureaucratic institutions; to further the Queen's project to encourage local forest conservation; and so forth.

In addition, a source such as Ko.o. khrongkan pho.mo.pho. phusadokbua (1998) says that the Queen's project to encourage local forest conservation by bestowing the royal-authorized flag, i.e., Khrongkan thong "phithak pa phua raksa chiwit," has the following ratings benchmarked for target selection: 1) organizing a "Voluntary forest guardian citizens" group through receiving training (20 points); 2) creating a body or village committee for forest conservation (20 points); 3) improving the conditions/situation of the targeted forest land (20 points); 4) establishing management regulations for conservation and utilization (20 points); 5) identifying short-, medium-, and long-term conservation plans and activities (20 points). Additionally, the source indicates that the evaluating committees for selections consist of a delegate from each of the following organizations: the Queen's secretary's office, the RFD, the provincial or district administration, and the regional armies or the Internal Security Operations Command (*ibid.*).

As presented above in the sections on historical background, purposes, and operational manners, in some respects, the "Voluntary forest guardian citizens" institution is a complementary part of existing Thai administrative order rather than a grass-roots and self-governing movement, even though the institution has evolved with the involvement of local inhabitants.

Do the "Foresters' Syndrome"-Free Foresters Reflect a Paradigm Shift?

Alternative Development in the Thai Local Forest Management Arena and the RECOFTC

Within the book summarizing the 20-year history of the Regional Community Forestry Training Center (RECOFTC) in Bangkok, a senior forester commented, "In 1993, I received funding for training from the RECOFTC, which provided me with the knowledge, working techniques, and frame of mind that takes people as central. Since then, I have participated in the seminars and research activities. The RECOFTC is a leading intellectual body in the sector of community forests for villagers. It is also the center that connects hundreds of government and private sector institutions with the people and then encourages them to form a network for participatory natural resource management…"

(Kitcawanichokcon 2007). This senior forester is the person who carried out action research in Tambon N.

As mentioned above, the senior forester often joined the RECOFTC's activities. Table 6 contains a partial list of documents issued by the RECOFTC. The authors focused on publications reporting the contents of training sessions, workshops, and seminars, at which the RECOFTC presided. Even the limited documents shown in Table 6 tell us that the senior forester attended trainings, workshops, and seminars more than 10 times since 1993. Moreover, he repeatedly fulfilled the roles of lecturer and coordinator. [15)]

It is possible that the senior forester has built particularly close ties with the RECOFTC. At the same time, many other foresters have taken part in the training, workshops, and seminars given by the RECOFTC, as evidenced by the documents listed in Table 6. [16)]

As shown in the table, the operations of the RECOFTC, a leading intellectual body in the "Community forest for villagers" sector, have covered a broad range of topics, and the outcomes are accordingly rich in diversity. Nonetheless, we consider that the most unique and distinctive accomplishment of the RECOFTC is to have involved and bridged multiple stakeholders under the principle of "Community forest for villagers." In particular, we can find no organization that has gone forward with such operations with a relationship with the forest administration as good as that forged by the RECOFTC.

An example of RECOFTC's activity is the workshop, "*Ethnobotany and Sustainable Uses of Plant Resources in the Northeast of Thailand*," held in 1998 (Sun fukoprom wanasat chumchon haeng phumiphak asia pasifik 1998). The goals included the collection/exchange of knowledge of ethnobotanical studies useful to various communities; building/developing networks between villagers with local wisdom and those who are interested in learning, so as to expand knowledge bases to other communities; developing research methods and then promoting sustainable resource utilization and management protocols.

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15) See documents nos. 3), 8), 11), 13), 15), 24), 34), 35), 37) in Table 6.

16) See documents nos. 2), 3), 4), 6), 7), 8), 10), 11), 12), 13), 15), 16), 20), 24), 25), 33), 34), 35), 37), 38), 39) in Table 6.

Table 6 Partial list of documents issued by the RECOFTC

	Year	Title (Thai publication=in English/ English publication)	First Editor/Author	Page
		Thai publication		
1)	1993	การจัดการเขตกันชนในประเทศไทย =Buffer zone management in Thailand	เพิ่มศักดิ์ มกราภิรมย์	134
2)	1994	การพัฒนาป่าชุมชนในประเทศไทย =Community forestry development in Thailand	เพิ่มศักดิ์ มกราภิรมย์	139
3)	1994	การฟื้นป่าโดยช่วยต้นไม้ให้สืบพันธุ์ตามธรรมชาติ =Forest restoration through natural regeneration	เพิ่มศักดิ์ มกราภิรมย์	96
4)	1995	การจัดการป่าชายเลนอย่างยั่งยืน=Sustainable mangrove forest management		
5)	1995	ป่าตะวันออก =Eastern forest		83
6)	1996	พฤกษศาสตร์พื้นบ้านและการใช้ทรัพยากรพรรณพืชอย่างยั่งยืน=Ethnobotany and sustainable uses of plant resources		56
7)	1996	พฤกษศาสตร์พื้นบ้านและการใช้ทรัพยากรพรรณพืชอย่างยั่งยืนครั้งที่2=Second ethnobotany and sustainable uses of plant resources		107
8)	1996	การจัดการทรัพยากรธรรมชาติอย่างยั่งยืนในระบบนิเวศวิทยาภาคอีสาน=Sustainable natural resource management in the ecological system of northeastern region		82
9)	1998	ไฟป่ากับการมีส่วนร่วมของชุมชน =Forest fire and community participation	เพิ่มศักดิ์ มกราภิรมย์	215
10)	1998	พระกับป่า:บทบาทของพระสงฆ์ในการสนับสนุนการมีส่วนร่วมของชุมชน เพื่อการอนุรักษ์ทรัพยากรป่าไม้ =Monk and forest: Role of monks for supporting community participation in order to protect forest resource	พระมหาเจิม สุวโจ	184
11)	1998	การฝึกอบรมด้านวนศาสตร์ชุมชน (เอกสารหลัก)=Training concerned community forestry (main document)	พรชุลีย์ นิลวิเศษ	201
12)	1998	การฝึกอบรมด้านวนศาสตร์ชุมชน (เอกสารภาคใต้)=Training concerned community forestry (south region version)	พรชุลีย์ นิลวิเศษ	127
13)	1998	การฝึกอบรมด้านวนศาสตร์ชุมชน (เอกสารภาคตะวันออกเฉียงเหนือ)=Training concerned community forestry (northeastern region version)	พรชุลีย์ นิลวิเศษ	123
14)	1998	การฝึกอบรมเรื่องชุมชนกับการจัดการทรัพยากรชายฝั่ง =Training on community and coastal resource management		84
15)	1998	พฤกษศาสตร์พื้นบ้านและการใช้ทรัพยากรพรรณพืชอย่างยั่งยืนภาคตะวันออกเฉียงเหนือ=Ethnobotany and sustainable uses of plant resources in northeastern region	เพิ่มศักดิ์ มกราภิรมย์	111
16)	1998	พฤกษศาสตร์พื้นบ้านและการใช้ทรัพยากรพรรณพืชอย่างยั่งยืนในภาคใต้ตอนล่าง=Ethnobotany and sustainable uses of plant resources in the lower part of south region	เพิ่มศักดิ์ มกราภิรมย์	104
17)	1999	วัฒนธรรมไทยกับไม้ในวงศ์ยาง =Thai culture and trees of *DIPTEROCARPACEAE*	ทัศนีย์ อนมาน	246
18)	1999	ป่าชุมชน:สาระสำคัญและประเด็น =Community forest: Essence and subject	เพิ่มศักดิ์ มกราภิรมย์	37
19)	1999	การฝึกอบรมเรื่องการจัดการทรัพยากรอย่างยั่งยืนสำหรับบุคลากรในระดับตำบล =Sustainable resource management for key personnel in the sub-district		
20)	1999	การจัดการทรัพยากรป่าไม้ที่เกี่ยวข้องกับพื้นที่อนุรักษ์และดูงานกิ่งอำเภอท่าตะเกียบ =Forest resource management around protected land and making an inspection in Thatakiap sub-district		118
21)	2000	รวมบทความป่าชุมชน=Digest of community forest	สมศักดิ์ สุขวงศ์ เพิ่มศักดิ์ มกราภิรมย์	100
22)	2000	ร่างพระราชบัญญัติป่าชุมชนของไทย:กลับนโยบายป่าไม้หรือพายเรือในอ่าง=Thailands community forest bill: U-turn or roundabout in forest policy	Verena Brenner	58
23)	2001	คิดใหม่ทำใหม่กับการเรียนรู้และการศึกษาด้านป่าไม้ =Rethinking and redoing, learning and education in forestry	Joe Peters	49
24)	2001	บทบาททรัพยากรป่าไม้กับการบรรเทาความยากจน =The role of forest resources in rural poverty alleviation	ระวี ถาวร	140
25)	2001	การฟื้นป่า:ถึงเวลาชุมชนมีส่วนร่วมหรือยัง? =Forest restoration : How long till people can be trusted?	ระวี ถาวร	154
26)	2002	การเรียนรู้ด้วยตนเองเพื่อความยั่งยืน=Learning oneself for sustainability	เพิ่มศักดิ์ มกราภิรมย์	199
27)	2002	การจัดการทรัพยากรป่าแบบพหุภาคี=Multilateral type of forest resource management	สุรินทร์ อ้นพรม	89
28)	2002	ป่าชุมชน:สาระสำคัญและประเด็น =Community forest: Essence and subject	เพิ่มศักดิ์ มกราภิรมย์	38
29)	2002	การจัดการป่าไม้และทรัพยากรชีวภาพโดยชุมชน=Forest and biological resource management by community		113
30)	2003	บทบาทอบต.ต่อการจัดการทรัพยากรธรรมชาติท้องถิ่นอย่างมีส่วนร่วม =Role of OoBoTo. to participatory natural resource management		39
31)	2003	นวัตกรรมท้องถิ่นเพื่อการจัดการป่าชายเลน =Local innovation for mangrove forest management	วีณา นำเจริญสมบัติ	80
32)	2005	การบริหารจัดการท้องถิ่น... สู่การจัดการทรัพยากรป่าไม้ที่ดี =Local management... toward good forest resource management		136
33)	2006	การติดตามระบบนิเวศอย่างมีส่วนร่วม :บทเรียนปัจจุบันสู่ทิศทางในอนาคต =Participantory monitoring and assessment of ecosystem:Lessons learned for development	ระวี ถาวร	235
34)	2007	วนวัฒน์เท้าเปล่าและเทคโนโลยีพื้นบ้านในการจัดการป่า =Bare-foot silviculture and local technology in forest management	ระวี ถาวร	353
35)	2008	ป่าชุมชน:กระบวนการเรียนรู้ในการจัดการทรัพยากรอย่างมีส่วนร่วมของสังคมไทย =Community forest: Process of learning in participatory resource management of Thai society	ระวี ถาวร	279
36)	2009	บทเรียนการพัฒนา แผนจัดการป่าชุมชน =Lesson of development community forest management plan	ระวี ถาวร	33
37)	2009	ป่าชุมชน:ความมั่นคงแห่งชีวิตท่ามกลางความเปลี่ยนแปลงและภาวะโลกร้อน =Community forest: Seculity of living in the midst of change and gloval warming	อัจลา รุ่งวงษ์	105
		English publication		
38)	1994	Community development and conservation through community forestry	Henry Wood	346
39)	1997	Community forestry at a crossroad: Reflection and future directions in the development of Community forestry	Michael Victor	324

Source: Made from the documents obtained in the Document Center, RECOFTC, and the search results with http://uc.thailis.or.th/ (22/11/2011).

CONCLUDING REMARKS

In Thailand, the human and social science studies relevant to riparian forest management characteristically encourage local villagers through action research to better direct natural resource management. We do not discount the effectiveness of this approach, but also espouse the objective and extensive study of local resource management dynamics facilitated by various institutions or stakeholders, including action researchers.

For example, staff from the Forestry and Nature Conservation Group, the Japan International Cooperation Agency (JICA) identified the following problem in their operations: "In the stage of investigation before launching the project, relatively elaborate research and examination are done on 'the challenge that each project should solve.' However, little attention is paid to the existing resources and capital that should be widely utilized… Here, we can understand the 'problems' of target inhabitants; on the other hand, we become less familiar with the resources and capital (bonding social capital). Moreover, in regard to the organizational analysis for the implementing agency [of the aid-receiving country], we have worked this into the investigation at the stage of project formation, with the purpose of strengthening administrative function or creating organizational institutions. In regard to the aspect of interacting with citizens (bridging social capital), however, we have not yet conducted substantial investigation and analysis" (Saito and Mutsuyoshi 2002). The recognition of these issues by an international cooperation agency, we consider, suggests the necessity for objective and extensive studies with respect to social capital. Also, such needs are arising under more complex conditions of local resource management, as mentioned in the Introduction, which are common to riparian areas. Thailand, a medium-developed nation, has itself been stepping away from the position of aid receiver. However, the historical process and the precedence of established local resource management dynamics should be instructive to other less-developed countries.

In this study, the authors traced not only local resource management dynamics but also their background and development including legislation, institutions, organizations, lineages, and ideological trends at the state level, with the riparian area of northeastern Thailand as the main field research site. As a result of this study approach, we suggest that we can draw two structural implications. First, any change that contributed to the pattern of the dynamics at the research site was directly or indirectly catalyzed by legislation, institutions, organizations, lineages, and ideological trends, which themselves transformed at the state scale, even though the foundations to respond to the initiatives had been laid at the local level. This indicates the possibility that, to a certain extent, places with patterns similar to the research site are ubiquitous throughout the region or the country. Second, the resource management area of the research site attracted various state-scale agencies other than the forest administration and NGOs. In this regard, however, such agencies had no ideologically or operationally consistent system. Furthermore, some embraced conflicting perspectives, such as where to place ideological and operational emphases.

In particular, we regard the "Voluntary forest guardian citizens" institution led by the forest administration and security authorities, with its stake in complementing national bureaucracy order, and the "Community forest for people" network bridged by the RECOFTC, with its stake in popularizing local wisdom and pluralistic natural resource management, as examples of conflicting perspectives. Within the conflicting dimensions involved in the two, we see the likely origin of some confusion in the field of local resource management.

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Ethnobotanical Study of Local People at Lam Se Bai Swamp Forest in Yasothon Province, Northeast Thailand

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Pipat Patanaponpaiboon[1]

ABSTRACT

An ethnobotanical study was undertaken with local communities at Lam Se Bai Swamp Forest, Nakae Subdistrict, Khum Khuang Kaew District, Yasothon Province, Northeast Thailand. Interviews and field surveys were used to record ethnobotanical information. Two traditional healers and 100 members of the local communities were interviewed. The information from the informants was grouped into four categories based on the uses of the plants for food, medicine, fuel wood and others. Seventy four plant species in 31 families were utilized. Plants were mainly used for food (74.05%), followed by fuel wood (15.14%), medicine (5.95%) and others (4.86%). However, 45 plant species were used for medicine and 39 plant species were consumed as food. Some interesting uses of plants were recorded, for example, *Barringtonia acutangula* shoots and leaves were consumed as vegetables while the bark was used for medicine and dyeing. The majority of informants planted several species of swamp forest food plants within their home gardens. This study shows that local people still have and actively utilize ethnobotanical knowledge regarding plant species from freshwater swamp forests.

Keywords: ethnobotany, local people, community forest, freshwater swamp forest

INTRODUCTION

Freshwater swamp forests are important transitional ecosystems between terrestrial forests and water ecosystems. Freshwater swamp forests have a patchy distribution along rivers in many regions of Thailand. The origin of Lam Se Bai River, which is a branch of Moon River, is at Phuphan Mountain, a transition area between Yasothorn, Sakonakorn and Mookdahan Provinces. Lam Se bai swamp forest is seasonally inundated during the rainy season and it provides diverse resources for local communities such

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as food, forest products and fish (Tabuchi, 2009). The forest has an important role in the everyday lives of local people, the forest is a community forest which is conserved and managed by the local communities. However, conversion of forest areas into the agricultural fields has reduced plant populations and may have lead to the extinction of plant species. The inhabitants that live in areas surrounding the forest are extremely knowledgeable regarding plant species and their uses, and this knowledge has been passed down through the generations (Cunha and Albuquerque, 2006; Ayantunde *et al.*, 2009). The knowledge of local plants species and their uses means that the communities value the forests and actively manage and conserve them.

Although the elderly members of the communities are extremely knowledgeable regarding the plant species and their uses of the swamp forest, this traditional knowledge is not being passed onto younger generations, as many younger people have left the villages to work in cities. Therefore, conducting study on this knowledge is needed before it will be extinct.

Ethnobotanical knowledge in Thailand has mostly studied within ethnic minority groups such as the Karen or local people who are dependent upon nature for their survival (Trisonthi and Trisonthi, 2009; Khamfachuea *et al.*, 2010; Intha *et al.*, 2010). This study documents the ethnobotanical knowledge of local people at the Lam Se Bai swamp forest in Yasothon Province. The community is approximately 40 kilometres from Yasothon city. The objective of this study was to investigate the number of species and their uses by local people at Lam Se Bai swamp forest.

MATERIALS AND METHODS

Lam Se Bai swamp forest (15° 35’ 23” N 104° 27’ 43” E), is located near Pla It village, Nakae Subdistrict, Khum Khuang Kaew District, Yasothon province, Northeast Thailand. It covers 13.44 ha and is composed of the community forests Dong Nong Saeng and Don Khi Ma. The mean annual precipitation is approximately 1,600 mm. The rainy season occurs from May to October during the southwest monsoon, and the dry season from November to April during the northeast monsoon. Dry Dipterocarp Forest (DDF) and Mix Deciduous Forest (MDF) are found surrounding the swamp forest. Each year the forests are partly inundated for 3 months from August to October. The inundation decreases with the distance from the river line and the elevation between the lowest and the highest ground height is approximately 8 m (Yoneda, *et al.*, 2009).

Pla It village is comprised of 2 communities, Moo 2 and Moo 8. The ethnobotanical study was conducted in 2010, using interviews and field surveys to record ethnobotanical data i.e. local plant names, plant parts used and their uses. Forest plant species that had been domesticated and planted in home gardens were also recorded. Plant samples were collected, photos taken and identification made with reference to taxonomic literature using flora of Thailand, flora of China etc. Moo 2 community comprises of 151 households (306 females and 352 males) while Moo 8 community comprises of 64 households (150 females and 151 males). All the people are Thai Nationals. In order to capture as much local knowledge as possible two key informants, traditional healers, from each community were included. These two key informants participated in field surveys. The informants were interviewed from the local people who utilized the Dong Nong Saeng and Don Khi Ma community forests. The individual uses were grouped into 4 categories based on the information gathered from informants. The use categories were food, medicine, fuel wood and others i.e. dyeing, ornamental and domestic utensils.

RESULTS AND DISCUSSION

The average age of the informants was 58 years (59 male and 57 female). The average age is relatively high as working-age people have left the villages to work in urban areas, especially Bangkok. The majority of informants were rice farmers (58.9%) and rice and crop farmers (31.4%). Their educational background was generally at the elementary school level.

Seventy four plant species in 31 families were reported and grouped into 4 use categories: food, medicine, fuel wood and others. According to these use categories, the informants used plants mainly for food (74.05%), followed by fuel wood, medicine and others, respectively (Figure 1).

Thirty-nine plant species were used as food (Figure 2).The plant species used for food, were divided into 3 subgroups: vegetables, fruits and bamboo shoot. The bamboo shoot (*Dendrocalamus asper*) was used by the highest number of informants (Figure 1), the shoots are collected from forest areas and consumed during the rainy season. Five plant food species were known by nearly all the informants namely *Barringtonia acutangula*, *Cratoxylum formosum*, *Syzygium gratum*, *Uvaria rufa* and *Xylopia vielana*, these are all common species found in the Lam Se Bai swamp forest area (Yoneda *et al.*, 2009). The young shoots and leaves of the first three species are traditionally served as fresh or boiled vegetables and eaten with local Northeast food i.e. Nam Prik. The fruits of *Uvaria rufa* and *Xylopia vielana* are consumed when they ripen during April-July (Pawaputanon, 2002; Khumkatok and Klinhom, 2001).

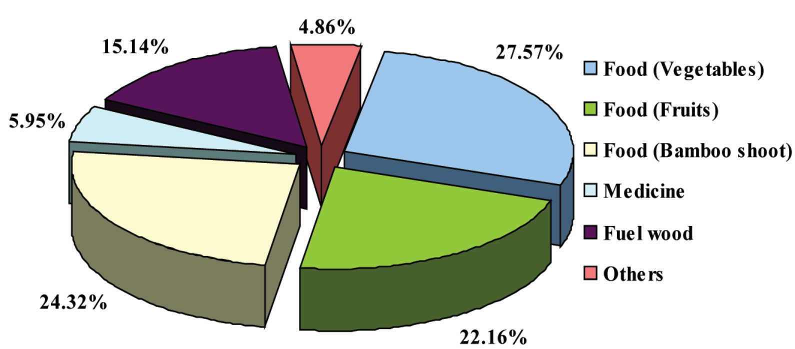

Figure 1 The percentage of use categories of plant species as reported by local people at Lam Se Bai swamp forest, Yasothorn Province.

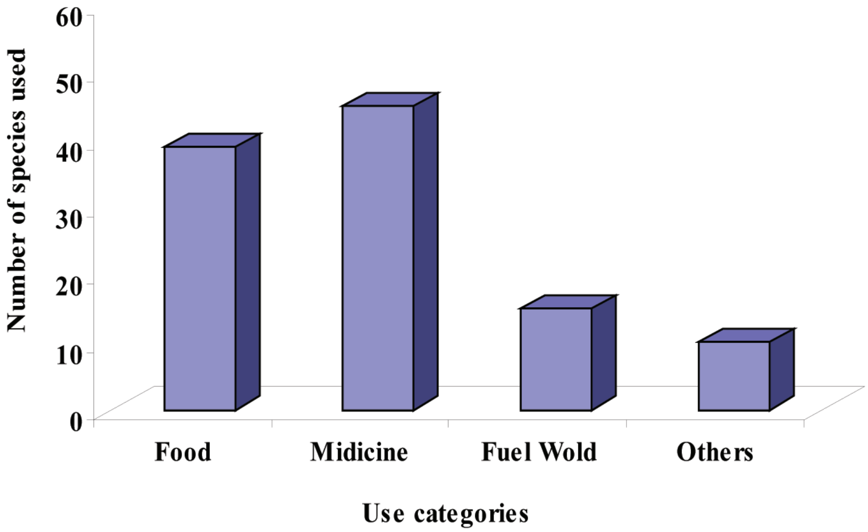

Figure 2 The number of species used in each category by local people at Lam Se Bai swamp forest, Yasothorn Province.

Forty-five plant species or 60% of the total plant species were utilized in traditional medicines (Figure 2). The two key informants, the traditional healers, were the most important persons who provided information regarding the traditional use of plants in medicines. Besides the traditional healers only 6% of informants utilize medicinal plants, indicating their use is generally restricted to traditional healers (Figure 1). It could result from that the local people go to traditional healers who care them or some informants prefer to be treated by medicines from the hospital and they also believe that the time to cure the ailments is shorter than using traditional medicines. Generally the data showed local people have less knowledge of medicinal plant species than the traditional healers. Medicinal plant species are typically used to treat a single ailment only. For example Cissampelos pareia was recorded by our informants as a treatment for fevers, this medicinal species is well known for treating fever ailment (Pawaputanon, 2002). Salacia verrucosa was used to treat constipation and *Suregada multiflorum* for body pain.

The plant parts used for food and traditional medicine are shown in Figure 3. Fruits (45.65%), and shoots and leaves (41.30%) are common plant parts consumed in our study site whereas for medicine, roots (24.59%) and the hardwood (22.95%) were the most frequently used plant parts.

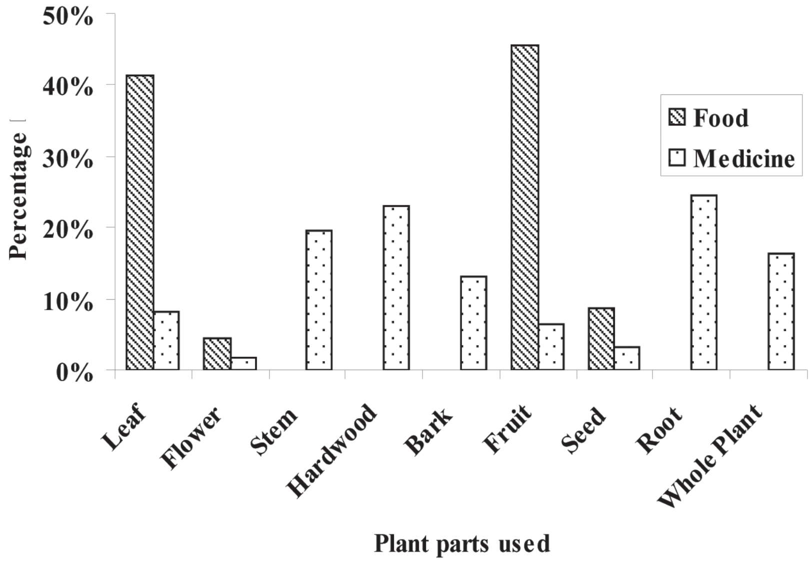

Figure 3 The percentage of plant parts used as food and medicine as reported by local people at Lam Se Bai swamp forest, Yasothorn Province.

Plant species used for fuel wood are listed in table 1. Woody parts from the study area are exploited as fuel wood. Women normally collect deadwood for cooking. However, the percentage to utilize plant species as fuel wood is not high (15.14%) due to mostly local people use the fuel from gas. This suggests that local people are partly reliant upon plant species as fuel wood. Cutting stems and live branches in this forest is prohibited, as the Lam Se Bai swamp forest is a community forest with rigorous management rules. Due to the strict regulations, trees are not used for construction purposes, however, the village chief may grant exceptions and allow the use of specific trees for specific construction uses.

Other uses of plant species in the study area included dyeing, domestic utensils, fishery tools and ornaments (Table 1). However the percentage using plant species in this category is less than 5%. For dyeing, the bark of plant species is commonly used by normal socking in boiled water with cloth. The bark of Barringtonia acutangula gives a brown color whereas the bark of Peltophorum dasyrachis and Pterocarpus macrocarpus give shades of red.

Table 1 Species lists, use category and plant parts used by local people at Lam Se Bai swamp forest, Yasothorn Province. Use categories: Ct = construction; Fd = food; Fl = fuel; Me = medicine; De = Dyeing; Orm = ornament; Ot = other. Parts used: Sht = shoot, Lf = leaf; Flo = flower; Fr = fruit; Ro = root; Se = seed; St = stem, Ba = bark, Hw = hardwood.

No.	Scientific Name	Family	Thai name	Uses Category	Parts used
1	*Antidesma* sp.	Euphorbiaceae	Mak mao	Fd	Fr
2	*Bhesa robusta* (Roxb.) Ding Hou	Celastraceae	Krabok khai	Me	Hw
3	*Barringtonia acutangula* (L.)	Lecythidaceae	Kradon	Fd, Me, De	Lf, Flo, Ba, Ro
4	*Calophyllum calaba* L.	Guttiferae	Tang hon	Me	Ba, Se
5	*Catunaregam tomentosa* (Blume ex DC.) Tirveng.	Rubiaceae	Ma khet	Me	Ro
6	*Cinnamomum porrectum* (Roxb.) Kosterm.	Lauraceae	Theptharo	Me	St, Ba, Ro
7	*Cissampelos pareia* L.	Menispermaceae	Krung khamao	Fd, Me	Lf, St, Ro
8	*Clausena harmandiana* (Pierre) Pierre ex Guillaum.	Rutaceae	Song fa dong	Fd	Lf
9	*Clausena wallichii* Oliv.	Rutaceae	Song fa	Fd	Lf
10	*Combretum trifoliatum* Kurz	Combretaceae	Khot sang	Fd	Lf
11	*Cratoxylum formosum* (Jack) Dyer	Guttiferae	Tio khao	Fd, Me, Fl	Lf, St, Ro
12	*Crudia chrysantha* (Pierre) K. Schum	Leguminosae-Caesalpinioideae	Satue	Fd	Lf, Fr
13	*Dalbergia foliacea* Wall.	Leguminosae-Papilionoideae	Kra phi khruea	Fd	Lf
14	*Dendrocalamus asper* Backer	Gramineae	Pai tong	Fd, Ot	Sht, St
15	*Dialium cochinchinense* Pierre	Leguminosae-Caesalpinioideae	Khleng	Fd, Fl, De	St, Fr
16	*Diospyros rhodocalyx* Kurz	Ebenaceae	Tako na	Fl, De	St
17	*Dipterocarpus alatus* Roxb. Ex G. Don	Dipterocarpaceae	Yang na	Ct	St
18	*Dipterocarpus intricatus* Dyer	Dipterocarpaceae	Yang krat	Me, Ct, De	St
19	*Dipterocarpus obtusifolius* Teijsm. ex Miq.	Dipterocarpaceae	Hiang	Me, Ct	St
20	*Dregea volubilis* (L.f.) Hook.f.	Asclepiadaceae	Kra thung ma ba	Me	Lf, Ba, Ro
21	*Elaeocarpus hydrophilus* Kurz	Elaeocarpaceae	Ma kok nam	Fd	Lf
22	*Ellipanthus tomentosus* Kurz	Connaraceae	Kham rok	Fd, Me	Hw, Fr, Ro
23	*Erythrophleum succirubrum* Gagnep.	Leguminosae-Caesalpinioideae	Sat	Me	Ba
24	*Fagraea fragrans* Roxb.	Gentianaceae	Kan krao	Fl, Orm	Flo, St
25	*Garcinia cowa* Roxb. Ex DC.	Guttiferae	Cha muang	Fd	Lf, Fr

Table 1 Cont.

No.	Scientific Name	Family	Thai name	Uses Category	Parts used
26	*Garcinia schomburgkiana* Pierre	Guttiferae	Madan	Fd, Me	Lf, Fr, Ro
27	*Gardenia obtusifolila* Roxb. Ex Kurz	Rubiaceae	Krabork	Fd, Fl	St, Fr
28	*Gardenia sootepensis* Hutch.	Rubiaceae	Khammok luang	Me, Ot	Lf, St, Ro
29	*Gomphia serrata* (Gaertn.) Kanis	Ochanceae	Chang nao	Me	St
30	*Hopea odorata* Roxb.	Dipterocarpaceae	Ta khian thong	Me, Ct	St
31	*Hydrocarpus antheminthicus* Pierre ex Laness.	Flacourtiaceae	Kra bao yai	Fd, Me	Hw, Fr, Se
32	*Hymenocardia wallichii* Tul.	Euphorbiaceae	Faep nam	Me, Fl	St, Fr, Ro
33	*Irvingia malayana* Oliv. ex A. W. Benn.	Irvingiaceae	Krabok	Fd	Se
34	*Lepisanthes rubiginosa* (Roxb.) Leenh.	Sapindaceae	Mahuat	Fd, Me	Fr, Ro
35	*Lepisanthes senegalensis* (Poir.) Leenh.	Sapindaceae	Mak wo	Fd	Fr
36	*Litsea glutinosa* (Lour.) C. B. Rob.	Lauraceae	Mi men	Me	Lf
37	*Mallotus macrostachyus* Muell.Arg.	Euphorbiaceae	Plao yai	Me	Lf, St, Ro
38	*Mallotus thorelii* Gagnep.	Euphorbiaceae	Fai nam	Me	St
39	*Memecylon edule* Roxb.	Melastomataceae	Phlong mueat	Ot	St
40	*Millingtonia hortensis* L.f.	Bignoniaceae	Pip	Me, Orm	Hw, Flo
41	*Nephelium hypoleucum* Kurz	Sapindaceae	Kho laen	Fd	Fr
42	*Oxyceros horridus* Lour.	Rubiaceae	Khat khao khruea	Me	Lf, St, Ro
43	*Parinari anamense* Hance	Chrysobalanaceae	Ma phok	Me, Fl	St, Fr
44	*Peltophorum dasyrachis* (Miq.) Kurz	Leguminosae-Caesalpinioideae	A rang	Fd, Me, Fl	Lf, St, Hw
45	*Phoebe* sp.	Lauraceae	Than nam	Me	Fr
46	*Phyllanthus* sp.	Euphorbiaceae	Siao na	Fd, Fl	Lf, St
47	*Phyllanthus taxodiifolius* Beille	Euphorbiaceae	Khrai hang nak	Fd, Me	Lf, St, Ro
48	*Polyalthia evecta* (Pierre) Finet & Gagnep.	Annonaceae	Nom noi	Fd, Me	Fr, Hw, Ro
49	*Pterocarpus macrocarpus* Kurz	Leguminosae-Papilionoideae	Pradu	Fl	St
50	*Pterygota alata* (Roxb.) R. Br.	Sterculiaceae	Hua ka	Me	Hw
51	*Rauvolfia serpentina* (L.) Benth. ex Kurz	Apocynaceae	Rayom	Me	Lf, St, Ro
52	*Salacia chinensis* L.	Celastraceae	Kam phaeng chet chan	Fd, Me	Lf, St, Fr, Ro
53	*Salacia verrucosa* Wight	Celastraceae	Ta kwang	Fd, Me	St, Fr
54	*Sampantaea amentiflora* (Airy Shaw) Airy Shaw	Euphorbiaceae	Sam phan ta	Me	Hw
55	*Shorea obtusa* Wall. ex Blume	Dipterocarpaceae	Teng	De	St

Table 1 Cont.

No.	Scientific Name	Family	Thai name	Uses Category	Parts used
56	*Shorea roxburghii* G. Don	Dipterocarpaceae	Phayom	Me	Ba, Hw, Ro
57	*Sindora siamensis* Teijsm & Miq.	Leguminosae-Caesalpinioideae	Ma kha tae	Me, Fl	Lf, St, Se, Ro
58	*Stereospermum cylindricum* Pierre ex Dop.	Bignoniaceae	Khae foi	Fd	Flo
59	*Streblus asper* Lour.	Moraceae	Khoi	Me	Lf, Hw
60	*Suregada multiflorum* (A. Juss.) Bill.	Euphorbiaceae	Khan thong phayabat	Me	St, Hw
61	*Symplocos sumuntia* Buch.-Ham. ex D. Don	Symplocaceae	Mueat pla sio	Fd, Me	Lf, St, Ba, Ro
62	*Syzygium gratum* (Wight) S. N. Mitra	Myrtaceae	Samet chun	Fd, Me, De	Lf, St, Hw, Ro
63	*Syzygium polyanthum* (Wight) Walp.	Myrtaceae	Samak	Fd, Fl	St, Fr
64	*Terminalia cambodiana* Gagnep.	Combretaceae	Khro ngo	Me, Fl	St, Hw
65	*Terminalia chebula* Retz. var. *chebula*	Combretaceae	Samo thai	Fd	Fr
66	*Tiliacora triandra* (Colebr.) Diels	Menispermaceae	Thao yanang	Fd, Me	Lf, St
67	*Uvaria fauveliana* (Finet & Gagnep.) Pierre ex Ast.	Annonaceae	Ngo phuang phon klom	Fd	Fr
68	*Uvaria rufa* Blume	Annonaceae	Phi phuan noi	Fd	Fr
69	*Willughbeia edulis* Roxb.	Apocynaceae	Khui	Fd	Fr
70	*Xylopia vielana* Pierre	Annonaceae	Kluai noi	Fd, Me	Lf, St, Fr, Ro
71	*Ziziphus cambodiana* Pierre	Rhamnaceae	Ta khrong	Me	St
72	Unknown 1	Myrtaceae	Wa pla buek	Fl	St, Fr
73	Unknown 2		Khamin khruea	Me	Lf, St, Ro
74	Unknown 3		Nam phrom	Me	Ba

In the study area, 60% of informants who used plant parts from Lam Se Bai swamp forest introduced plant species within their home gardens. All of the domesticated species were food plants (Table 2), eight plant species were consumed as vegetables and three species as fruits. The most popular domesticated plant species were Tiliacora triandra, Barringtonia acutangula and Elaeocarpus hydrophilus. The informants domesticated these plant species as it is more convenient to have them available near home than to travel to the forest for supplies. Furthermore, people would not collect plants from the swamp forest when these were inundated during the rainy season, whereas they can collect from non-inundated areas during all seasons.

This study showed that the informants living at the village are elderly (average in age 58 years old). Their occupations were mainly rice farmer, and rice farmer together with crop farmer which might be limited by the low level of their education. However, the local people were knowledgeable regarding ethnobotanical plant species uses from the swamp forest area. The highest percentage, 74.05%, plants used by the informants was mainly for food (Figure 1). Some used plant species are very interesting and useful i.e. *Barringtonia acutangula* and *Dendrocalamus asper*. The shoots and leaves of *Barringtonia acutangula* were consumed as vegetables while the bark used for dyeing and medicines. Local people in this study area had little knowledge regarding medicinal plants which is indicated by low percentage of used plants by the informants (Figure 1). This result could be explained by the fact that using plants as medicines requires specific knowledge. However, the traditional healers in our study were highly knowledgeable which was indicated by the high percentage of total number of plant species used (60% or 45 of 74 species; figure 2). Moreover, the methods to use medicinal plant to cure the ailments were mostly concealed from the public and were inherited by descendants only. Our study showed that the ethnobotanical knowledge of this local people has been inherited from their ancestors, the knowledge is verbally

Table 2 Species lists of plant species from Lam Se Bai swamp forest that informants

No.	Scientific Name	Family	Thai name
1	*Tiliacora triandra* (Colebr.) Diels	Menispermaceae	Thao yanang
2	*Barringtonia acutangula* (L.)	Lecythidaceae	Kradon
3	*Cratoxylum formosum* (Jack) Dyer	Guttiferae	Tio khao
4	*Syzygium gratum* (Wight) S. N. Mitra	Myrtaceae	Samet chun
5	*Dendrocalamus asper* Backer	Gramineae	Pai tong
6	*Clausena wallichii* Oliv.	Rutaceae	Song fa
7	*Elaeocarpus hydrophilus* Kurz	Elaeocarpaceae	Ma kok nam
8	*Xylopia vielana* Pierre	Annonaceae	Kluai noi
9	*Lepisanthes senegalensis* (Poir.) Leenh.	Sapindaceae	Mak wo
10	*Garcinia schomburgkiana* Pierre	Guttiferae	Madan
11	*Cissampelos pareia* L.	Menispermaceae	Krung khamao

transferred and not recorded in writing. Nevertheless, all informants in this study are elder except the only one is the teenager. He has limited knowledge of plant species uses from freshwater swamp forest, comparing to his parents. This suggests that in the future ethnobotanical knowledge could decrease or become extinct, if it is not studied and not actively utilized by young generations.

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Forest Products of the Trans-Boundary Mekong River Watershed: Lac and Teak in the Lao Forests

Shinya Takeda[1]

ABSTRACT

This paper examines forest products of a trans-boundary watershed taking the examples of Lao lac to Bangkok and Thai teak to Saigon being transported to markets over watersheds divide and international boundaries. Extracting products from deep in the forest is not an easy process. A light product can be carried along mountain paths on the backs of pack mules, but there is no alternative to transporting heavy products by floating them down rivers. On the one hand these were high-priced non-bulky, easily-preserved non-timber forest products (lac), and on the other hand, heavy, bulky timber (teak). What happened to lac and teak in the 20th century? In this paper, I shall focus on these two commodities that flowed down the Mekong and Chao Phraya Rivers and attempt to trace the history of forest product utilization. I shall combine the forests of the northern Laos and northern Thailand Mekong River watershed, the main production regions of these two commodities, into the term "the Lao forests" and look back at the historical trail of the utilization of forest products from these forests.

1. East India and Borneo: Two companies

What happened in the forests of Southeast Asia in the 20th century? In a word, "commodification of the forest." The daily life of the forest was swallowed up by the boundless desire of the market.

The forests of Southeast Asia had naturally been providing forest products such as eagle wood as "commodities" since ancient times, but not in such quantities as to cause changes to the forest itself. Quantity transforms quality. It was in the 20th century that this occurred.

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How and when did the commodification of the forest, especially the excessive commodification of the forest carried out by the Western countries in the colonial period, begin? Was there possibly some difference in the rate of progression of the commodification between different regions? Were there some conditions functioning to control the rate of progress? Let us try to gather information from the fragmentary records that exist.

The ocean trading network that carried out lively east-west ocean trade in Southeast Asia during the 15th to the 17th centuries also incorporated the landlocked Lao Kingdom of Lan Xang (Masuhara 2003, 54). For instance, in the records of a visit to Vientiane by the Dutch East Indies Company in 1641 we find, "Contracts were concluded to procure 123 kg of gold, 18,500 kg of benzoin, 9,250 kg of sticklac and so on" (Lejosne 1993; Stuart-Fox 1998, 181). Especially important among the export products of the Kingdom of Lan Xang were gold, lac and benzoin. These forest products were carried over mountain passes on the backs of people and pack horses, transported down rivers on boats to port cities such as Ayutthaya, and then on to the Coromandel Coast across the Indian Ocean, from where they were exported to Europe. The special characteristics of these commodities were that they were preservable throughout the long voyage, were easy to transport, and that they fetched a high price.

Up until the time when Siam was opened by the Bowring Treaty, the forest products that came down to the port cities from the forests in the upstream hinterlands were important commodities in Siam's royal monopoly trade. As shown in Table 1, these included teak, sappanwood, cardamom, lac, ivory, gamboges, animal hides, benzoin, Siamese rosewood, and eagle wood.

Table 1 Main Siamese Export Products as Noted in Observation Records (Ingram 1971: 25)

Commodity[b]	White (1679)	Crawfurd (1821)	Pallegoix (1850)	Malloch (1850)	Bowring[c] (1855)
Rice	x	x	x	x	x
Teak	x		x		x
Sugar	x	x	x	x	x
Coconut oil	x	x	x	x	
Sapanwood	x	x	x	x	
Salt	x	x	x	x	x
Pepper		x	x	x	x
Cardamoms		x	x	x	x
Sticklac		x	x	x	x
Iron	x	x	x	x	
Ivory	x	x	x	x	x
Gamboge		x	x	x	x
Hides and horns	x	x	x	x	x
Benjamin			x	x	x
Dried fish		x	x	x	x
Rosewood		x	x	x	x
Agilawood	x	x	x	x	x
Areca nuts	x	x			x
Tin	x	x	x	x	
Cotton		x	x	x	x
Tobacco			x	x	x

[a] The lists are designed to show that there was a considerable amount of uniformity in Siamese exports over this period.

[b] None of the lists include *all* of the commodities listed by the different authors.

[c] The list given for Bowring refers to the export commodities specified in the treaty negotiated by Bowring.

Sources: White, in *Records of the Relations Between Siam and Foreign Countries in the 17th Century*, II, 204–6; Crawfurd, *Embassy to Siam*, pp. 405–15; Pallegoix, *Description du Royaume Thai ou Siam*, I, 327–28; Malloch, *Siam, Some General Remarks on Its Productions*, pp. 34–51; Bowring, *The Kingdom and People of Siam*, II, 224–26.

After the conclusion of the Bowring Treaty, the upstream forests that had been providing these forest products were more firmly incorporated into the global economy, with Bangkok as the point of contact. The major commodity was teak.

The first Western company to begin commercial logging of teak in northern Thailand around the middle of the 19th century was the Borneo Company Limited, whose name derived from the island of Borneo and which was one of the largest timber companies in Southeast Asia (Brown 1988, 110). It was natural for the Borneo Company Limited to begin its logging operations deep in the mountains of the continent. At the time, teak was the most valuable timber material available. It was in strong demand as material for shipbuilding, high quality furniture, and for the sleepers required for railroad construction, indispensable for the running of colonies. The mountain areas of northern Thailand were very quickly shaded into different colors demarcating the logging concessions of the various companies. The East Indies Company and the Borneo Company handled different commodities during different periods of time. On the one hand these were high-priced non-bulky, easily-preserved non-timber forest products (lac), and on the other hand, heavy, bulky timber (teak).

What happened to lac and teak in the 20th century? In this paper, I shall focus on these two commodities that flowed down the Mekong and Chao Phraya Rivers and attempt to trace the history of forest product utilization. I shall combine the forests of the northern Laos and northern Thailand Mekong River watershed, the main production regions of these two commodities, into the term "the Lao forests" and look back at the historical trail of the utilization of forest products from these forests. [2]

2. Lac: A light, preservable non-timber forest product

Lac is a resin secreted by the insect Laccifer lacca (hereafter called the "lac insect"). The larvae of the lac insect spread all over the branches of the host tree and fasten themselves onto the branches by piercing the bark with their mouths. While sucking the sap from the branch, the lac insect secretes lac from the secretory glands covering its epidermis. The lac insect covers itself over with the shell formed from the lac secretion, the shell increasing in size until it envelops the whole twig.

Lac was once used as a red dye, but after the development of synthetic aniline dyes it has become widely used as resinous raw material, as a varnish, and as a gloss agent.

[2] "The area that the Siamese called the Lao region in the middle of the 19th century is not limited to the territory that is now known as Laos, but was a vast region that included areas west of the Mekong River. In other words, almost the whole area of present northeast Thailand and the area once covered by the Kingdom of Lanna was considered to be a Lao region quite separate from Siam." (Iijima 1994, 348)

Lac was an important export item from Siam (Table 1), its major production area being the Lao region comprising the present north and northeast of Thailand and Laos.

The following record concerns the lac from different production areas around 1930 (Thailand, The Ministry of Commerce and Communications 1930, 236-237).

1. Chiang Mai lac; this is the best of all Siam lac, as it is very carefully collected and contains a very small quantity of dust and wood. About 90% of this lac is grown in this province and is obtained chiefly from *Butea monosperma* and *Albizia saman*. The remainder comes from Chiang Tung and some districts of Chiang Rai and Mae Hong Son.

2. Chiang Rai lac; This lac, which contains a little more dust and wood than that of Chiang Mai, is chiefly supplied by foreign provinces, namely Chiang Tung, Sipsong Panna, Yunnan and Luang Prabang, the local production being only about 10%. The local lac is obtained from *Butea monosperma*, while foreign lac is propagated on *Ficus* spp., *Dalbergia* spp., *Butea monosperma* and *Cajanus cajan*. Chiang Rai lac is exported sometimes direct to Bangkok and sometimes through Lampang, Phrae and Uttaradit, and is known in the Bangkok market as Lampang lac.

3. Lampang lac; not more than one half is the local production, which is obtained from *Albizzia lucida*. The greater part of Lampang lac comes from Chiang Rai and is of foreign source. Some districts of Lampang, Chiang Mai and Chiang Rai supply a very small quantity. Lampang lac is exported direct to Bangkok.

4. Prae lac; this lac has the same quality as that of Chiang Mai. It contains a small quality as that of Chiang Mai. It contains a small quantity of dust and wood and obtains a good price in the market. The local production is about 75%, the rest is supplied by the province of Nan and some districts of Chiang Rai. The production of this province is very small, as compared with that of other provinces, and forms about 5% of all Siam's lac.

5. Uttaradit lac; Lac cultivation in this province is only in the experimental stage. Uttaradit is a transit market and receives lac from Nan (obtained from *Albizzia lucida*), Luang Prabang and Pak Lai (obtained chiefly from *Cajanus cajan*).

6. Khorat lac; as to quality, Khorat lac comes last, being much adulterated with dust and wood. It is supplied by the Circle of Nakhon Ratchasima (Khorat), chiefly the province of Ubon and Roi Et, and by the Circle of Udon and, some time ago, by French Indo-China. Khorat lac is obtained principally from Combretum quadrangulare and, in a small percentage, from *Dalbergia* spp., *Ficus* spp., *Zizyphus jujube* and *Cajanus cajan*. Formerly its quantity equalled that of Chiang Mai lac, but it has gradually decreased since some of the foreign lac is now passing through Uttaradit and Lampang.

From this record, the lac trade route network of around 1930 can be reconstructed as in Figure 1. It can also be seen from this figure that lac was widely collected from the Lao region.

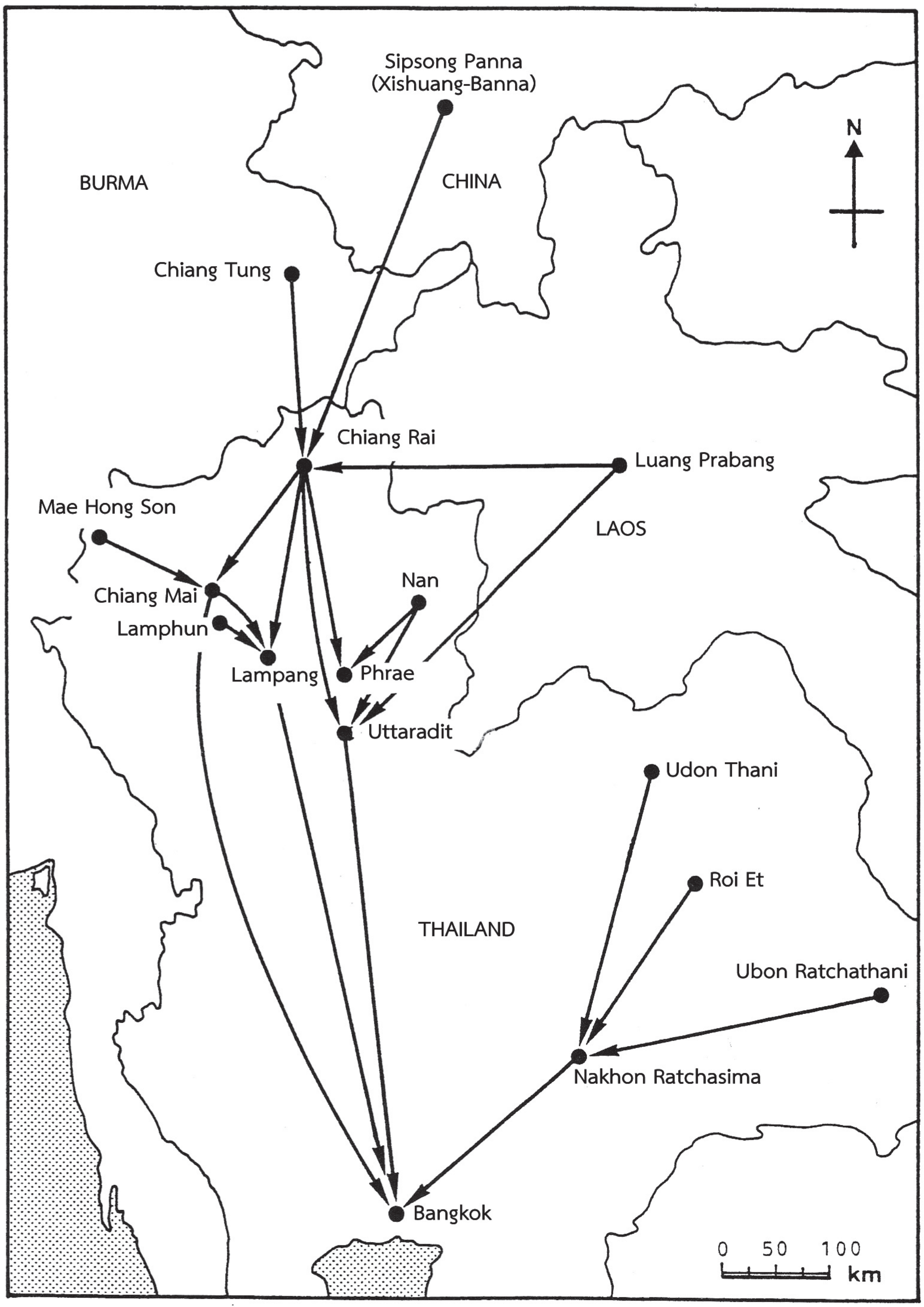

Figure 1 Lac Trade Routes in 1930 (Modified from Takeda 1990: 202)

The fact that lac was transported from this broad area not only by riverine transport but also overland is due to a high price per unit weight and to its preservability. Kakizaki, who has compared transportation costs between Bangkok and the regions with the top prices of the main commodities at the beginning of the 20th century, has pointed out the following.

"The main commodities conveyed from the Middle Mekong basin to Bangkok before railway construction were cattle, buffaloes, and jungle products such as sticklac, cardamom, Benjamin gum, hide and horn. Prior to the railways, there were the only products traded from "isolated" regions, either because they could transport themselves (that is, walk), or their scarcity, combined with their lightness, made their export price high enough to offset the cost of transportation." (Kakizaki 2005, 44). "Since trade between the Mekong Basin and Bangkok was solely dependent on land transport, the transportation of heavy goods such as teak was out of the question. Hence, trade to Bangkok was limited to light commodities with a high unit price, things such as jungle products, or livestiok, that is, cattle and buffalo, which could transport themselves. Of the jungle products, cardamom was the most signigicant." (Kakizaki 2005, 54).

Even after left bank of the Mekong River became French territory, the Lao forests continued to play their part as Bangkok's hinterland. This was because, "While in large part due to the good condition of transportation routes on the Thai side, on the other hand, the fact that French failed to make the effort to overturn the Thai advantage was an important factor. . . Thailand won an outright victory in the provision and maintenance of transportation routes in the Mekong River watershed and the acquisition of commercial hinterlands" (Kakizaki 2005, 305). Thus even following the establishment of French Laos, the lac from the Lao forests was linked to the market through Bangkok.

Around 1930, the host trees that were being cultivated in northern Thailand were *Albizia saman* and pigeon pea (*Cajanus cajan*), both exotic species. Two systems are recorded for the use of the pigeon pea, these being known as the Burmese system and the Luang Prabang system (The Ministry of Commerce and Communications 1930, 234).

The Burmese system: In the Circle of Payab, Cajanus cajan live from 3 to 4 years. They are planted 4 meters from each other and can be used within 2 to 3 years. If they are well looked after, they yield about 2 piculs per rai (120 kg/0.16ha).

The Luang Prabang system: This consists of planting trees at a distance of 2 metres from each other and of propagating lac within six to ten months. This is done twice, after which the trees are cut down, and new trees are planted again. This system of lac growing yields about ten to twenty catties of lac per rai.

The lac cultivation carried out in swidden fields using pigeon pea as the host tree is now being resuscitated in areas of northern Laos, centering on Luang Prabang Province (Takeda 2007).

3. Teak in the Mekong River watershed: Heavy, bulky timber

In this section, based on Laohachaiboon and Takeda (2007), I would like to examine teak logging in the Ing River basin at the beginning of the 20th century.[3] This will provide a clear description of the characteristics of the early period of commercial logging in Southeast Asia at a time when the commercial logging business was heavily reliant on the natural environment.

From the time when the Borneo Company business office was established in Chiang Mai, the northern Thai forests in the basins of each of the tributary rivers were allocated and sold to the various logging companies.

The watershed of the Chao Phraya River (Figure 2) was the most important for teak logging, teak being floated down from the tributary Ping, Wang, Yom, and Nan river basins.

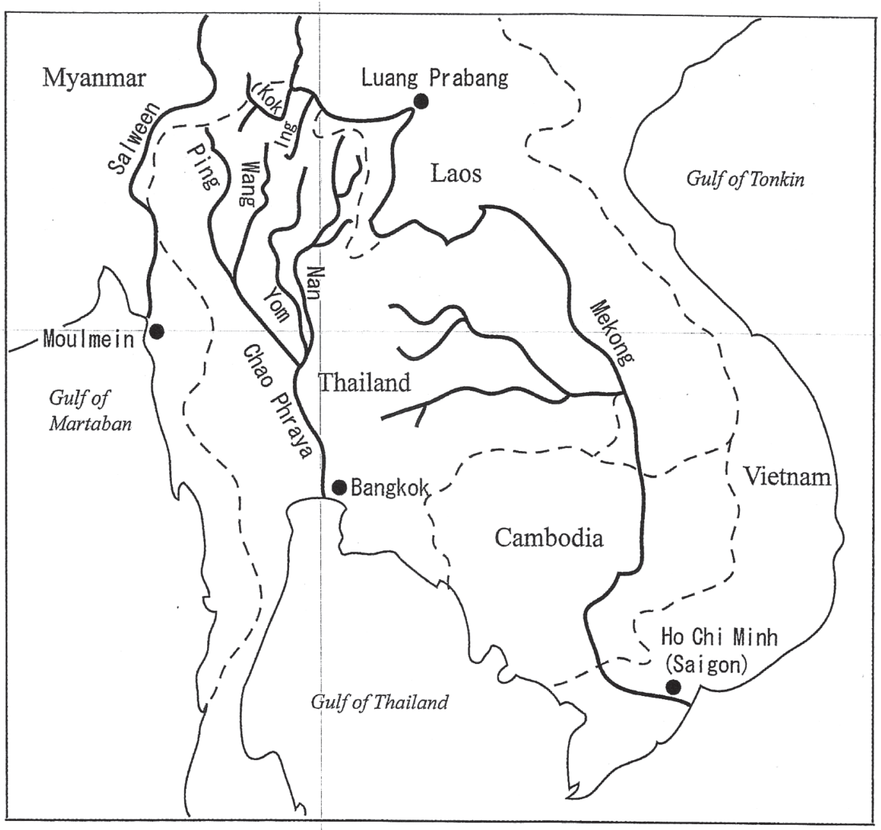

Figure 2 Map of the Watersheds of the Chao Phraya, the Salween and the Mekong (Laohachaiboon and Takeda 2007: 124)

[3] The period from 1909 to 1924 will be described here.

Of the teak logged from 1896 to 1925, 81% was floated down the Chao Phraya, 16% down the Salween and 3% down the Mekong Rivers (Suehiro 1996:30). The timber collection centers were Bangkok (on the Chao Phraya River), Moulmein (on the Salween River) and Saigon (on the Mekong River). Teak logging in Siam was handled by six foreign logging companies. Of these, four were British (the Borneo Company Limited, the Bombay Burmah Trading Corporation, the Siam Forestry Company and the Louis T. Leonowens Company), one was Danish (the East Asiatic Company Limited), and one was French (the French East Asiatic Company Limited).

The British companies were the most influential. The Borneo Company was the groundbreaker and was formerly the largest teak logging company. It had forged intimate relations with the Thai royal family from the time it began operations in 1888, and this had led to success (Falcus 1989, 138). The Bombay Burmah Trading Corporation, however, having initiated operations two years later, in 1890, grew to cover half of the logging concessions in the Chao Phraya watershed by the 1900s (Macaulay 1934, 75). While European companies accounted for 85% of all teak logging concessions from 1896 to 1930, local companies accounted for 14% and the Royal Forest Department held a meager 1% (Brown 1988, 119).

The first Chief Conservator of Forests of the Royal Forest Department, H.A. Slade, who served from 1896 to 1901, proposed the systematic implementation of logging, a review of the granting of concessions over large areas of forest to a small number of companies, and the encouragement of trade in non-teak woods as a means of livelihood for local people. In 1897 and 1899, the minimum girth of teak trees to be cut and royalty rates were fixed. Leases were split into two, each half to be harvested over a six-year period, thus creating a “felling cycle” of 12 years. In 1909, the Brandis selective logging system was introduced. This divided forest areas into two portions, each to be harvested over 15 years, establishing a 30-year felling cycle.

It was in this way that the Royal Forest Department organized forest administration through the leasing method, allocating the Chao Phraya watershed teak forests to the various logging companies.

The Mekong River watershed teak forests

The left bank of the Mekong River became French territory through the France-Siam Treaty of 1893, concluded following the Paknam Incident. Then, in an Anglo-French Declaration of 1896, the two parties recognized the Chao Phraya watershed as a buffer zone. Let us look here at the course of the teak logging in the two right-bank tributaries of the Mekong River, the Kok and Ing Rivers.

The Kok River basin: In 1909, the Borneo Company gained the rights to work the Fang forests situated in the Kok River basin. The Kok River is a tributary of the Mekong, and thus the teak harvested there would be sent down the Mekong River. However, the Siamese government of the time imposed the condition that the teak timber be transported across the Phi

Pan Nam Mountain Range, which formed the divide between the Mekong River and the Chao Phraya River watersheds, to the Ping River, a tributary of the Chao Phraya.

The Fang forests were contiguous with the Southern Shan states of British Burma, and the Siamese government preferred to lease the forests to any British timber firm possessing adequate capital to transport the logs as far as the Ping River. From a survey conducted by the Borneo Company, of the two possible transportation routes, the northern route and the southern route, it became clear that the southern route was the more suitable. Although this route ran counter to the natural flow of the Kok River, between 1912 and 1930 the Borneo Company extracted the logged teak along the Mae Phan and Mae Poi, tributaries of the Chao Phraya River. For the climb to the top of the divide the teak was loaded onto trucks drawn by elephants up a tramway, and for the descent the teak was sent plummeting down a chute, or timber-slide, to the Chao Phraya watershed.

The Ing River basin: A concession for the Ing forests was granted to the French East Asiatic Company in 1909. The Siamese government's judgment in doing so was partly due to the pressure of the French government, but more likely the decisive factor was that the concession was located in the Mekong watershed. In 1899, a French merchant named Leon Gravy petitioned for teak concessions in the Ing River basin. The Siamese government declined the petition on the grounds that no single Siamese company would be involved in the operation. In 1901, M.C. Waternau, who worked for a French newspaper publisher, also sought permission to work teak forests in the Ing and Kok River basins. He claimed that only the companies in French territory, which were able to float timber down the Mekong River, were capable of carrying out the logging of teak from the two basins, whose rivers are tributaries of the Mekong. Despite the validity of his statement, the Siamese government, citing political problems, also refused to grant the concessions to Waternau.

This was not a problem that was confined to the Ing and Kok basins alone. The Siamese government was reluctant to release control over teak forests in the sub-district of Phayao in Lampang Province, also within the Mekong watershed. This was a strategy to deter French encroachment. The government still preferred to have either the British or local chiefs manage the forests, but eventually granted the Ing basin logging concessions to the French.

Initially, the Bombay Burmah Trading Corporation expressed enthusiasm about leasing the Ing forests. In 1901, the corporation asked the Siamese government for a concession after hearing of the ongoing plan of the French to practice teak logging in that area. The government hastily agreed in the hope that the British presence would curb the increasing influence of the French. In a report written in 1902, (Figure 3) the Assistant Chief Conservator of the Royal Forestry Department W.F.L. Tottenham went so far as to state, "It is absolutely necessary to exclude French logging activities from this watershed." [4] Nevertheless, the Bombay Burmah Trading Corporation did not make use of the concession, since the teak logs harvested in the Ing basin had to be floated down the Mekong River, and there was no local market along that river. Rather than work the Ing basin forests the corporation logged the forests at Tam Yai and Tam Noi in the sub-district of Phayao in Lampang District, from where the logs could be transported via the Yom River to the Chao Phraya.

Granting of the rights to work the Ing forests to the British did not work out, but the local chief of Nan, Chao Suriyaphong Pharitdet later applied for a six-year concession in the Ing and Nan forests.[5] The Siamese government harbored doubts about his application since he could have been acting as an agent for the French to extract teak from the Ing River basin, but in the end granted him a six-year concession in 1902.

Four years later, in 1906, the Siam Forest Company also asked to operate teak logging in the Ing River basin. This was for the area located in the region of Nan adjacent to the Ngao forests in Lampang District, which were already being worked by the same company.[6] The company wanted to extract teak trees that were already girdled in this part of the Ing forests and transport

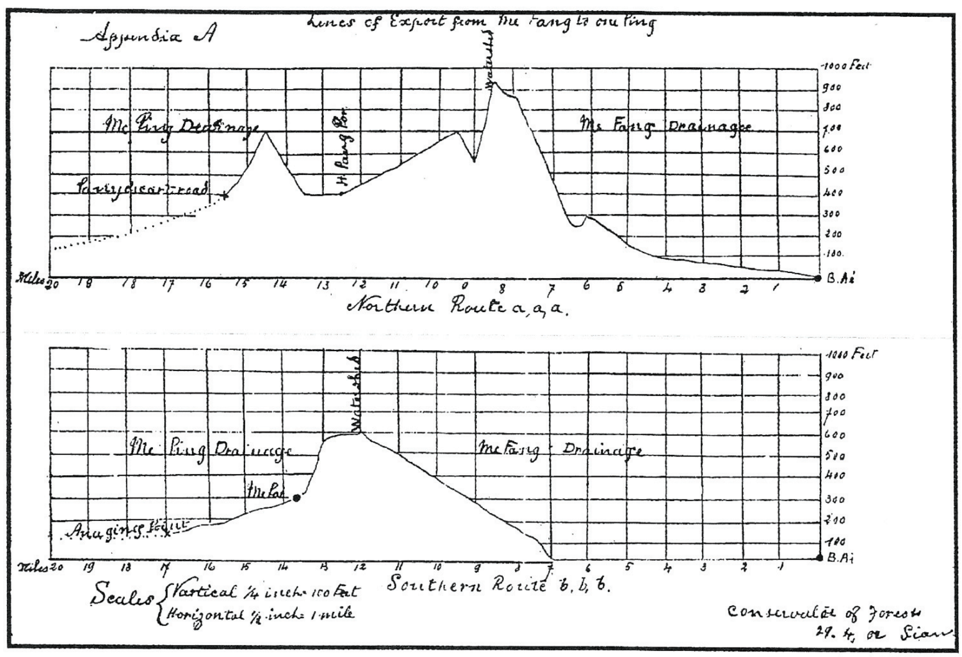

Figure 3 Plan for Teak Transportation from the Fang River to the Ping River (NA r5 M 16.1/23, 28 Jan. 1902)

[4] NA r5 M 16.1/23, 28 Jan. 1902
[5] NA r5 M 16.2/53, 9 Jan. 1903
[6] NA r7 KS 5.1/2, 10 Dec.1926

them to the Yom River in the Chao Phraya watershed. According to Prince Damrong, the company should actually have been granted the concessions of the Ing forests, because the company was the primary timber firm expressing an intention to practice teak logging in the Ing forests, and the teak timbers were likely to be exported into the Chao Phraya watershed. Nevertheless, the government was uncertain how to manage the Ing forests due to mounting pressure from the French.

The conclusion reached by the Siamese government to deal with these problematic concessions was to divide the Ing River basin into three sections, the north, central, and south forests. The south section, the timbers of which could be worked into the Yom River, was granted to the Siam Forest Company. However, the north and central sections, from where the only feasible export route was via the Mekong watershed, were eventually granted to the French East Asiatic Company in 1909.

The Siam Forest Company had difficulty extracting teak from the south section (the Chun forests in the Nan region) because the area was geographically closer to the head of the Ing River basin in the Mekong watershed, and because of the considerable distance across the watershed divide to the Yom River in the Chao Phraya river system. The company eventually managed to float the logs into the Yom River by constructing a logging railway (Pendleton 1963).

In 1909 the French East Asiatic Company finally won concessions and began teak logging operations in the Ing forests. The harvested teak logs were floated down the Ing River and then continued their log journey down the Mekong to Saigon.

The practice of teak logging in the Ing River basin

The division of the Ing forest into north, south, and central zones was determined from the viewpoint of the relative merits of extracting teak to either the Mekong or the Chao Phraya watershed. Between 1909 and 1924, the French East Asiatic Company was the major firm operating in the central and north sections, located in the Nan region, from where the teak timbers were floated down to the Mekong River. Meanwhile, the Siam Forest Company managed the logging in the south section, floating the timbers down to the Yom River.

Although the capital invested by the French company was sizeable, it harvested only a meager quantity of teak from the forests it had been allocated for logging. Thus, in 1912, the French company requested the government to grant another portion of forest comparable in size to that of the Ing forests. The Siamese government allotted the Kok forests to the company with a concession period lasting from 1925 to 1940.

In 1909, the Royal Forest Department stipulated that any concession area would alternate between open and closed periods of 15 years, and this condition was also applied to the forests in the Mekong watershed. The French company therefore harvested the Ing forests for the first 15 years (1909-1924), and then the Kok forests for the next 15 years (1925-1940).

Recognizing that forest operations in the Ing River basin were much more difficult than in the Chao Phraya watershed, the Siamese government set lower royalty payments for that basin.

Teak royalties from the Chao Phraya watershed were gathered at the Paknampho duty station. For the Mekong watershed, a tax station under the supervision of forest officials in Nan was established at the confluence of the Ing River. In practice, the Royal Forest Department ruled that a quarter of the total amount of the royalty would be collected at the logging site, and the remaining three-quarters be collected at the confluence of the Ing River with the Mekong.

The same royalty rate for teak logs originating from the Ing forests was applied regardless of which watershed the teak was floated down. The difference was that for areas of the Mekong forests worked by the French East Asiatic Company the royalties were collected at the confluence of the Ing River with the Mekong, whereas for the Siam Forest Company the royalties were collected at Paknampho.

The process of teak logging in the Ing River basin

Teak logging in the Ing River basin was practiced in a similar fashion to that of other river basins, but was much more difficult. In general, the forest operations in this basin began in June or July, at the beginning of the high-water period, when teak logs were transported by Khmu laborers to the Mekong River, from where they were floated down the river to the distant Saigon.

Teak felled in villages such as Ban Tam Nai, Ban Ronghai and Ban Phin in the upper Ing River basin was brought down to the Mekong River via the town of Thoeng. At Thoeng the logs were assembled into rafts, which were floated downriver to Chiang Khong, at the confluence of the Ing River with the Mekong. The floating of rafts in this area was problematic, because the lower course of the Ing River has many twists and turns as it meanders down to the Mekong. The local dialect word for a ‘meander’ is lhong. Navigating rafts through the lhong was difficult, causing the deaths of some laborers and damage to the teak due to collisions. The French East Asiatic Company cut a canal to shorten a lhong at Thung Ang village near the confluence of the Ing with the Mekong. By cutting the canal it was possible to turn the former stream of the river into a lumber yard for the teak logs, where they could be assembled into rafts or stockpiled while waiting for the river to rise.

For extraction work in the Ing River basin, the French East Asiatic Company invented a special cart, known as “high wheels,” which had enormous wheels and axles high above the ground (Bourke-Borrowes 1927, 33). Loading the logs under the axles gave the cart a low center of gravity, and thus great stability, while the large circumference of the wheels allowed the carts to travel at higher than usual speed.

The Royal Forest Department established a duty station at Ban Ten village, near the confluence of the Ing and Mekong Rivers, to collect royalties on the teak before it entered the Mekong River. If the water levels in the Ing and Mekong were unequal, a back-flow of water would occur near the confluence, causing difficulties in floating the teak logs downriver.

From the confluence of the Ing River at Chiang Khong, teak logs were floated down the Mekong River to Saigon. Log floating began in March or April. From Chiang Khong to Luang Prabang, except for some minor rapids, the Mekong River had no great obstacles. Some teak logs were sold locally at Luang Prabang, but almost all of the logs continued to float downriver to Vientiane. Along this stretch from Pak Ta, near Luang Prabang, to Vientiane, Khmu laborers from Luang Prabang were employed for rafting services. The French company preferred to employ these Khmu, because they had great experience of rafting on the Mekong and could be hired for low wages (Dauphinot 1905, 630; Bedetty 1900, 648). Logs were moored at Vientiane before being sent onward to Savannaket or Kemmarat, where they were assembled into rafts.

Between Vientiane and Saigon lay the Khone rapids and the innumerable rocks and rapids of the Sipandon area. Depending on the season, two methods were applied.[7] During the rainy season, the rafts were firstly moored at Don Dek or Don Khone and dismantled into individual logs, which were then floated down through the narrow channels between the islands. During the dry season, logs were landed on the largest island, Don Khone, and after being transported across the island by tramcars were reassembled into rafts at the downstream end. The logs required about two years to float down the Mekong from Chiang Khong to Saigon (Cordier 1907, 666).

At two sawmills, one in Saigon and one in Phnom Penh, the French East Asiatic Company processed an annual total of about 4,000 teak logs (Smith 1915, 20). The Saigon sawmill was located about 35 km from the city and stocked about 700 tons of teak logs on the site, the largest stock of its kind in Indochina.

During the initial phase, exports were limited to France, but after 1914 teak was also shipped to the United States, Britain, Singapore, and Hong Kong.

There were two factors in the background making possible the extraction of teak from the Ing River basin by the French East Asiatic Company.

The first was the highhanded approach of the French. To overcome the hesitancy of the Siamese government, the French obtained concessions in the Mekong watershed while concluding a pact with the British. That the French East Asiatic Company was also able to gain the concessions for the Ing River basin was due to the Franco-Siamese Convention of 1904.

The second was that, given the underdeveloped state of road and rail networks of the time, there was little option but to rely on floatation to transport heavy loads such as teak out of the Ing River basin and to make use of Saigon as the outport. It was found impossible to implement the early plan of granting the logging rights to the British Bombay Burmah Trading Corporation. The Thai Royal Forestry Department had planned to fell teak in the Mekong watershed and transport it over the divide to the Chao Phraya watershed, but this proved to be fraught with difficulties. There was no alternative to floating the heavy and bulky teak into the Mekong River.

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[7] NA r5 M 16.2/61, 29 July 1892

4. Market coupling and decoupling: War, markets and power machines

Forests were once deep and far-off entities. Forest-inhabiting peoples made a living by gathering scattered forest products. The forest products gathered were transported down the rivers by middlemen to port cities from where they were shipped to the outside world over the sea. In northern Laos, the lives of people who lived a subsistence lifestyle through swidden farming and supplemented their income with forest products continued for many centuries. The following account is found in the introduction to "Forests of Siam," written by the Research Department of the Secretariat of the Governor-General of Taiwan in 1931.

"Siam is a 'country of forests,' possessing untold riches in forest products, but because of the underdeveloped nature of transport, with the exception of teak, almost all of the promising resources of the region, though they may be exploited in the future, lie untouched in the sleep of ages" (Taiwan Branch of the Nan-yo Kyokai 1931, 1).

The forest was not the object of conservation and preservation, but was thought of as a treasure chest of unlimited resources that awaited development. The development of the forest lying "untouched in the sleep of ages" proceeded in the form of the commercial logging of teak from the continent and dipterocarp from Borneo. Although in different periods, the forests of Southeast Asia were irrevocably altered by the exploitation of these two timbers.

The distribution of these two species of tree has a common characteristic. It is that they do not form a pure forest, consisting of only the one kind of tree. Because of this, in the case of both the mixed deciduous forest of teak and the tropical rainforest of dipterocarp, the felling of the natural forest is carried out through selection cutting, leaving the forest itself intact. However, farmland was opened up hard on the heels of the logging, and the expansion of oil palm or Acacia mangium "plantations" took place leading to the loss of much of the tropical forest.

In this paper, we have looked at the examples of Lao lac to Bangkok and Thai teak to Saigon being transported to markets over watersheds divide and international boundaries. Extracting products from deep in the forest is not an easy process. A light product such as lac can be carried along mountain paths on the backs of pack mules, but there is no alternative to transporting heavy products by floating them down rivers.

In the times when lac and benzoin were carried over mountain passes on the backs of horses and donkeys, and teak felled with a two-handed saw was transported out by elephants, there was a definite limit to the amounts of products that could be extracted from the forests. Looking widely over Southeast Asia, however, in the latter half of the 20th century road networks were improved, tireless power machines came to be used to open up the forest, and overexploitation of the forest for the market greatly expanded. In northeast Thailand, the Friendship Highway linking Bangkok with Nong Khai was opened during the Cold War era, in 1958. As the road network spread out over the whole area of northeast Thailand, the northeast Thai section of the "Lao forests" was transformed into an upland cropping zone for commercial crops such as kenaf, cassava, and eucalyptus. Thailand became a member of the Western countries during the Cold War, but in the 30-year "era of development" 70% of the forests of the northeast were lost.

Contrastingly, in Laos, on the left bank of the Mekong River, the "Lao forests" were not all one-sidedly subordinated to the whims of the market. Even after the end of the Second World War, the war continued in Indochina. The First Indochina War against the French lasted from 1946 to 1954 was followed by the Second Indochina War against the United States from 1960 to 1975, after which came the Third Indochina War, consisting of the Cambodian-Vietnamese War in 1978 and the China-Vietnam War in 1979.

During the French Indochina period, the Indochina Wars, the links with the Communist Bloc, and the marketization of the Doi Moi policy, the forest products market of Indochina and Laos experienced repeated episodes of couplings and decouplings with different markets in each period. In other words, there was no extreme simplification of forest and wilderness utilization by a one-sided industrialization and market economization that enveloped the entire region.

According to the 2005 FAO Global Forest Resources Assessment (FAO 2006, 191), the percentage of forested land in Laos was 69.9%, the highest in South and Southeast Asia, exceeding that of Bhutan (68.0%), Malaysia (63.6%) and Cambodia (59.2%). The forests in Laos are exceptional in that they have remained intact, and it is possible to observe in that country the local utilization and production of diverse forest products.

Nevertheless, with the advance of developments in transport infrastructure such as the construction of bridges spanning the Mekong River at Vientiane, Pak Xe, and Savanaket, and the improvement of the Asia Highway, the economic integration of remote forests is progressing.

The abundant Lao forests have been preserved due to their fortuitous natural location and history. Entering the 1990s, the registration of a series of new species of large mammals such as Saola (*Pseudoryx nghetinhensis*), Large-antlered Muntjac (*Muntiacus vuquangensis*), Annamite Muntjak (*Muntiacus truongsonensis*), and Annamite Striped Rabbit (*Nesolagus timminsi*) has occurred in the Annamite Range, and Kha-nyou or Laotian rock rat (*Laonastes aenigmamus*) has been "discovered" in the market at Tha Khek. In this sense, not only are the Lao forests extensive, they are also forests that conceal a wealth of undiscovered treasures. How to make use of in the future, these Lao forests that have survived through to the 21st century in a highly natural condition, even among the forests of Southeast Asia, is a question that is now being broached.

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Swamp Forest Resources to Sustain Local Livelihoods at Lam Se Buy River, Aston, Thailand : Wood Demand for House Construction and Forest's Potential Productivity

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Sasitorn Poungparn[3] Pipat Patanaponpaiboon[3]
Takeshi Toma[1]

ABSTRACT

The amount of trees required for building a traditional house in a village in Yasothon province was examined so that the area of riparian forest required to produce sufficient timber resources for house building could be determined. A tree census revealed that 97 trees per hectare of a suitable size and species were available in locally riparian forests and that ca. 40 trees are necessary for building a house. Monitoring forest dynamics and interviews concerning the past history of forest use suggested around 40 years were enough to recover the tree stock if seed dispersal from neighboring forests or isolated mother trees were available.

Keywords: riparian forest, stand structure, wood use, house construction, allowable harvest

INTRODUCTION

The history of village development in many regions in the tropics is one of families' moving to new locations and the consequent conversion of forests to other land use such as houses, roads, paddy fields both irrigated and rain-fed, crop farms and ranges to feed cattle and thus deforestation.

This scenario was true too in recent centuries or decades in northeast of Thailand. Local residents undoubtedly harvested and used trees for several purposes to sustain their livelihoods and converted forests to agricultural land. Trees were used for fuel and charcoal and building houses and animal huts, making cattle fences, piers, bridges,

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and making tools for daily use (Prachaiyo 2000, Fujita 2000, Shibahara 2002a).

The pattern and variety of forest and wood use have been studied in several papers qualitatively (Fujita 2009, Shibahara 2002b) however most studies elucidated their diversity and quality to describe local wisdom to use resources in sustainable way. Among such local knowledge, the local wisdom to use riparian swamp environment in northeast Thailand is one of the most attractive issue due to its combination of village, forest and water, and several studies have evaluated this issue qualitatively e.g. Lower Songkhram river researcher network 2005 and Yukhong *et al*. 2007. Quantitative approaches, however, are still required so that the allowable amounts of forest products that can be used from nearby forests can be elucidated and local livelihoods sustained.

Quantitative analysis on resource use are generally however, mainly found change in forest area or land use pattern with using administration data and/or aerial photographs (Kono *et al*. 1994). Information detailing the amount of wood required for constructing a house or a village and how many trees of a particular size and species were used and the forest area cleared consequently since the establishment of a village is, however, still limited. House construction is surely one of the major wood consumable uses both in amount and size. Wanliphodom's (1999) pioneer work studied shape variations within typical traditional Thai houses by region although his study emphasized only variations in house shape rather than the quantity and species of trees utilized in their construction.

The major interest of this study is therefore to determine the amount of forest resource e.g. wood and non-timber forest products that can be used sustainably and the actual pattern and manner of usage in the life by local residents..

The wood consumed during house construction, and the size and species used was measured in a village in Yasothon Province. The stand structure of riparian forests surrounding the village was also evaluated and the potential capacity of the forest to provide wood resources determined. Thus, the number of houses that can be built from a certain area of forest was analyzed and the condition and the time period required to recover the utilized wood stock estimated.

METHODS

Study site

The settlement selected for study was PI hamlet (15°35' N 104°27' E) of NK village, Kham Khuan Kaeo District, Yasothon Province, northeast Thailand. The riparian forest at Lam Se Buy river which runs within the vicinity of the hamlet was also studied. The hamlet became established in 1929, at this time the forest surrounded a large swamp which has largely been converted to rain-fed paddy during the history of hamlet.

Lam Se Buy is a tributary that originates within Roi Et Province and the river joins the Moon River in Ubonrachathani Province. This river has a small and winding current in the late dry season but expands and is larger than a kilometer wide in the rainy season as it gathers a huge amount of rain water from its wide catchment. The runoff raises the water level compared to the dry season and submerges riparian forests regularly during the middle to late rainy season. The shift in stand structure therefore is observed along the gradient of inundation period. The forest vegetation of the lower ground which is frequently waterlogged is called paa tham locally, the area is swampy and small to medium sized shrubs cover the area. Forests on the higher ground are characterized by tall and large trees including some Dipterocarp species and Legume species, this area is called paa khok and plants and trees are submerged less frequently than at lower levels.

Measurement of wood consumption for house building

The size and amount of pillars, beams and panels used for building a house in PI hamlet were observed. Observations suggested that area of a standard sized house was 6 by 9 m^2 and 6 by 6 m^2. A bird view in Google Earth browser image showed the 6 by 9 m^2 sized house shared about half number of 186 houses in PI hamlet. The size, i.e. length, width and thickness as well as their amounts were measured by part.

Villagers elder than 50 years old who had built their own house were interviewed to discover the preference of tree species for house construction..

Tree census

Rectangular shaped study plots established in 2005 and (Plot-1) measuring 30 m by 120 m established at right angles from the river towards the interior were utilized for the tree census so that the size structure, tree growth and stand development could be elucidated. The plot was extended in 2009 to 30 m by 150m, and another square plot sized 30 m by 30 m was made (Plot-2) at a similar level as the extended plot. Another one 30 m by 60 m sized plot was set up within the secondary forest that had developed on former cropland that had been abandoned 20 to 30 years ago according to the owner, this plot was utilized to evaluate the forest recovery in addition to the other measurements. The exact period since the land was last farmed was unfortunately unclear.

Plots were sub-divided into 10 m by 10 m subplots, and all trees larger than 4 cm in DBH were numbered, tagged, DBH measured and position within the subplot recorded for further re-census to detect dynamics. Annual census has been carried out regularly.

RESULTS AND DISCUSSION

Tree species suitable for house construction

Within the riparian forest in proximity to the village, the major tree species used in house construction were listed (Table 1). Many Dipterocarps tree species are used for making panels and legume trees for pillars. Some tree species that can attain large sizes e.g. *Irvingia malayana* are not used for construction since the wood is too hard.

Table 1 Tree species harvested for house construction in PI hamlet and their use.

scientific name	Local name	family	use
Dipterocarpus alatus	Yaang Naa	Dipterocarpaceae	Panel
Dipterocarpus obtusifolius	Saat	Dipterocarpaceae	Panel
Shorea roxburghii	Phayoum	Dipterocarpaceae	Panel
Dipterocarpus intricatus	Sabaen	Dipterocarpaceae	Panel
Anisoptera costata	Tabaak	Dipterocarpaceae	Panel
Erythrophleum succirubrus	Phan Saat	Leguminosae	pillar
Xylia kerrii	Daeng	Leguminosae	pillar
Shorea obtusa	Taeng	Dipterocarpaceae	pillar
Syzygium gratum	Samet	Myrtaceae	pillar

Wood required for building a house

It was observed that 20 cm is the standard unit width of wood used for construction in the region. Timbers were sawn out from fallen trees within the forest using a chain saw. The standard timber length is 6 m usually and 3 to 2 m panels are cut out from that 6 m. Panels are sliced off from the standard timber into 2, 1.5 and 1 cm in thickness. Craftsmen are hired and they cut the wood in various sizes. A standing tree with a stem diameter larger than 30 cm is necessary to saw 20 cm width timber out (Figure 1). The remainder of the tree that are not used for construction e.g. big branches and bent part of the stem are processed into charcoal at hand made in *situ* kilns.

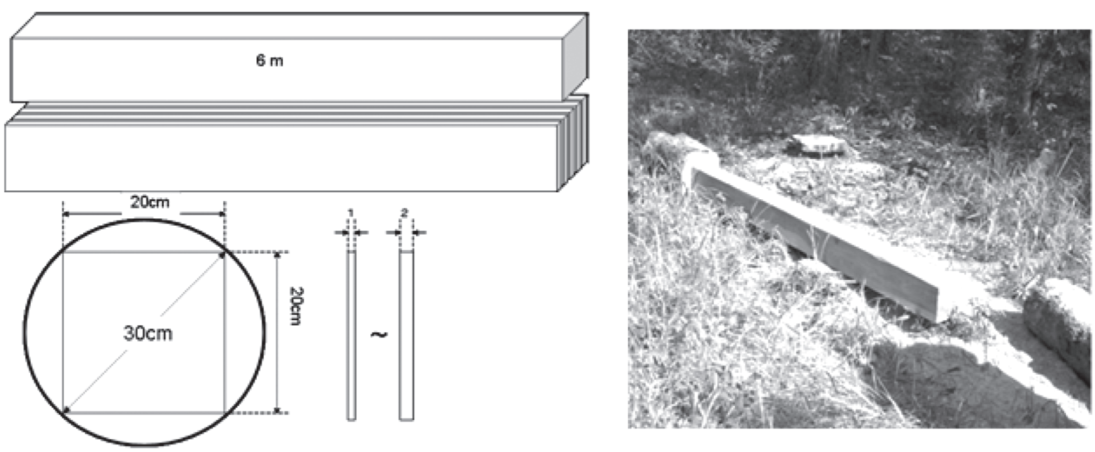

Figure 1 The timber size required for sawing standard 20 cm width wood out (left), and in *situ* processing of a pillar (right). The tree being processing is *Erythlophleum succirubrus*.

The size of wood beams, panes, pillars and shingle (thin oblong piece of wood laid in overlapping rows to cover the roof of houses) were measured and counted. Construction of a standard two storied house 6 m by 9 m in area in this region requires the wood parts listed in Table 2, when timber is utilized for all parts of the building. The total amount of construction wood for a standard two storied, earthen floored house with no walls on the ground floor was 9.6 m^3, and 6.72 m^3 for 6 m by 9 m and 6 m by 6 m sized houses respectively. The average wood volume necessary for the construction for a house with horizontally projected area of 6 m by 9 m and 6 m by 6 m sized houses was thus 0.178 or 0.187 $m^3\ m^{-2}$, respectively. The amount of wood required for house construction is quite uniform according to house size (6 by 9 m^2 or 6 by 6 m^2) since houses are typically built in a standard housing pattern within the region. Japanese wood house uses about 0.2 m^3 wood per square meter (FFPRI 2012) traditionally. Thus, 0.18 to 0.2 m^3 can therefore be assumed to be the basic unit amount for house construction (Table 2).

The relationship between stem diameter at 1.3m height (DBH) and height of the crown bottom (HB) is shown in Figure 2. There is a tendency that standing tree within the forest have a higher HB than trees in the edge and in the rain-fed paddy areas. The clear pole of trees in the paddy field is shortest and trees larger than 30 cm in DBH in forest and some of forest edge have branchless clear pole longer than 6 m which is suitable for construction.

In Table 3, estimates of the amount of logs larger than 30 cm in diameter required are listed by house parts. The amount of logs required can be considered the same as the number of standing trees required. This estimate suggests around 40 logs or standing trees are consumed for building a standard house of 6 m by 9 m (Table 3).

Table 2 Amount of wood necessary for building a house in the region

use	wood size (m)	amount	use	wood size (m)	amount
beam	0.1x0.02x3	9	wall panel	0.2x0.01x3	350
beam	0.2x0.02x3	8	wall panel	0.15x0.01x3	48
floor panel	0.2x0.02x3	90	roof shingle	0.2x0.02x3.5	8
pillar	0.2x0.2x2	20	roof shingle	0.2x0.01x3.5	90
pillar	0.2x0.2x3	4			

example of house with projection area of 6 m x 9 m

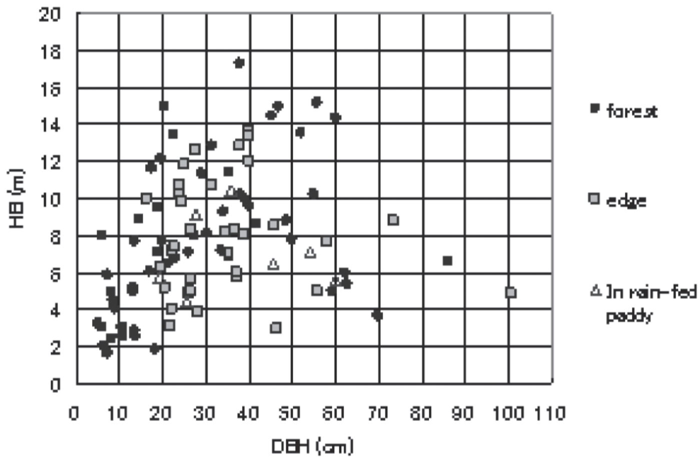

Figure 2 Relationship between DBH and HB. Solid circle for forest, square for forest edge and triangle for trees remaining in rain-fed rice paddy fields

Table 3 Amount of timber required for construction by house size

timber larger than 30 cm indiameter		6 m x 9 m 2nd floor only	6 m x 9 m 1st and 2nd floor	6 m x 6 m 2nd floor only
panel	6 m	17	34	11
panel+shingle	6.5 m	11	11	8
pillar	6 m	12	12	9
number of timber		40	67	28

Stand structure of riparian forests

The species composition of study plots 1 to 3 are shown for the main species with and their basal area (BA: m^2 ha^{-1}). The rectangular shaped Plot-1 is waterlogged regularly in the rainy season up to 80 m from river edge. In the table, plot-1 is subdivided into 4 zones i.e. 0 to 40m, 40 to 80 m, 80 to 120 m from the river edge as well as the 120 to 150m zone newly extended in 2009. Around 10 tree species with the largest BA in each zone or plot is shown in Table 4 so that composition and size can be compared between plots. The Dipterocarps and Legumes suitable for house construction are shown separately. A clear difference in dominant species and BA influenced by water condition is reflected as well as the small young tree stock in the recovering stand (Plot-3).

Table 4 Species compositions and stand parameters.

		Plot-1				Plot-2	Plot-3
	spp.	0-40 m	40-80 m	80-120 m	120-150 m		
Dipterocarpaceae	*Dipterocarpus alatus*	0.96	0.96	11.24	7.57	9.18	
	Hopea odorata			0.96			
	Shorea roxburghii				5.93		
	Anisoptera costata				0.27		0.77
	Shorea obtusa					0.10	2.30
	Dipterocarpus obtusifolius						4.31
Leguminosae	*Sindora siamensis*				0.26	0.21	
	Peltphorum dasyrachis						0.55
	Vatica harmandiana	1.51	1.51				
	Mallotus thorelii	3.04	3.04	0.13			
	Barringtonia acutangula	1.38	1.38				
	Syzygium spp.	1.31	1.31	4.41			
	Hydnocarpus anthelminthics	0.88	0.88				
	Garcinia schomburgkiana	0.54	0.54	0.92			
	Terminalia cambodiana	0.43	0.43				
	Dalbergia foliaceae	0.33	0.33				
	Terminalia pedicellata	0.28	0.28				
	Irvingia malayana			8.95			2.77
	Fagraea fragrans			2.40			
	Melodorum siamensis			1.51	1.31		
	Cinnamomum porrectum			0.65			
	Parinari anamense Hance			0.39	0.59		0.58
	Mangifera caloneura Kurz			0.37			
	Dialium chochinchinense				7.33		
	Grewia spp.				0.32		
	Milletia xylocarpa				0.24		
	Diospyros spp				0.15		
	Arcangelisia flava				0.06	4.95	
	Memecylon scutellatum					3.55	
	Markhamia stipulata					0.24	
	Sindora siamensis					0.21	
	Streblus asper					0.19	
	Syzygium gratum					0.15	
	Semecarpus cochinchinensis					0.06	0.61
	Calophyllum calaba						1.49
	Cratoxylum formosum					0.20	1.29
	Schima wallichii						1.19
	Ziziphus cambodiana						0.07

	Plot-1				Plot-2	Plot-3
stand parameter	0-40 m	40-80 m	80-120 m	120-150 m		
Basal Area (BA: $m^2 \cdot ha^{-1}$)	14.4 (21.4)	13.5	36.2	26.7	33.1	18.5
BA growth rate ($m^2 \cdot ha^{-1} \cdot yr^{-1}$)	0.59 (0.58)	0.52	0.67	0.17	0.56	0.21
Share of trees ≧30cm in DBH (%)	0.00 (0.4)	1.50	8.90	7.60	8.40	0.70

In Table 4, some parameters to present stand condition i.e. BA, growth rate of BA (m^2 ha^{-1} yr^{-1}) and the share of trees larger than 30 cm in DBH for zone 0-40m, 40-80m, 80-120m, 120-150m and Plot 2 and 3 in 2011 are also shown. There was a large Syzygium tree in 0-40m zone which may affect on those values due to its extraordinary largeness in the low swamp. Values of that zone therefore are shown two types i.e. figures which exclude the large tree data and figures that include are shown in parenthesis. There are obvious differences in BA and species by zone which reflect site conditions and species environmental preference. The dominant species for timber in the 80-120m zone was *Dipterocarpus alatus* while large Shorea roxburghii trees are also found in the stands towards the interior. Stand development at the abandoned farm shows only a *Dipterocapus obtusifolius* individual larger than 30 cm in DBH (density: 5 trees ha^{-1}). *D. obtusifolius* and *Anisoptera costata* were present in Plot-3 but *D. alatus* was absent. The *D. alatus's* preference to the riverine site with alluvial soil (PROSEA 1995) is well illustrated in their distribution pattern.

Capacity of riparian forest as the source of construction wood

The frequency distributions of Plot-1 by zone are shown in Figure 3. The open part of the bars represent trees larger than 30 cm classes in DBH are the share of tree species suitable for house construction. Stands more than 80 m from the river edge in this plot can be classified as *paa khok* in local name at where the influence of annual flooding is less severe in ordinary years, and is characterized by the existence of large trees. The density of trees larger than 30 cm of species suitable for construction in 80-120m and 120-150m zones of Plot-1, and Plot-2 was 92, 122 and 78 trees ha^{-1}, respectively, thus the mean density of suitable trees in *paa khok* was 97 trees ha^{-1}. The *paa khok* part of the riparian forest therefore is able to provide timber for two houses in standard size (6m by 9m) per hectare.

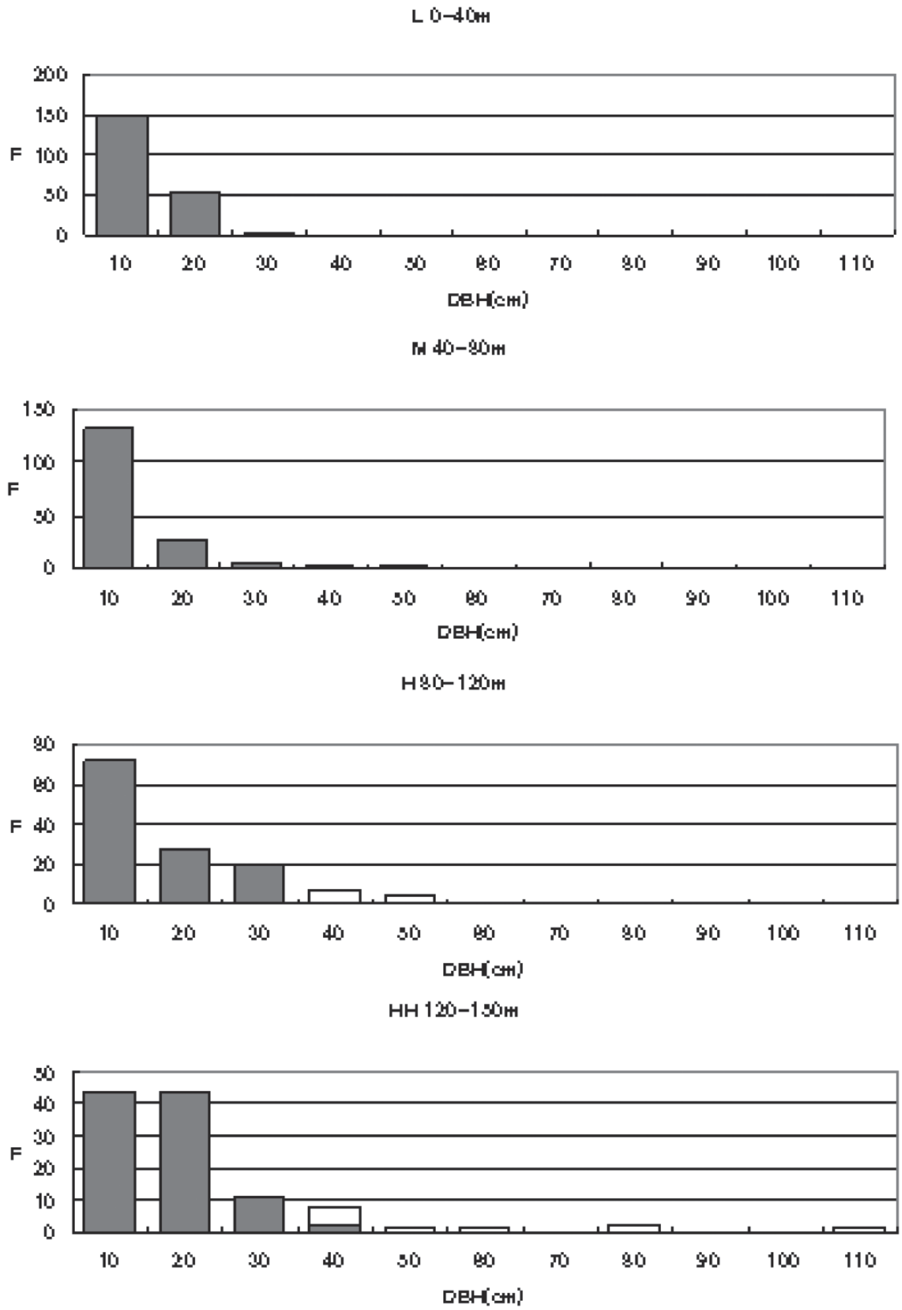

Figure 3 Stand size structure by zone in Plot-1 in DBH. Open part of bar shows the share of tree species suitable for construction.

The number of houses of PI hamlet shown in the Quick Bird orbiter Image taken in January 2008 was 188, and about half of them were sized 6 m by 9 m. The unit amount of timbers larger than 30 cm in diameter required for house of 6 m by 9 m and 6 m by 6 m was about 40 and 28, respectively as shown in Table 3. The number of standing trees larger than 30 cm in DBH of the species harvested in the past for 188 houses was therefore about 5,500 trees, which is equivalent to about 58 hectares of forest with taking into account the average density of useful tree species and their size. The village's history records over eight decades since people moved in to the present location and established the PI hamlet in 1929. The lifespan of wooden houses was not determined, and it is possible that some houses have been reconstructed or timbers within them replaced over the eight decades so that the number of trees actually harvested is probably larger than 5,500 trees, however the precise number and size as well as the amount of reused wood and forest recovery after harvesting was not able to be determined.

Recovery of forest

The growth rates of stem diameter in DBH were estimated on *D. alatus* using census data that had monitored survival and radial growth on an individual basis over 5 years. The average annual growth rate varied from 0 to 0.9 cm in diameter. We then applied the growth rate of each tree obtained by the individual based monitoring to estimate the size structure of this cohort of *D. alatus* assuming the present rate has been maintained over some decades since local residents ever exploited the *paa khok* for crop farming and then abandoned it about four decades ago and entirely stopped around 30 years ago.

The DBH of certain individual tree *i* in 40 years ago (DBH -40years i) was simply estimated applying the following equation as,

$$DBH_{-40years}\, i = DBH_{present}\, i - GR\, i*40 \quad (1)$$

$DBH_{present}\ i$ and GRi stands for present stem size of certain individual tree i and recent Growth Rate of tree i, respectively. We judged trees showed negative $DBH_{-40years}\ i$ were recruited within last 40 years. It was obvious that only sixteen *D. alatus* trees per hectare were stood 40 years ago and the number of trees of a size suitable for construction increased from 16 to 60 within 40 years. The recovery of the timber stock could possibly have occurred quicker as the growth rate of young trees is generally larger than matured (Kozlowski 1971). The difference between the restored and present structure suggests that recovery can occur when a seed source is available from forests in the vicinity or from mother trees that were left standing when the forests were disturbed.

The present estimation of wood consumption and recovery illustrates a basic way to quantitatively evaluate forest dynamics where timber is harvested to provide building materials for houses. There are many exceptions e.g. large sized trees can produce more than one lumber of standard size, most household build a second house for new generation, they may re-use some parts of wood for building new house and/or they use concrete pillar partly, and thus there may be wide variations in the amount of wood used. The historical trend of village development also shall be taken into account to fully evaluate the human impact on the surrounding forest. Other issues such as the amount of trees including the left over parts used as fuel wood, for making charcoal or other purpose should also be considered. Trees and forest have sustained the livelihood of local residents in diverse manners over a long period. This type of quantitative approach, therefore, represents a fundamental way to describe past use and to predict the future use of natural resource and will thus contribute towards to evidence-based natural resource management based upon quantitative data.

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Estimation of Litter Productivity in a Seasonal Flooded Forest Along Lam Se Bai River, Northeast Thailand

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ABSTRACT

Litter productivity was estimated in a seasonal flooded forest along Lam Se Bai river in Yasothon province at northeastern Thailand. A study plot (30x150 m2) was established on the river edge. It was divided into 3 zones based on relative ground height and level of inundation. They were in low, middle, and high zone, respectively from the river edge. Using litter traps, the monthly litterfall was collected from October 2009 - July 2011. However, the litterfall could not be collected in any months because of flood and lost of the litter traps. To solve the problem of missing data of monthly litterfall, we estimated the missing monthly litterfall by using relationships between monthly litterfall and climatic factors separately by the zone. The monthly litterfall in the low zone was significantly related to rainfall. However, the relationships for estimating monthly litterfall in the middle and high zone was obtained by using a dependent variable related to air temperature. Finally, the litter productivity was calculated for the respective zone during January to December 2010. It was at 13.48, 7.70 and 10.39 ton/ha, respectively for low, middle, and high zone. The trend of litter productivity was high in the low zone, where is usually flooded during rainy season. The litter productivity in middle and high zones was similar to that of reported for other dry evergreen forest in northeastern Thailand. We discussed and compared the variation of litter productivity by the zone.

Keywords: litter productivity, seasonal flooded forest

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INTRODUCTION

Linking aquatic ecosystem with upland terrestrial one, seasonal flooded forest distributes along the margins of streams and rivers. Most of trees are adapted to saturated soils and acted as a retention zone for drifting sediments and organic matter during large flow (Wantzen *et al.*, 2008). Much of sediments and organic matter come along with flood (Vreugdenhil *et al.*, 2006). The sedimentation may affect the growth and thus ecological productivity (Kvist and Nebel, 2001; Giese *et al.*, 2003; Cavalcanti and Lockaby, 2006). Net Primary Productivity (NPP) is one of an important part to estimate ecological productivity. Generally, NPP can be estimated by the summation of biomass increment and litter productivity. Large amount of biomass in vegetation canopy is returned to forest floor as litter productivity. Several studies reported that litterfall in seasonal flooded forests shared 30-70 % of NPP (Hasse, 1999; Nebel *et al.*, 2001; Giese *et al.*, 2003; Cavalcanti and Lockaby, 2006; Ozalp *et al.*, 2007). However, the forest has been flooded for a few months during rainy season. So, it is difficult to directly estimate litter productivity by using litter traps during inundated period.

Litter productivity related with climatic factors, i.e. annual precipitation (Deng and Janssens, 2006; Nebel *et al.*, 2001; Clark *et al.*, 2001) and air temperature (Clark *et al.*, 2001). It will allow to estimate the litterfall by using the relationship between the litterfall and climatic factors when the direct estimating by using the litter traps was inapplicable. In the present study, litter productivity in a seasonal flooded forest will be estimated using litter traps. Relationship between litterfall and climatic factors will be established to estimate litterfall during the inundated period.

STUDY SITE

The study site was located in a seasonal flooded forest along Lam Se Bai River in Nakae village, Yasothon Province, Northeast of Thailand (Figure 1). This forest plays a significant role both direct and indirect forest-utilization by the local people i.e. timber and charcoal production, edible and medicinal plants, fisheries etc. The annual precipitation was averaged at 1502.8 mm during 2001 to 2010 (Department of Meteorology, Thailand). A rainy season occurs from May to October and shares 93.4 % of annual precipitation in average.

(Source: maps.google.com)

Figure 1 The study plot was located along Lam Se Bai River in Nakae village, Yasothon Province, Thailand.

A study plot of a width of 30 m was established in 2009 on the Lam Se Bai river edge and extended towards inland with a distance of 150 m. Trees (diameter at breast height, DBH ≥ 4.0 cm) were identified to species and measured DBH and height. The elevation increased with the distance from the river. The difference between the lowest and the highest ground height was calculated at 7.5 m. According to the ground height and level of inundation, this forest was divided into 3 zones; low zone (0-2.5 m), middle zone (2.5-5.0 m), and high zone (5.0-7.5 m) (Figure 2). The approximate area in low, middle, and high zone were 2,125, 794 and 1581 m2, respectively. Inundation day in low zone was estimated at 50.4 – 90.8 days in year 2010. It was 15.6 – 50.4 and 0 – 15.6 days, respectively for middle and high zone.

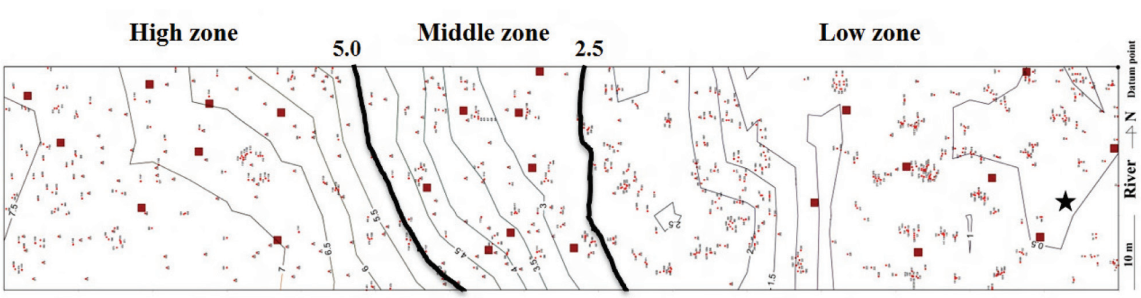

Figure 2 Illustration of the study plot, showing 10-m contour lines and the zones (low, middle and high zone). Eight litter traps were placed (indicated by red square) in each zone. A reference point (indicated by star) where the water level logger was attached at tree number 32.

The tree species were different among zones, especially between the low and high zones. Tree density, average DBH and total basal area in the low zone were 1,675 stems/ha, 9.4 cm and 17.57 m^2/ha, respectively. The dominant tree species were *Mallotus thorelii* Gagnep., *Hymenocardia punctata* Wall. Ex Lindl. and *Garcinia schomburgkiana* Pierre. Many woody climbers form a complex canopy among the neighbor trees. Such a canopy structure may prevent litter to fall into the ground. However, in the high zone, the tree density was relatively low, at 999 stems/ha with average DBH and total basal area of 14.0 cm and 27.76 m2/ha, respectively. *Dipterocarpus alatus* Roxb. ex G.Don, *Melodorum fruticosum* Lour. and Shorea roxburghii G. Don were dominant species. These species were commonly found in dry evergreen forest of Thailand (Santisuk, 2006). Because the middle zone was the buffer zone between the low and high zone, the dominant tree species commonly found in the low and high zone were also found in this zone (i.e., *Mallotus thorelii* Gagnep., *Garcinia schomburgkiana* Pierre, and *Dipterocarpus alatus* Roxb. ex G.Don). The tree density, average DBH and total basal area in this zone were 360 stems/ha, 12.7 cm and 30.72 m^2/ha, respectively.

MATERIALS AND METHODS

Collection of litterfall

Eight litter traps (1 m^2 for each) per zone were randomly placed at the height of 1.3 m from the ground (Figure 2). Litter in the traps was collected monthly from October 2009 to July 2011. It was oven-dried at 80 ºC until obtaining a constant weight. Then, it was manually separated into plant organs (leaf, woody and reproductive parts) before measurement of dry weight.

Measurement of climatic factors

Air temperature (minimum, maximum, and average) was recorded by HOBO® temperature data logger (Onset Computer Corporation, USA) at 30 minutes of time intervals from October 2009 to July 2011. The absolute pressure was recorded at a reference point locating at tree number 32 in low zone (Figure 2) by HOBO® water level logger (Onset Computer Corporation, USA) at every 3 hours during the flooded period. It was automatically converted to water level in the plot by using HOBO ware Pro software (Onset Computer Corporation, USA). Monthly Rainfall was recorded by HOBO® rain gauge sensor (Onset Computer Corporation, USA) from October 2009 to July 2011.

Measurement of topography level

Instrument siteline builders level tool (Laser level, USA) was used to measure topography level of the study plot at every 10 m from the datum point at the right-corner of the study plot towards inland (Figure 2). A topography map was done by mapping tree and contour lines of ground height all over the plot. The ground height and the depth of inundation at the reference point (Figure 2; tree no.32) were used for calculation of the inundation depth all over the plot.

Data analysis

Statistical analysis was done by using SPSS® for Windows version 19. Regression analysis was determined between the monthly litterfall and climatic data. Then, the regression was used to estimate the monthly litterfall during the inundated period separately by zone. The litter productivity (ton/ha/yr) was calculated by summing monthly litterfall obtained from January to December 2010.

RESULTS AND DISCUSSION

The monthly litterfall obtained from the litter traps in all 3 zones was not complete during the period of study (January to December 2010). During July to September 2010 of flooding period (Figure 3b), the monthly litterfall could not be collected from the traps in the low zone (Figure 3a). The litter traps were submerged during the large flow of water from the upstream of the Lam Se Bai river in the rainy season (Figure 3b). Moreover, the monthly litterfall during April - May and October - December 2010 was lost in all zones due to the lost of entire traps (Figure 3a). The available data of monthly litterfall showed a trend that the woody part was high in the low zone (5-66 %). But the leaf litter shared a high portion of total litter in the middle zone (63-94 %) and high zone (63-95 %). In low zone, many woody climbers and shrubs were formed a dense canopy with trees. After the flood, some woody climbers have died. So the dense canopy may cause the high portion of woody litter in the low zone. Haase (1999) also reported such a dense structure of canopy in a flood plain forest in Brazil.

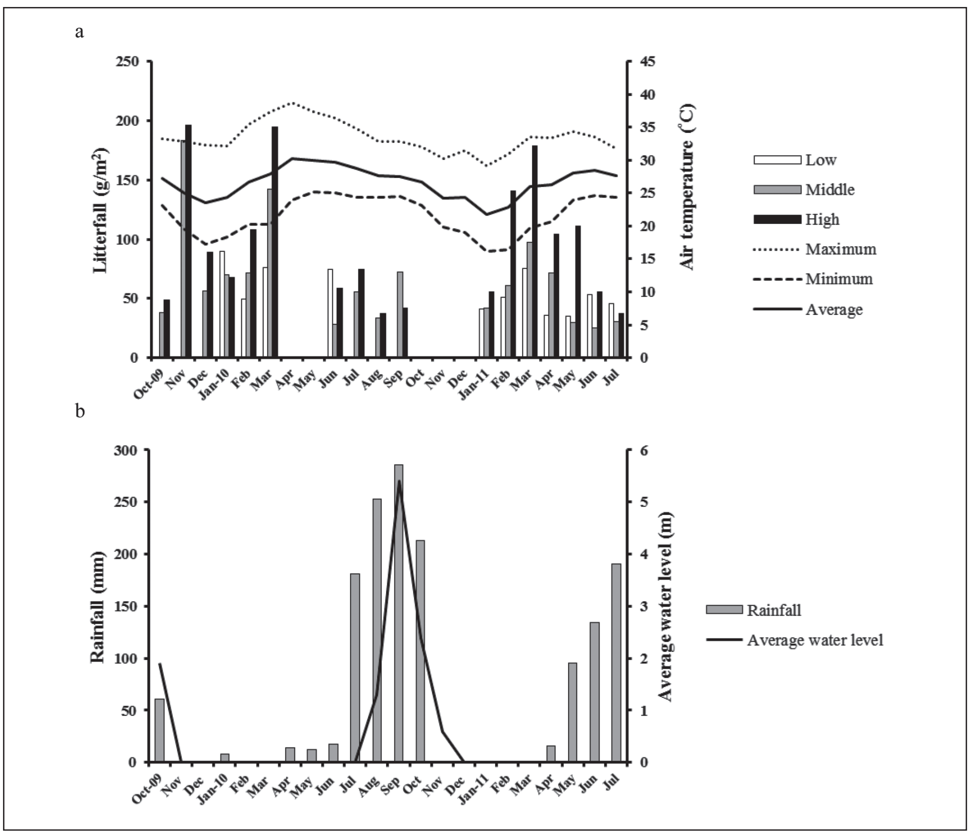

Figure 3 (a) Monthly litterfall of the three zones and air temperature during October 2009 to July 2011.
(b) Monthly rainfall and average water level during October 2009 to July 2011.

The problem of missing data of monthly litterfall by flooding over the traps was also reported by some studies. Giese et al. (2003) lift-up the height of litter trap above the water level to study the litter in riparian forest at South Carolina, USA. Nebel et al. (2001) also adjusted the height of the litter trap above the inundation level at flood plain forest in Peru. Ozalp et al. (2007) used fiber glass as the material instead of nylon for the trap to prevent the litterfall to be soaked by submerged condition.

In the present study, we solved the problem of missing data of monthly litterfall by estimating them from relationship between monthly litterfall and climatic factor. Minimum, maximum and average air temperature of the study site was respectively averaged at 18.5, 36.8 and 26.7 ºC during October 2009 to July 2011. The annual rainfall was calculated at 985.2 mm from January to December 2010. During July to October, the monthly rainfall was relatively high, 233. 1 mm. In a contrast, the average monthly rainfall during the dry season (November to June) was given only at 6.6 mm.

Relationships between monthly litterfall and climatic factor were obtained separately by the zones (Table 1). They were significant at $p<0.05$. In the low zone, the monthly litterfall positively related with the monthly rainfall (Table 1, equation 1) (Figure 4). The monthly rainfall usually affects the level of inundation in the study plot (Figure 3b). The high amount of litterfall during the inundation period was partly explained by plant stress induced by flooded condition (Richards, 1996). It was coincided with a study of litterfall at a seasonal flooded forest in Peruvian Amazon (Nebel *et al.*, 2001). They found that the monthly litterfall increased with increasing rainfall and water level.

Table 1 Relationships and Pearson correlations between the monthly litterfall and the climatic factors for each zone.

Zone	Relationship	R^2	p-value
Low	(1) Litterfall = 0.553 Rainfall + 46.392	0.378	0.034
Middle	(2) Litterfall = 7.511 Trange – 29.189	0.301	0.028
High	(3) Litterfall = 13.751 Trange – 70.664	0.513	0.001

Remark: Litterfall means monthly litterfall (g/m2), Rainfall and Trange mean monthly rainfall (mm) and monthly air temperature

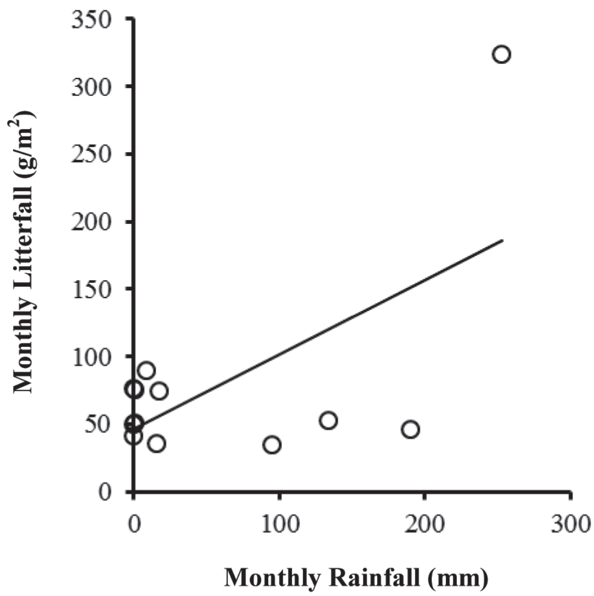

Figure 4 Relationship between the monthly rainfall and monthly litterfall of low zone. The regression line was significant at $p<0.05$.

In the middle and high zone, we found that monthly litterfall positively significantly related with the difference between maximum and minimum air temperature (T_{range}) (Table 1, equation 2-3) (Figure 5-6). Therefore, it implied a phenomenon that a narrow range of air temperature may stabilize the monthly litterfall in the middle and high zone. On the other hand, a large variation of air temperature probably promotes the monthly litterfall. Similarly to some of previous studied reported that temperature had a significantly positive effect on litterfall production (Lam and Dudgeon, 1985; Zhou *et al.*, 2007).

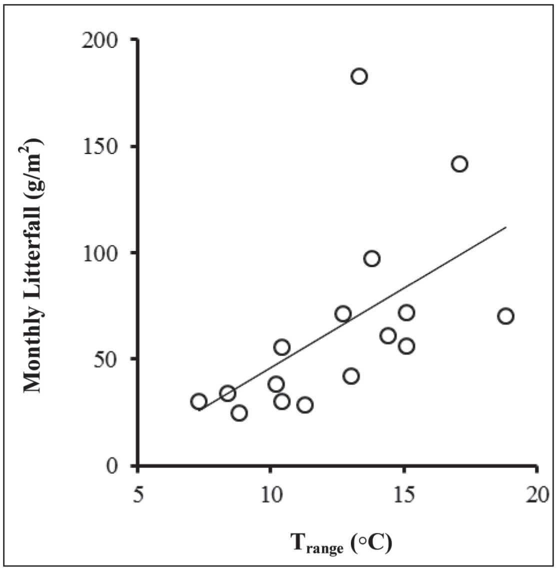

Figure 5 Relationship between the monthly air temperature range (Trange) and monthly litterfall of middle zone. The regression line was significant at $p<0.05$.

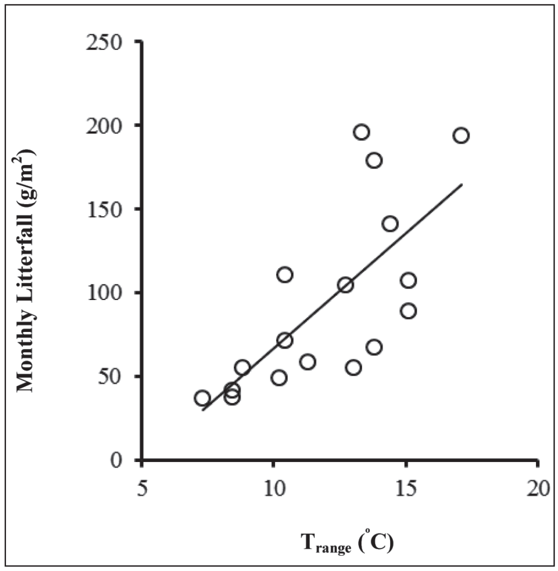

Figure 6 Relationship between the monthly air temperature range (Trange) and monthly litterfall of high zone. The regression line was significant at $p<0.05$.

Finally, the litter productivity was calculated for the respective zone during January to December 2010. It was given at 13.48, 7.70 and 10.39 ton/ha, respectively for low, middle, and high zone (Table 2). The highest tree density in the low zone (1675 stems/ha) was caused the highest litter productivity among zones. Higher tree-density typically has greater productivity for a variety of reasons, including more rapid deployment of leaf and then resulting in more litterfall (Binkley, O'Connell and Sankaran, 1997). When we compared the litter productivity with other flood plain forests in South Carolina, USA (Shure and Gottschalk, 1985) and Peruvian Amazon of Peru (Nebel *et al.*, 2001), our estimate was higher than them (Figure 7). This difference may be caused by the high ecological productivity in the tropical regions in a comparison to that of high latitude region. The litter productivity of high zone was comparable to that of a dry evergreen forest in Sakaerat, northeastern of Thailand (Visaratana and Chernkhuntod, 2006) (Figure 7).

Table 2 Monthly litterfall and litter productivity in 2010 for low, middle, and high zone.

Month	Zone		
	Low	Middle	High
January	90.02	70.05	67.71
February	49.82	71.66	107.67
March	76.12	141.96	194.40
April	54.13*	81.97*	132.85*
May	53.25*	62.45*	97.10*
June	74.46	28.53	58.90
July	146.71*	55.45	74.47
August	342.28	33.75	37.63
September	204.27*	72.54	41.55
October	164.13*	37.66*	51.72*
November	46.56*	49.68*	73.72*
December	46.39*	64.70*	101.22*
Total (g/m2/yr)	1348.14	770.39	1038.94
Total (ton/ha/yr)	13.48	7.70	10.39

Remark: * indicates an estimated monthly litterfall by using the regressions reported in Table 1.

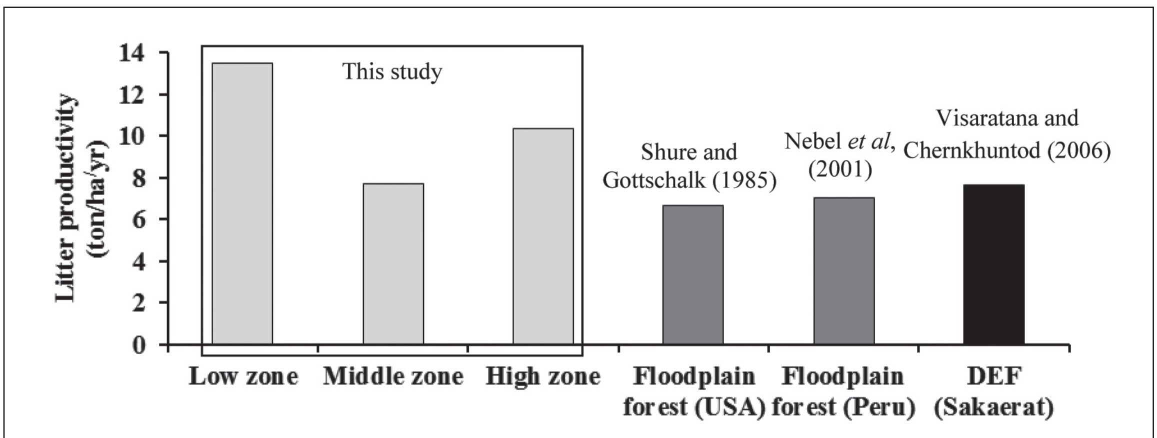

Figure 7 Comparison of litter productivity among zones in seasonal flooded forest at Yasothon, Thailand (light grey bar), flood plain forest (dark grey bar) and dry evergreen forest (black bar).

CONCLUSION

The monthly litterfall related with climatic factors, thus the regression models predicting monthly litterfall in each zone were obtained when the independent variable of rainfall and air temperature were used. The problem of missing data of monthly litterfall during the flooding period was solved by indirect estimation by these regressions. Finally, we calculated the litter productivity in each zone. The trend of litter productivity was high in the low zone, which is usually flooded during the rainy season. The litter productivity in middle and high zone was similar to that of reported for other dry evergreen forest in northeastern Thailand.

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Zonal Variation on Decomposition Rate of Leaf Litter in Seasonal Flooded Forest Along Lam Se Bai River

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ABSTRACT

Leaf-litter decomposition was studied by using the litter-bag method at a seasonal flooded forest locating on the edge of Lam Se Bai River, northeastern Thailand. The forest was divided into 3 zones (Low, Middle, and High zones) based on the height of ground level and number of inundation days. The results showed that the leaf litter lost rapidly during the first two months of the study in the Middle and High zones, but it was lost very slowly in the Low zone. The decay coefficient, K, of leaf litter was calculated at 0.089, 0.132, and 0.405, for the Low, Middle, and High zones respectively. The trend is that the rate of decomposition of leaf litter is very much higher on the zone located on high elevations and with a lower frequency of inundation than compared with the rates of the forest decay on lower elevations. We explained the high rate in the High zone in a relation to abundance of termites. The low rate of leaf-litter decomposition in the Low zone was compared and discussed with other studies in wetland vegetation.

Key Words: Litter decomposition, seasonal flooded forest

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INTRODUCTION

Seasonal flooded forest typically distributed along the edge of major rivers in the northeast of Thailand. These forests play a significant role both direct and indirect forest-utilization by the local people, i.e. timber and charcoal production, edible and medicinal plants, fisheries *etc*. (Baird 2007).

Lam Se Bai River is an important branch of the Muun River, running about 233 km in length through Yasothon and Ubonrachathani Province in northeastern Thailand. The forest along the river edges is annually flooded during July – October of the monsoon season. The seasonal flooded forest along Lam Se Bai River is approximately 800 ha, it provides various kinds of products and ecosystem services to local communities.

Despite of the significant importance of the seasonal flooded forest, studies on ecological traits are still scarce, although Yoneda *et al*. (2009) estimated tree biomass in the seasonal flooded forest along Lam Se Bai River. Another component of ecological productivity is litter production. There are some studies suggesting large amount of litter production in seasonal flooded forest because of their inundated condition (Shure and Gottschalk 1985; Haase 1999; Nobel *et al*. 2001). Consequently, litter production is decomposed by soil micro-organisms and nutrients returned to soils for plant growth. Also, the amount of lost litter may indicate the amount of CO_2 released to the atmosphere via the process of decomposition by microbial activity.

This study, therefore, aims to estimate rates of litter decomposition within the seasonal flooded forest along Lam Se Bai River. We hypothesized that the rate of litter decomposition differs along different forest zones that have different inundation regimes.

METHODOLOGY

Study Site

The study site is located at a seasonal flooded forest along Lam Se Bai River, Nakae village, Yasothon Province, northeastern Thailand (15°35’N, 104°27’E) (Figure 1). A study plot of 30 x 120 m2 size was established from the river edge towards inland (Figure 2). It was divided into 10 x 10 m^2 subplots. Trees having diameter at breast height (DBH) more than 4.0 cm were tagged for numbering, and the species identified. These selected trees were measured for DBH and total height (H).

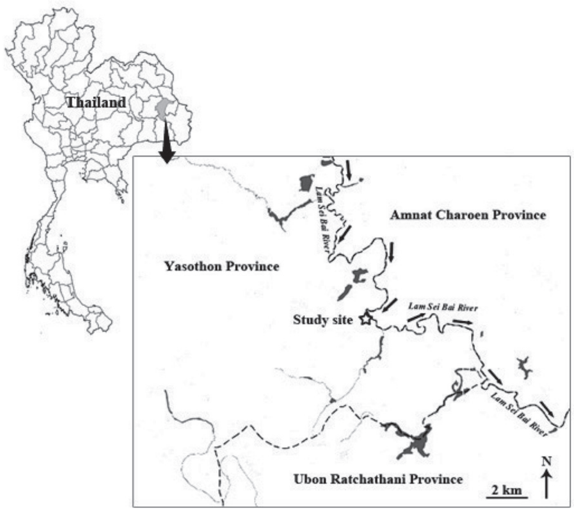

Figure 1 Location of the study plot on the edge of Lam Se Bai River, Yasothon Province, northeastern Thailand

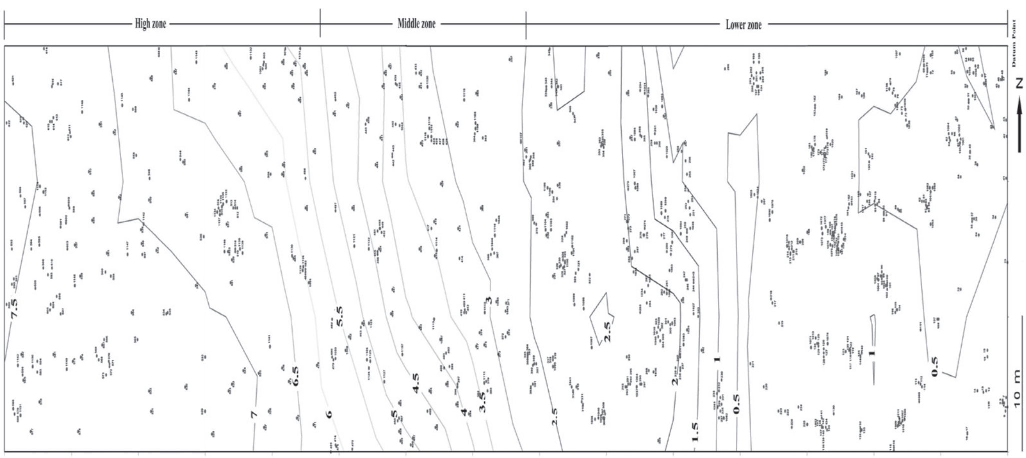

Figure 2 A study plot of 30 x 120 m2 size. It was divided into 3 zones (Low, Middle, and High zone) from the river toward inland part.

Tree density was calculated at 1,311 stems/ha, with an average DBH of 12.2 cm. The study plot was divided into three zone based two criterions, namely relative elevation of the forest floor and the duration of inundation period observed in the previous year. The three zones were Low zone (0 - 2.5 m in height, inundated 50 - 90 days/year), Middle zone (2.5 - 5.0 m in height, inundated 15 - 50 days/year), and High zone (5.0 - 7.5 m in height, inundated 0 - 15 days/year) (Figure 2).

The Low zone composed of small-tree species and shrubs in a relatively large area of the study plot. Species included Mallotus thorelii Gagnep., *Hymenocardia punctata* Wall. Ex Lindl., *Garcinia schomburgkiana* Pierre, *Syzygium* spp., *Barringtonia acutangula* (L.) Gaertn. The canopy is relatively low and intertwined among neighboring trees. Forest gaps exist between the canopy. Next to the inland part of the Low zone, the Middle zone occupies a relatively smaller area. The dominant trees of this zone are *Dipterocarpus alatus* Roxb. ex G.Don, *M. thorelii* Gagnep., *Irvingia malayana* Oliv. ex A.W.Benn., *Vatica harmandiana* Pierre and *Syzygium* spp. With the small area and 2.5-5.0 m of ground height, the trees of this zone are distributed on a moderate slope area. The last zone is the High zone occupied by dominant trees commonly found in dry dipterocarp forest. They are *D. alatus* Roxb. ex G.Don, *Melodorum fruticosum* Lour., *Shorea roxburghii* G.Don, *Dialium chochinchinense* Pierre and *Parinari anamense* Hance. The forest canopy is relatively dense and high with few gaps.

Experiment of leaf-litter decomposition

The determination of leaf decomposition was conducted using the litter-bag method as described elsewhere (Ashton et al. 1999; Imgraben and Dittmann 2008). Mixed senescent leaves (green/yellow color) were manually collected from the forest floor throughout the study plot. The soil or sediment was roughly sorted out. An approximately 30 g of fresh leaf-litter was put in a litter-bag made by nylon mesh (2 x 2 mm) of 40 x 40 cm2 size. Five replications were done for each zone. For Middle and High zone, one replication was composed of 7 litter-bags, but it was 8 bags for the Low zone. All of the litter-bags were randomly placed on the forest floor in each zone.

The litter-bags were harvested periodically for a year. Five litter-bags were harvest for each zone in each harvesting. For Middle and High zone, the experiment was conducted from October 2009 to September 2010. The experiment in Lower zone was done from March 2010 to February 2011.

After the litter-bag was harvested, it was brought to the laboratory. The remaining litter in an individual bag was carefully washed by tap water and a stainless-steel mesh of 500 µm. It was oven-dried at 80°C until a constant weight was obtained, and then weighed. For a conversion of ratio between remaining and initial weight of leaf litter, a dry/fresh weight ratio was calculated and averaged from 20 samples of approximately 30 g of fresh leaf-litter.

Data analysis

The percentage of remaining weight was fit through time for each zone using a negative exponential model (Olson, 1963):

$$Y_t = Y_0 e^{-Kt}, \text{ ----------------- } (1)$$

where Y_t is the percentage of weight remaining after time t (months), Y_0 is the percentage of the initial weight, and *K* is a decay coefficient. The data were fit to the model using Microsoft Excel 2011 for Macintosh (Microsoft, USA). The obtained regression was statistically tested at $P < 0.05$ of significant level using SPSS 14 for Windows software (SPSS Inc., USA).

RESULTS AND DISCUSSION

Leaf litter decreased sharply in the first two months after the start of the trial in the High and Middle zones. Residual of leaf litter was at 50.7 ± 30.2 and 35.2 ± 25.0%, respectively for the Middle and High zones. Then, it gradually decreased until the end of the trial at 12 months. Finally, the remaining of leaf litter was at 19.5 ± 10.4 and 9.4 ± 6.1%, respectively for the Middle and High zones.

In a contrast to the two previous zones, the leaf litter in the Low zone was slowly lost during the first few months of the trial because the remaining of leaf litter averaged 97.5 ± 15.4% after 3 months of the trial. Decreasing gradually, it was left at 33.8 ± 13.6% at the end of the trial.

Then, the remaining of leaf litter of each zone was plotted with the time based on the equation 1 (Figure 3). A significant regression ($P<0.05$) was obtained for the individual zone (Equation 2 to 4).

$$Y_t = 100e^{-0.089t}, \quad r^2 = 0.870 \text{ -------} (2)$$

$$Y_t = 100e^{-0.132t}, \quad r^2 = 0.430 \text{ -------} (3)$$

$$Y_t = 100e^{-0.405t}, \quad r^2 = 0.722 \text{ -------} (4)$$

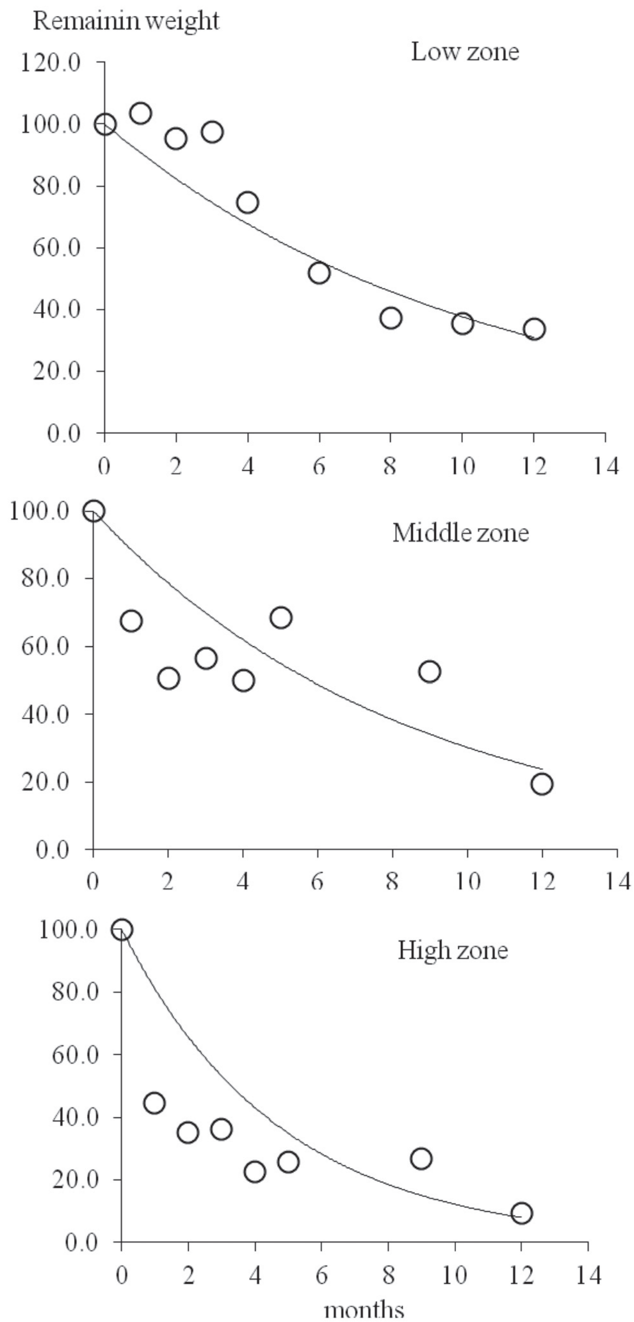

Figure 3 Relationship between the remaining weight of leaf litter (%) and time (months) in the Low, Middle, and High zone. All the regression lines were significant at $P<0.05$.

The decay coefficient, K, of leaf litter was 0.089, 0.132, and 0.405, for the Low, Middle, and High zones respectively. There was no significant difference observed among them (Two-way ANOVA, P = 0.486) because of a wide range of variation in remaining of leaf litter in each zone. Nevertheless, the results of this study showed a trend that K rate was relatively low in the Low zone, which was affected by a high frequency of flooding, an unusual occurrence, during the study period.

The decomposition rates in the Low and Middle zone of seasonal flooded forest obtained by the present study (0.089 – 0.132) were slightly higher than those values of vegetation in wetland locating in northeastern China (0.060 – 0.072) reported by Haitao *et al*. (2007). This difference may be caused by high temperature in the tropical region. The decomposition process by soil microbes is generally limited by temperature (Valiela et al. 1985, Witkamp 1966). Nevertheless, the decomposition rates in the Low and Middle zone of seasonal flooded forest were much higher than the decomposition rates in a riverine mangrove forest in Thailand studied by Suchewaboripont (2011). The submerged condition by a daily tide of mangrove forest mechanically activates the fragmentation of the leaf litter to decompose easily, while it usually inhibits the biological process of decomposition by soil microbes under anaerobic conditions.

In the High zone where is typically a dry evergreen forest, the K rate was calculated as 0.405. A magnitude of annual decay rate of litter was reported as 0.363 in a tropical forest of west India (Sundarapandian and Swamy 1999), and 0.140 in a subtropical forest of Spain (Rodríguez *et al*. 2009). The higher decay rate obtained by our study may be explained by an abundance of termites in the High zone of this seasonal flooded forest. Termites are the major component of lowland tropical ecosystem, and play an important role to plant decomposition (Donovan *et al*. 2001). Yang and Chen (2009) compared the rate of litter decomposition between forest sites with and without soil fauna in tropical forest of southwestern China. They reported that the decomposition rate in the forest site excluding soil fauna was less than a half of the rate obtained in the control site (2.213 VS 0.872). Takeda *et al*. (1984) studied leaf litter decomposition in a tropical forest in northeastern Thailand where had low population densities of soil micro-arthopods and low feeding activities of termites. It reported a decay rate of 0.231 accounting for a half of decay rate in the High zone of our study.

With the decomposition rate of leaf litter in the three zones of seasonal flooded forest obtained by the present study, we roughly calculated the amount of decomposed leaf litter by using litter productivity estimated in the respective zone of this study plot by assuming that there is no import and export leaf litter from the forest. The productivity of leaf litter was estimated as 7.24, 6.02, and 8.15 ton/ha/yr, for the Low, Middle, and High zones, respectively (Bamrungsook, personnel communication). Consequently, the amount of decomposed leaf-litter was calculated as 4.75, 4.78, and 8.09 ton/ha/yr, for the Low, Middle, and High zones, respectively. The average rate of decomposed litter in this seasonal flooded forest was then given at 5.87 ton/ha/yr. It was lower than that of estimated value in a riverine mangrove forest in Thailand (7.23 ton/ha/yr; Suchewaboripont, 2011). It possibly implies a low rate of CO_2 released via leaf-litter decomposition in the seasonal flooded forest.

CONCLUSION

In conclusion, the decomposition rate of each zone of a seasonal flooded forest showed a trend with increasing with the forest elevation, although the different rate was non significant. The low rate of decomposition in the Low zone was affected by the flooded condition, however the high rate in the High zone was activated by the abundance of termites in the dry evergreen forest.

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Fisheries and Fishery Resources in the Middle Lam Se Bai, a Tributary of the Mekong River Basin

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Makoto Sano[4] Hisami Kuwahara[5]
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ABSTRACT

Riparian swamps provide fundamental ecological services of abundant fishery resources for local inhabitants living along the river. We demonstrated in this study, fisheries activities and fishery resources observed in riparian swamps of the middle Lam Se Bai, which is a tributary of the Mekong river basin, to reveal the relationships between wetlands and the livelihood of local inhabitants, and discussed appropriate strategies to use sustainably fishery resources. In the Na Kae village, Yasothon province, northeastern Thailand, almost all the local inhabitants were associated with fisheries activities at the Lam Se Bai, reservoirs, irrigation channels, ponds, swamps and paddy fields. The efficient use of indigenous fishing gears depended on understanding of fish behaviors, habitats and seasonal environmental conditions. A total of 59 kinds of fishing gears and the related items including 15 net, 29 trap and 3 hook fishing gears were observed in the Lam Se Bai basin. Villager's income by fisheries activities was only 1.7 % of the gross income and the most fishery products were predominantly consumed within the communities. Fishery production in the Plait communities was estimated as 16.2 kg/villager/year, which was corresponded to about 50 % of fish protein intake. Development of agriculture technologies resulted in spread of fish aquaculture in reservoirs and irrigation channels. In several community management reservoirs

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and in a lot of private reservoirs, local inhabitants culture more than a dozen fish species. A total of 91 fish species belonging to 57 genera and 28 families were identified in the Lam Se Bai basin. By sharing fishing grounds, fishing gears, target species and fishing season based on fisheries laws and community rules, local inhabitants could avoid competition each other, and consequently, utilize sustainably fishery resources in the river and the riparian swamps.
Key words: riparian swamp, fisheries, fishery resources, fishing gear, Mekong river

INTRODUCTION

Riparian swamps and floodplains are important for nursing aquatic organisms with supplying potential source of food, breeding sites, nursery grounds, shelters and habitats. They provide diversity and productivity of natural resources and other fundamental ecological services for local inhabitants living in the vicinity of river basin. Among them, fishery resources are one of the most important natural resources and more than 90 % of protein is obtained from fishery resources in the Mekong river basin (Dugan *et.al.,* 2010). Fisheries activities also support their livelihood to obtain cash income. Understanding the diversity and the productivity of fishery resources as well as the allowable catch are important to establish the management policy for sustainable swamp use.

However, as forest decreased drastically from 50 % to 20 % of total area coverage in the past half century in Thailand (Tabuchi, 2010), fishery production except for aquaculture decreased both in coastal and inland areas (DOF, 2008, FAO, 2010, 2011). In coastal areas, mangrove forests decreased by half due to intensive shrimp aquaculture, charcoal making, urbanization and some other reasons (Barbier *et.al*., 2004, Patanaponpaiboon, 2010). While in the inland areas, natural forests decreased largely due to farm land reclamation and urbanization (Sano, *et.al.* 2011). Dam and other artificial constructions disturb habitats of aquatic organisms and obstruct seasonal migration of fishes inhabiting the Mekong river basin (Sluiter, 1992, Paulsen *et.al.* 2002, Mekong Watch 2004, 2008a, 2008b). Appropriate management and conservation of riparian ecosystem are required for utilizing sustainably the fishery resources. We demonstrated in this study, fisheries activities and fishery resources observed in riparian swamps to reveal the relationships between riparian swamps and livelihood of local inhabitants, following our previous reports (Fujioka *et.al.,* 2010, 2011). We also discuss their appropriate strategies to use sustainably fishery resources.

MATERIALS AND METHODS

We selected main study site at riparian floodplain of the middle Lam Se Bai (15°35’23” N, 104°27’44”E) in Na Kae village, Kham Khuan Kaeo district, Yasothon province, northeastern Thailand (Figure 1). In the northeastern Thailand, there is an extensive hydrological network consists of a lot of tributaries, ponds and wetlands of the Mekong river basin. The streams of the Lam Se Bai start from the northern hillside, flow toward southward and connect to the Mun river which is one of the main tributaries of the Mekong river, and therefore, the Lam Se Bai is a small secondary tributary of the Mekong river basin. The main stream of the Lam Se Bai positions approximately 270 km from the origin to the intersection to the Mun river, with the approximately elevation between 110-120 m above sea water level. Extensive riparian swamps and floodplains are distributed along the Lam Se Bai basin.

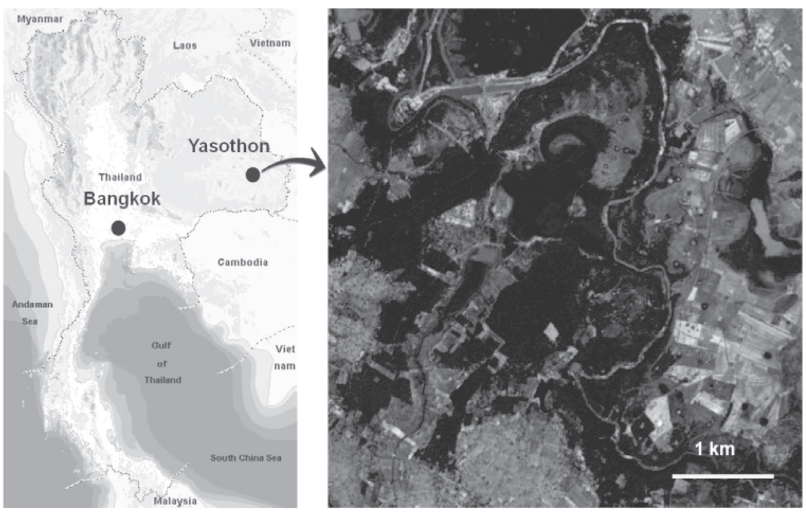

Figure 1 Map of Thailand (left) and Na Kae village (right), Yasothon province, showing the main study sites of the middle Lam Se Bai basin.

In this study, we demonstrated three subjects; that is, (1) aquatic organisms in riparian swamps, (2) fisheries activities and fishing gears in riparian swamps, (3) livelihood of fishermen, from the biological, fisheries and social scientific standpoints, respectively. In addition of administrative information about population of the Na Kae village, we obtained knowledge about the fisheries activities by interviewing village mayor and every community leaders. Especially, we studied at Plait communities (No. 2 and No. 8 communities) within the Na Kae village because these communities are close to the mainstream of the Lam Se Bai. We carried out structural questionnaire survey for 16 fishermen households of the Plait communities to obtain detailed information about fishing grounds, fishing gears, fishery production, occupation, income and other routine activities. The fishery production was estimated based on their knowledge and our quantitative observational results. We also carried out comprehensive survey about fishing gears and fish species throughout the Lam Se Bai basin from the origin to the intersection to the Mun river.

This study was implemented in collaboration and coordination among several Japanese and Thailand research institutes; that is, National Research Institute of Aquaculture, Japan (NRIA), National Research Institute of Fisheries Engineering, Japan (NRIFE), Forestry and Forest Products Research Institute, Japan (FFPRI), Japan International Research Center for Agricultural Sciences (JIRCAS), Kasetsart University, Thailand (KU) and the Chulalongkorn University, Thailand (CU).

RESULTS AND DISCUSSION

(1) Fisheries and fishing grounds

Land use of the Na Kae village was compared between 1954 and 2008 on the basis of landscape analysis (Sano et.al. 2011). The aerial (1954) and the satellite (2008) photo images of dry season (Jan-Mar) were extracted within 5 km x 5 km areas and compared in Figure 2, in which land use were classified into 20 categories. Extensive riparian forests, floodplains, grasslands, paddy fields, arboricultural lands, small villages, water systems and other rural landscape were recognized in this area. During the 54 year periods from 1954 to 2008, areas of paddy fields, arboriculture lands, villages, road and some artificial structures were largely increased, whereas areas of low density forests, bare lands, dwarf forests, and some other natural structures were decreased and fragmented into small patches.

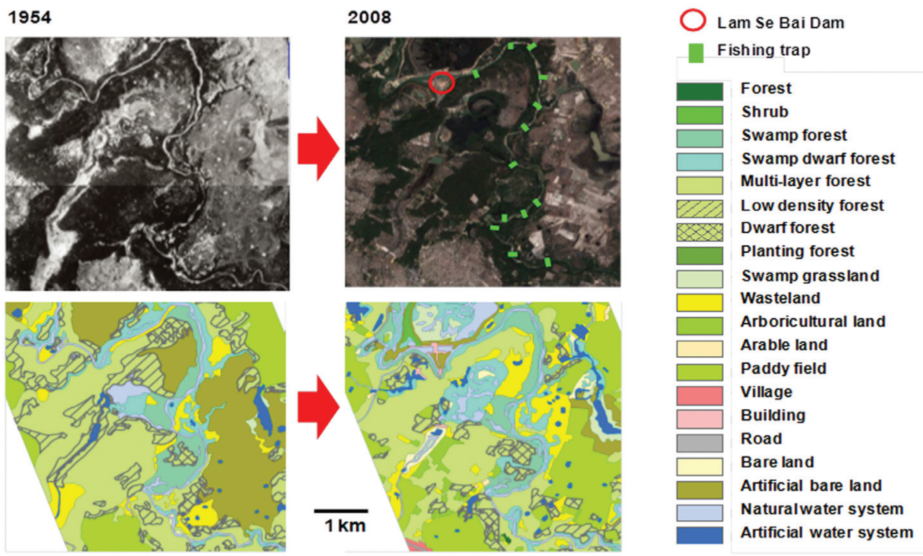

Figure 2 Change in land use during 54 years in Na Kae village, Yasothon. (after Sano *et.al.* 2011).

In Figure 2, natural water systems such as river, ponds and swamps were expressed as sky blue color and artificial water systems such as reservoirs and channels were expressed as dark blue color. Changes in areas of the water systems from 1954 to 2008 were summarized in Table 1. The areas of natural water systems were increased from 357.17 ha to 526.10 ha and subdivided into small patches. However, this is not due to the topographical changes during the periods but the difference in amount of rain fall of the latest months. As shown in the bottom of Table 1, precipitation of both the upper area (Roi Et province) and the lower area (Ubon Rachatani province) was small in 1953 and large in 2007. Actually, main stream of the Lam Se Bai was not largely changed over the past 54 years from 1954 to 2008, except for the construction of Lam Se Bai dam (circle in Figure 2). While artificial water systems such as reservoirs and channels were increased threefold from 169.13 ha to 488.04 ha in relation to development of agriculture and aquaculture technologies. The patch density and the average patch areas were also increased.

Table 1 Change in water systems during 54 years in Na Kae village, Yasothon.

	1954	2008
Natural water system (river, pond, swamp)		
Area (ha)	357.17	526.10
Number of patches	25	103
Patch density (n/km^2)	0.25	1.03
Average patch area (ha)	14.29	5.11
Artificial water system (reservoir, channel)		
Area (ha)	169.13	488.04
Number of patches	86	227
Patch density (n/km^2)	0.86	2.27
Average patch area (ha)	1.97	2.15
Precipitation of the previous year	('53)	('07)
Roi Et (mm)	1240.0	1523.2
Ubon Rachatani (mm)	1345.7	2035.5

In the Na Kae village, Yasothon province, 3,605 inhabitants of 788 households were living in eight small communities; that is Na kae, Plait , Na lue, Noang toe, Moang, Laow trong, Noang tug luk and Plait (Table 2). Almost all the households (96.7 %) were associated with fisheries activities at the natural and the artificial water systems within the village. Actually, between half and one-third of households caught fishes in channels and paddy fields during the rainy season. A hundred villagers (12.7 % of all the households) engaged routinely in fisheries activities at the main stream of the Lam Se Bai.

Table 2 Population composition and fishermen in Na Kae village, Yasothon.

No.	village	population	household	fishermen's households	
				reservoir, canal, paddy field	river (Lam Se Bai)
1	Na kae	520	126	110	20
2	Plait	663	151	149	29
3	Na lue	1,018	196	190	15
4	Noang toe	423	89	89	5
5	Moang	324	71	70	15
6	Loaw trong	163	40	40	5
7	Noang tug luk	198	51	50	0
8	Plait	296	64	64	11
	Total	3,605	788	762 (96.7%)	100 (12.7%)

Water systems and fishing grounds in the Plait communities (No. 2 & No. 8 communities of the Na Kae village) were distinguished on the satellite image (Figure 3). The water systems were consisted of the river (Lam Se Bai), two big reservoirs (Huai Sok and Huai Bo Kae), approximately 40 small private reservoirs, irrigation channels, ponds, swamps and paddy fields. Local inhabitants of the Plait communities were closely associated with fisheries activities at the Lam Se Bai and the related water systems. The upper big reservoir (Huai Sok) was managed by villagers of the Plait communities and the lower one (Huai Bo Kae) was cooperatively managed by the Plait and the neighboring communities. The number of small reservoirs was recently increasing in relation to development of irrigation systems for agriculture. Local inhabitants constructed and managed personally their own reservoirs by themselves.

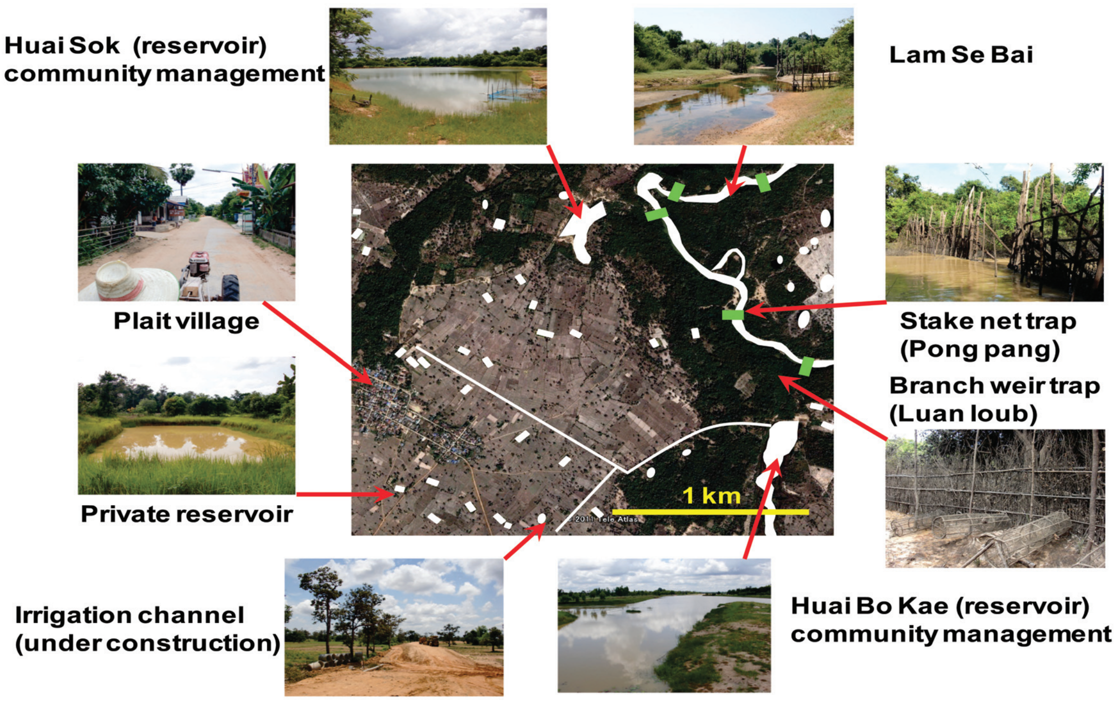

Figure 3 Fisheries grounds in Na Kae village (Plait communities), Yasothon. White color represents natural and artificial water systems.

(2) Fishing gears

Spatial arrangements of indigenous fishing gears, stake net trap “pong pang” and branch weir trap “luan loub”, around our survey site were shown in Figure 4, in which velocity and direction of water currents at a depth of 1 m were expressed based on the field survey by means of electromagnetic flow meters (Kuwahara *et.al.* 2011). The stake net trap “pong pang” was set in the center of the river stream. The “pong pang” was made by wall of long wood poles and big bag net and operated collaboratively by several villagers to collect various fishes migrating in the middle and the bottom layers. Whereas “luan loub” was a kind of branch weir trap found in the floodplain and personally operated by villager. More detailed structures were described in our previous report (Fujioka *et.al,* 2011). The water currents were expressed by arrows in Fig. 4. In the center of the river stream, the water currents were rapid, whereas the currents were slow and stagnant or sometimes reversed in the riparian floodplain.

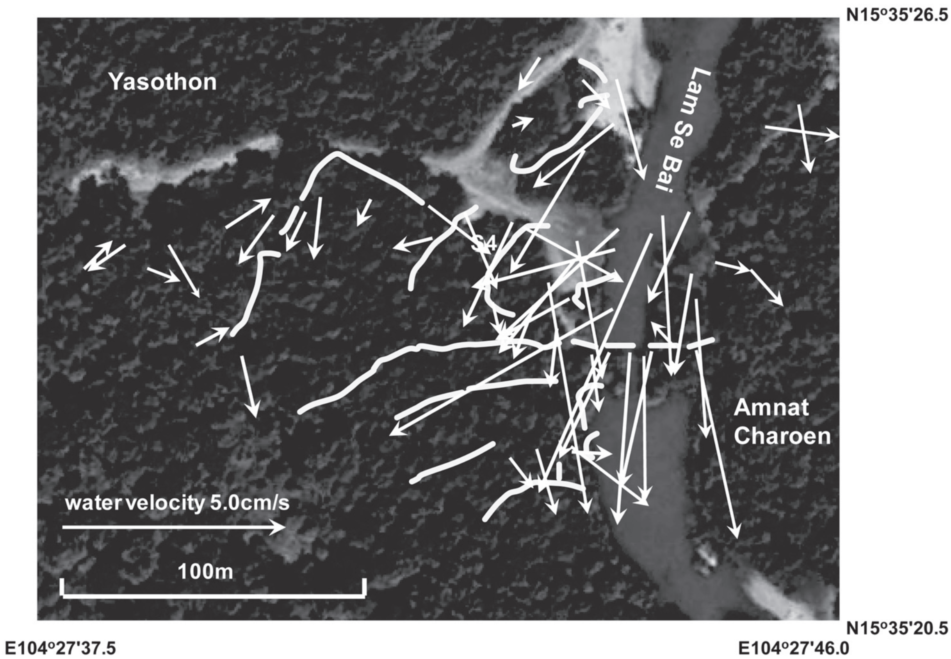

Figure 4 Spatial arrangement of indigenous fishing gears in the middle Lam Se Bai. Curved lines: position of indigenous fishing gears, arrows: water current.

Fishing gears and the related items used in the Lam Se Bai basin were demonstrated in Table 3, which was based on our comprehensive field survey (Fujioka and Srithong, 2012). A total of 59 kinds of fishing gears and the related items were observed along the Lam Se Bai basin and they were categorized into 15 net fishing gears, 29 trap fishing gears, 3 hook fishing gears and 12 other miscellaneous items. Most of the fishing gears were compact, easy operation and low investment cost because the Lam Se Bai was relatively small and the fishing grounds were limited. It seems to difficult to introduce large mechanized fishing gears. Some popular fishing gears, such as gill net, cast net, hook and line, were similar to that operated in other river basins and coastal areas. While some fishing gears such as stake net trap "pong pang" and branch weir trap "luan loub" were the unique and indigenous ones observed predominantly in the Lam Se Bai basin. The indigenous gears have been developed in the Na Kae village through generations of fisheries experience and knowledge of fish behaviors, habitats, and seasons. Generally speaking, net fishing gears were frequently operated in river, ponds and reservoirs, and the small trap fishing gears were predominantly operated in shallow water systems such as irrigation channels, paddy fields and swamps. However, the structure, the method for using and the target fishes were different among the fishing gears. We demonstrated the detailed structure and the method for using in another paper (Fujioka and Srithong, 2012). Thus, local inhabitants of the Na Kae village were associated closely and routinely with fisheries activities by means of various kinds of fishing gears. Similar fisheries activities were reported from Songkhram river and Mun river which were other tributaries of the Mekong river basin. (Friend, 2005, MRC, 2007).

By Thailand fisheries law, every fishing gears, except for hooks, scoop net, portable liftnet, basket traps, pot trap, eel trap and some other simple fishing gears, were prohibited in freshwater areas during breeding season from 16th May to 15th September (DOF, 2003). Large fishing gears, such as big seine net, big surrounding net, trawl, drive-in-net, big bag net across the river and lift net bigger then 2 m, were also prohibited in most freshwater areas throughout the year. In addition to these fisheries laws, local inhabitants preserved fishery resources and shared fishing grounds by their own community rules and agreements or voluntary understanding.

Fishing gears of 16 main fishermen households were surveyed in the Plait communities (No. 2 and No. 8 communities of Na Kae village) and summarized in Figure 5. Fish traps were the most popular in this area, followed by bag nets, hooks, gill net and cast net. Other local inhabitants in the Plait communities were associated with fisheries activities in swamps, reservoirs, channels and paddy fields, as explained in Table 2. Almost all the households have simple and compact fishing gears such as gill net, cast net, hooks, cover pot and scoop net.

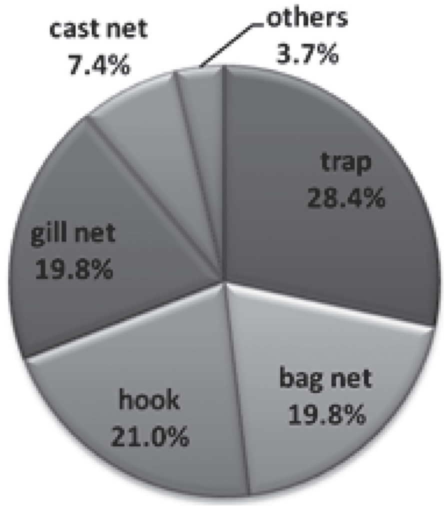

Figure 5 Fishing gears in Na Kae villagers.

(3) Fishery production

Local inhabitants of the Na Kae village were predominantly engaged in primary industries. Figure 6 exhibited the rate of income source for 16 households of the Plait communities (No. 2 and No. 8 communities of the Na Kae village), which was based on the interview and the official administrative research data. Their annual incomes were within the ranges from 30,000 to 220,000 Thai bahts/household. Agriculture and employee were the largest source of income for villagers, followed by livestock and farms. Four households have a small income from fisheries but the dependency rate on fisheries was only 1.7 % of the gross income. For local inhabitants, fisheries was not the main occupation but was considered as one of their routine activities to obtain ecological services from riparian swamps.

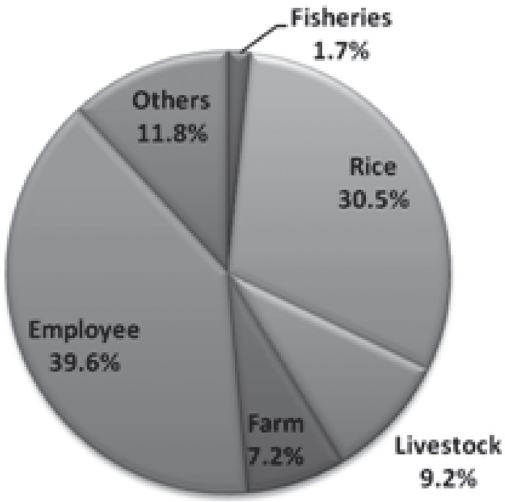

Figure 6 Income of Na Kae villagers.

Fishermen in the Na Kae village usually consumed fishes and fishery products by themselves and/or shared them together with their relatives and neighborhoods within the same village. When they got a good catch, they sometimes sold fishes to retailers and wholesalers or sold them by themselves at the local market along the main road, but the distribution areas of these fishery products might be restricted within the Kham Khuan Kaeo district. Thereby, most fisheries activities in the Lam Se Bai basin were not the commercial fisheries but were considered as a kind of the community-based activities. In other tributaries, Mun river and Chi river, commercial fisheries were developed and most of fishery products were traded as fresh fish in central and local markets or as processed products through dealers and traders (MRC 2007).

Table 3 List of fishing gears in the Lam Se Bai basin (after Fujioka & Chumpol 2012).

【Net fishing】	**20. Door trap (Jun)**	**41. Crab trap (Loub phu)**
1. Gill net (Mhong, Khai)	**21. Weir trap, Fishpound (Lee)**	**42. Frog trap (Ngaeb, Duk gob)**
2. Drift gill net (Mhong lai, Khai loy)	**22. Shrimp trap (Loub khung)**	**43. Brush shelter trap (Yo, Klum)**
3. Handy surrounding net (Dang)	**23. Funnel basket trap (Sai)**	**44. Brush shelter (Klum, Ban pla)**
4. Handy seine net (Pason, Payen)	**24. Upright basket trap (middle)(Tum)**	**【Hook fishing】**
5. Seine net (Uwan tub taling)	**25. Upright basket trap (bottom)(Tum)**	**45. Hook and line (Bed)**
6. Portable liftnet (Sadung lek, Yo)	**26. Small basket trap (hanging)(Tum kom)**	**46. Pitch hook (Bed tong)**
7. Liftnet (Sadung yai, Yor prajam tee)	**27. Small basket trap (bottom)(Tum kom)**	**47. Long line (Bed rao)**
8. Mobile pushnet, dip net (Chon sanan)	**28. Grass bush trap (Sue non gin)**	**【Miscellaneous】**
9. Handy pushnet (Chon, Chon ka kim)	**29. Eel basket trap (Eju,Tum ju)**	**48. Plunge basket, Cover pot (Sum)**
10. Cast net (Hae)	**30. Flog basket trap (Tum gop)**	**49. Fish catching boat (Rua pe roak)**
11. Drop net (Sai, Sai lee, Tom lee)	**31. Upright shrimp trap (Tum khung)**	**50. Spear and harpoon (Chamouk)**
12. Bag net (Sai, Tong pla)	**32. Pot trap (Thong)**	**51. Scoop net (Sawing, Takpra)**
13. Shrimp net (Sai khung)	**33. Horizontal cylinder trap (Loub noan)**	**52. Long scoop net (Susk)**
14. Bag net (Pong pang)	**34. Vertical cylinder trap (Loub yuen)**	**53. Scoop basket (Chanang, Takpra)**
15. Stake net trap (Pong pang, Jip yai)	**35. Flexibility trap (Loub yued, Eroa)**	**54. Water scoop (Phoang, Kaso)**
【Trap fishing】	**36. Lying trap (Suan, Son)**	**55. Other collecting items**
16. Branch stake net trap (Jip)	**37. Snakehead trap (Chud)**	**56. Container (Khong)**
17. Branch weir trap (Luan loub)	**38. Eel trap (Run)**	**57. Basket (Takra, Kata)**
18. Bamboo screen trap (Fuak, Pok)	**39. Box trap (Jun pla chon)**	**58. Crawl, Fish preserve (Kan pla)**
19. Marginal trap (Loub duk pla)	**40. Cat fish trap (Loub pla duck)**	**59. Fish cage (Grachan, Kan pla)**

Based on the results of this study, we estimated fishery production of the Plait communities (No. 2 and No. 8 communities of the Na Kae village) and demonstrated in Table 4. The annual catches were calculated individually for four major fishing grounds mentioned in Figure 3; that is (1) Lam Se Bai, (2) channel and paddy field, (3) private reservoirs and (4) community reservoirs (Huai Sok and Huai Bo Kae). The fishing periods and the volume of fish catches for every grounds were assumed based on villager's knowledge and our quantitative observational results. A hundred villagers engaged in fisheries activities every 3-4 days at the Lam Se Bai and catch approximately 0-1 kg fishes in the dry season and 0-2 kg in the rainy season. Between half and one-third of households caught fishes every 3-4 days in channels and paddy fields only in the rainy season, but the quantity is very small (0-1 kg). The quantities of cultured fishes in private reservoirs are large (30-90 kg) but the harvest was usually only once a year. Routine fisheries by means of small fishing gears was permitted in one community reservoirs, Huai Bo Kae, but it was not popular for the Plait villagers. At least once a year, fisheries of cultured fishes are permitted for 100-300 villagers in two community reservoirs, Huai Sok and Huai Bo Kae.

Table 4 Estimation of fishery production in Plait communities of Na Kae village.

(1) Lam Se Bai and floodplans
100 fishermen 100 days 0-1 kg/day in dry season, 0-2 kg/day in rainy sason
100 x 50 days x (0.5 kg + 1.0 kg) = 7,500 kg/year

(2) Channels and paddy fields
300 households 50 days in rainy season 0-0.6 kg/day

(3) Private reservoirs (aquaculture)
40 private reservoirs 30-90 kg 1 time
40 x 60 kg = 2,400 kg/year

(4) Community reservirs (aquaculture)
Huai Sok : 300 villagers 4 kg 1 day
Huai Bo Kae : 100 villagers 4 kg 1 day, 10 fishermen 50 days 0-0.8 kg/day
(300 x 4 kg) + (100 x 4 kg) + (10 x 50 x 0.4 kg) = 1,800 kg/year

Total fisheries production in Plait village (1) + (2) + (3) + (4)
16.2 ton/year ⟶ 16.2 kg/villager/year (46.3-54.0 % of fish protein)

cf. fish protein supply/capita = 17.1 kg/year (FAO 2010)
cf. fish protein uptake/capita in Mekong basin = 30-35 kg/year (MRC 2007)

The total production was 16.2 ton/year, which was equivalent to 16.2 kg/villager/year because the population of the Plait communities was about 1,000 (Table 2). According to FAO world statistics, annual fish protein supply per capita was 17.1 kg (FAO, 2010). However, in the Mekong river basin, fishery products were more important protein source and local inhabitants consumed about 30-35 kg/capita every year (MRC, 2007). Therefore, local inhabitants of the Plait communities obtain about 50 % (46.3-54.0 %) of fish protein intake from the Lam Se Bai and the related water systems.

(4) Fishery resources

Fish seed production center (Yasothon Inland Fisheries Research and development Center), Department of Fisheries (DOF), provide a total of about 20,000,000 fish fry and fingerlings for community management reservoirs within Yasothon province every year (DOF 2010). In the Na Kae village, about 1,600,000-1,800,000 fry were cultured every year in several community management reservoirs; that is, Huai Sok, Huai Bo Kae, Huai Yang, Huai Moang Ban and Tung Mon Yai (Table 5). They cultured thirteen species, in which nine species of cyprinid carps and barbs, two catfishes, tilapia and frog were included.

Table 5 Fish aquaculture in the community management reservoirs of the Na Kae village.

Scientific name	English name	Thai name	No. of stock	
			2010	2011
Leptobarbus hoeveni (Bleeker, 1851)	Hoeven's slender carp	Pla bar (ปลาบ้า)	50,000	0
Cyprinus carpio (Linnaeus, 1758)	Common carp	Pla nai (ปลาไน)	215,000	230,000
Barbodes gonionotus (Bleeker,1850)	Silver barb	Pla tapean kao (ปลาตะเพียนขาว)	830,000	525,000
Barbodes schwanenfeldii (Bleeker, 1853)	Schwanenfeld's tinfoil barb	Pla kahae (ปลากระแห)	150,000	250,000
Systomus orphoides (Valenciennes, 1842)	Red cheek barb	Pla gen chan (ปลาแก้มช้ำ)	50,000	40,000
Henicorhynchus siamensis (Sauvage, 1881)	Jullien's mud carp	Pla soi kao (ปลาสร้อยขาว)	250,000	60,000
Cirrhinus microlepis Sauvage, 1878	Small scale mud carp	Pha nuan jan ted (ปลานวลจันทร์)	50,000	250,000
Morulius chrysophekoides (Bleeker, 1850)	Great black shark	Pla ka dum (ปลากาดำ)	20,000	0
Labeo rohita (Hamilton, 1822)	Rohu, Indian carp	Pla yee sok ted (ปลายี่สกเทศ)	50,000	200,000
Pangasianodon hypophthalmus (Sauvage, 1878)	Striped catfish, Kaiyan	Pra sawai (ปลาสวาย)	0	9,999
Pangasius larnaudii Bocourt, 1866	Black ear catfish	Pla te po (ปลาเทโพ)	2,700	0
Oreochromis niloticus (Linnaeus, 1758)	Nile Tilapia	Pla nin (ปลานิล)	160,000	65,000
Hoplobatrachus rugulosa (Wiegmann, 1834)	Chinese Edible Frog,	Gob na (กบนา)	0	20,400
Total			1,827,700	1,650,399

Likewise, local inhabitants cultured fishes in their own private reservoirs and irrigation channels. They got fish fry and fingerlings from local breeding farms and/or dealers. In addition to above mentioned 13 species, they culture some common species; that is, walking catfish (*Clarias* spp.), striped snakehead (*Channa striata*), Common climbing perch (*Anabas testudineus*), spotted knifefish (*Chitala ornata*) and gray featherback (*Notopterus notopterus*). Cultured fishes, especially walking catfish, striped snakehead and nile tilapia were frequently observed in central and local markets. Thus, spread of fish aquaculture in rural areas was resulted from irrigation systems and development of agriculture technologies.

Fish species found in the Lam Se Bai basin was classified into the taxonomic list (Table 6), which was based on the present study and other knowledge previously reported (Ukong *et.al.* 2000, MNRE 2010, Vidthayanon *et al.,* 1997). A total of 91 fish species belonging to 57 genera and 28 families were identified in the Lam Se Bai basin. In addition to captured fishes and cultured fishes, some fishes sold in local and central markets were also included in the list. Species of catfishes belonging to the families Notopteridae (*Notopterus, Chitala*), Bagridae (*Mystus, Hemibagrus,* etc.), Siluridae (*Belodontichthys, Micronema, Ompok, Kryptopterus, Wallago*), Pangasiidae (*Helicophagus, Pangasius, Pangasianodon, Pteropangasius*), Sisoridae (*Bagarius*) and various cyprinid carps and barbs (*Paralaubuca, Rasbora, Cyprinus, Barbonymus, Cirrhinus, Cyclocheilichthys, Hampala, Systomus, Labeo*, etc.) were dominated in Lam Se Bai basin. The composition of dominant taxa was common to other areas of the Mekong river basin (MRC 2007, Vidthayanon *et al.,* 1997).

Table 6 List of fish species in the Lam Se Bai basin.

Order Osteoglossiformes
- **Family Notopteridae**
  - ***Notopterus notopterus* (Pallas, 1769)**
  - ***Chitala blanci* (d'Aubenton, 1965)**
  - ***Chitala ornata* (Gray, 1831)**
  - ***Clupeichthys aesarnensis* Wongratana, 1983**

Order Cypriniformes
- **Family Cyprinidae**
  - ***Paralaubuca harmandi* Sauvage, 1883**
  - ***Paralaubuca riveroi* (Fowler, 1935)**
  - ***Luciosoma bleekeri* Steindachner, 1878**
  - ***Parachela siamensis* (Günther, 1869)**
  - ***Leptobarbus hoeveni* (Bleeker, 1851)**
  - ***Rasbora borapetensis* Smith, 1934**
  - ***Rasbora myersi* Brittan, 1954**
  - ***Rasbora* spp.**
  - ***Cyprinus carpio* (Linnaeus, 1758)**
  - ***Thynnichthys thynnoides* (Bleeker, 1852)**
  - ***Cyclocheilichthys apogon* (Valenciennes, 1842)**
  - ***Cyclochelichthys enoplos* (Bleeker, 1850)**
  - ***Cyclocheilichthys repasson* (Bleeker, 1853)**
  - ***Puntioplites proctozysron* (Bleeker, 1865)**
  - ***Barbodes altus* (Günther, 1868)**
  - ***Barbodes gonionotus* (Bleeker,1850)**
  - ***Barbodes schwanenfeldii* (Bleeker, 1853)**
  - ***Hampala dispar* Smith, 1934**
  - ***Systomus brevis* (Bleeker, 1850)**
  - ***Systomus orphoides* (Valenciennes, 1842)**
  - ***Henicorhynchus siamensis* (Sauvage, 1881)**
  - ***Cirrhinus microlepis* Sauvage, 1878**
  - ***Cirrhinus chinensis* Günther, 1868**
  - ***Morulius chrysophekadion* (Bleeker, 1850)**
  - ***Osteochilus hasselti* (Valenciennes, 1842)**
- **Family Cobitidae**
  - ***Acanthopsis choirorhynchos* (Bleeker, 1854)**
  - ***Acanthopsis* spp.**
  - ***Botia eos* Taki, 1972**
  - ***Botia helodes* (Sauvage, 1876)**
  - ***Botia modesta* (Bleeker, 1852)**
- **Family Gyrinocheilidae**
  - ***Gyrinocheilus aymonieri* (Tirant, 1884)**

Order Characiformes
- **Family Characidae**
  - ***Colossoma bidens* Spix, 1829**

Order Siluriformes
- **Family Bagridae**
  - ***Leiocassis siamensis* Regan, 1913**
  - ***Mystus mysticetus* Roberts, 1992**
  - ***Mystus* sp.**
  - ***Heterobagrus bocourti* Bleeker, 1864**
  - ***Hemibagrus nemurus* (Valenciennes, 1839)**
  - ***Hemibagrus wyckii* (Bleeker, 1858)**
  - ***Hemibagrus wickioides* Fang & Chaux, 1949**
- **Family Bagriicthyridae**
  - ***Bagriichthys macropterus* (Bleeker, 1853)**
- **Family Siluridae**
  - ***Belodontichthys dinema* (Bleeker, 1851)**
  - ***Micronema apogon* (Bleeker, 1851)**
  - ***Micronema bleekeri* (Günther, 1864)**
  - ***Kryptopterus cryptopterus* (Bleeker, 1851)**
  - ***Kryptopterus limpok* (Bleeker, 1852)**
  - ***Ompok krattensis* (Fowler, 1934)**
  - ***Ompok bimaculatus* (Bloch,1794)**
  - ***Ompok hypophthalmus* (Bleeker, 1846)**
  - ***Wallago attu* (Bloch & Schneider, 1801)**
- **Family Schilbeidae**
  - ***Ladies hexanema* (Bleeker, 1852)**
- **Family Pangasiidae**
  - ***Pangasianodon hypophthalmus* (Sauvage, 1878)**
  - ***Helicophagus waandersii* Bleeker, 1858**
  - ***Pteropangasius pleurotaenia* (Sauvage, 1878)**
  - ***Pangasius macronema* Bleeker, 1851**
  - ***Pangasius larnaudii* Bocourt, 1866**
- **Family Sisoridae**
  - ***Bagarius bagarius* (Hamilton, 1822)**
  - ***Bagarius yarrelli* Sykes, 1829**
  - ***Bagarius suchus* Roberts, 1983**
- **Family Clariidae**
  - ***Clarias batrachus* (Linnaeus, 1758)**
  - ***Clarias macrocephalus* (Günther, 1864)**

Order Beloniformis
- **Family Hemiramphidae**
  - ***Dermogenys siamensis* Fowler, 1934**
- **Family Bolonidae**
  - ***Xenantodon cancilla* (Hamilton, 1822)**

Order Cyprinodontiformes
- **Family Aplochelidae**
  - ***Aplocheilus panchax* (Hamilton, 1822)**

Order Synbranchiformis
- **Family Synbranchidae**
  - ***Monopterus albus* (Zuiew, 1793)**
- **Family Mastacembelidae**
  - ***Macrognathus siamensis* (Günther, 1861)**
  - ***Mastacembelus armatus* (Lacepède, 1800)**
  - ***Mastacembelus erythrotaenia* Bleeker, 1850**
  - ***Mastacembelus favus* Hora, 1923**

Order Perciformes
- **Family Ambassidae**
  - ***Parambassis siamensis***
- **Family Nandidae**
  - ***Pristolepis fasciatus* (Bleeker, 1851)**
- **Family Eleotrididae**
  - ***Oxyeleotris marmorata* Bleeker, 1852**
- **Family Anabantidae**
  - ***Anabas testudineus* (Bloch,1792)**
- **Family Belontiidae**
  - ***Betta smaragdina* Ladiges, 1972**
  - ***Trichogaster pectoralis* (Regan, 1910)**
  - ***Trichogaster trichopterus* (Pallas, 1770)**
- **Family Helostomatidae**
  - ***Helostoma temmincki* (Cuvier, 1831)**
- **Family Ospronemidae**
  - ***Osphronemus goramy* Lacepede, 1802**
- **Family Cichlidae**
  - ***Oreochromis niloticus* (Linnaeus, 1758)**
  - ***Oreochromis niloticus* var. taptim**
- **Family Channidae**
  - ***Channa limbata* (Cuvier, 1831)**
  - ***Channa lucius* (Cuvier, 1831)**
  - ***Channa micropeltes* (Cuvier, 1831)**
  - ***Channa striata* (Bloch, 1797)**

Order Pleuronectiformis
- **Family Soleidae**
  - ***Euryglossa siamensis* (Sauvage, 1878)**

Order Tetraodontiformes
- **Family Tetraodontidae**
  - ***Tetraodon leiurus* Bleeker, 1851**

CONCLUSION

Riparian swamps provided fundamental ecological services of abundant fishery resources for local inhabitants living in the Lam Se Bai basin. Fisheries were not the commercial ones but their community-based routine activities to obtain ecological services from riparian swamps. The efficient use of indigenous fishing gears depended on understanding of fish behavior, habitats and seasonal environmental conditions. By sharing fishing grounds, fishing gears, target species and fishing season based on fisheries laws and community rules, local inhabitants could avoid competition each other, and consequently, utilize sustainably fishery resources in the river and the riparian swamps.

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Water Current at Riparian Swamps of the Middle Lam Se Bai Basin

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ABSTRACT

Current velocity and direction of the Lam Se Bai stream and the riparian floodplain were investigated in the dry season by means of electromagnetic flow meter. In the middle Lam Se Bai basin, water level and flow rate were controlled by two irrigation dams, i.e. Lam Se Bai dam and Pa Ao dam. Water level of lower side of the Lam Se Bai dam was very close to that of the upper side of Pa Ao dam, representing the river stream and the riparian swamps were very flat and little difference in elevation between two dams. In the dry season, the current velocity ranged between 0.6-6.1 cm/sec and only the surface water flowed downward due to wind drift. Water current might be frequently stagnant both in the dry season and in the rainy season because the riparian swamps were topographically very flat and the river meandered through them. Thus, water level and current velocity were predominantly determined by water control system of irrigation dams in addition to the topography and rainfall amount. Local inhabitants understand empirically the seasonal fluctuations of waters and the fish migrating behaviors in the Lam Se Bai basin. The efficient use of indigenous fishing gears depended on understanding of fish behaviors, habitats and seasonal environmental conditions, such as water level and current velocity, of the rivers and the floodplains.

Key words: water current, water level, riparian swamps, floodplain, Mekong River

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INTRODUCTION

Hydrological network of the middle Mekong river basin consists of a lot of tributaries, ponds and riparian swamps. They provide diversity and productivity of natural resources and other fundamental ecological services for local inhabitants living in the vicinity of river basin (MRC 2007, Tabuchi, 2010). The water level of the river basin is largely different between the rainy season and the dry season, and therefore, seasonal dynamics and daily fluctuation of water level and stream current are major concern for local inhabitants to carry out their routine fisheries activities (Fujioka *et al.,* 2011 a, b).

Although water level and flow rate are continuously monitored by the Irrigation Department offices of every dams in Thailand, there is no information about the current velocity in the tributaries and the riparian swamps. Thereby, we investigated current velocity and the direction at the middle Lam Se Bai which is a small secondary tributary of the middle Mekong river basin. In our previous report, we demonstrated water current of the middle Lam Se Bai in the rainy season (Kuwahara *et al.* 2011). We demonstrated in the present study water current in the dry season of the same site to compare the seasonal changes.

MATERIALS AND METHODS

Field survey was conducted at riparian swamps of the middle Lam Se Bai (15°35’24”N, 104°27’43”E) in Na Kae village, Kham Khuam Kaeo distinct, Yasothon province, northeastern Thailand. The Lam Se Bai is one of the secondary tributaries and the stream starts from the northern hillside, flows toward southward and connects to the Mun river which is one of the main tributaries of the middle Mekong river basin. The riparian forests in this areas are seasonally flooded during the rainy season every year and the structure of the riparian forests are investigated by several researchers (Yoneda *et al.,* 2011a, 2011b, Poungparn *et.al.,* 2011). Fisheries activities, plankton community and water quality are also surveyed in the same area by our survey team (Fujioka *et al.* 2011 a, b, Higano *et al.,* 2011, Srithong *et al.* 2011).

The measuring device and the methods were followed the previous procedures (Kuwahara *et al.,* 2011). The measuring device is consisted of two parts; that is, electromagnetic flow meter to record current velocity and direction (compact-EM, JFE Advantech Co., Ltd) and depth meter (compact-TD, JFE Advantech Co., Ltd.). They were attached on PVC pipe and vertically submerged from the surface to near the bottom. The data were recorded synchronously at the surface layer and every 1 meter deep. The sampling interval was 1 second and sampling time was 15 seconds. The survey was carried out on 18th January, 2011. Although a total of 58 observation points could be monitored in the rainy season (Kuwahara *et al.,* 2011), only 29 observation points of them were monitored this time because the riverbank and the floodplains were dried up during the dry season.

There are two irrigation dams along the Lam Se Bai basin; that is, the Lam Se Bai dam ("Fai Lam Se Bai", 15°37'19"N, 104°26'56"E) at the upstream area and the Pa Ao dam ("Fai Pa Ao", 15°21'41.40"N, 104°41'4.80"E) at the downstream area. The stream between these two dams was about 70 km in length and the linear distance was about 39 km. The river meandered largely through the riparian swamps and the floodplains. Daily monitoring data (more accurately, daily average of hourly observation data) on water level and flow rate of the dams were obtained from the Irrigation Department offices of Amnat Charoen and Ubon Ratchathani provinces.

RESULTS AND DISCUSSION

In the middle Lam Se Bai basin, water level and flow rate were controlled by two irrigation dams, the Lam Se Bai dam and the Pa Ao dam. Water levels of these two dams were summarized from daily monitoring data for the last five years (Figure 1), in which data of both the upper (upstream) side and the lower (downstream) side of every dams were drawn in the same figures. Under any circumstances, water level of our survey site should represent intermediate value between the lower side of the Lam Se Bai dam and the upper side of the Pa Ao dam because the Na Kae village was situated between these two dams.

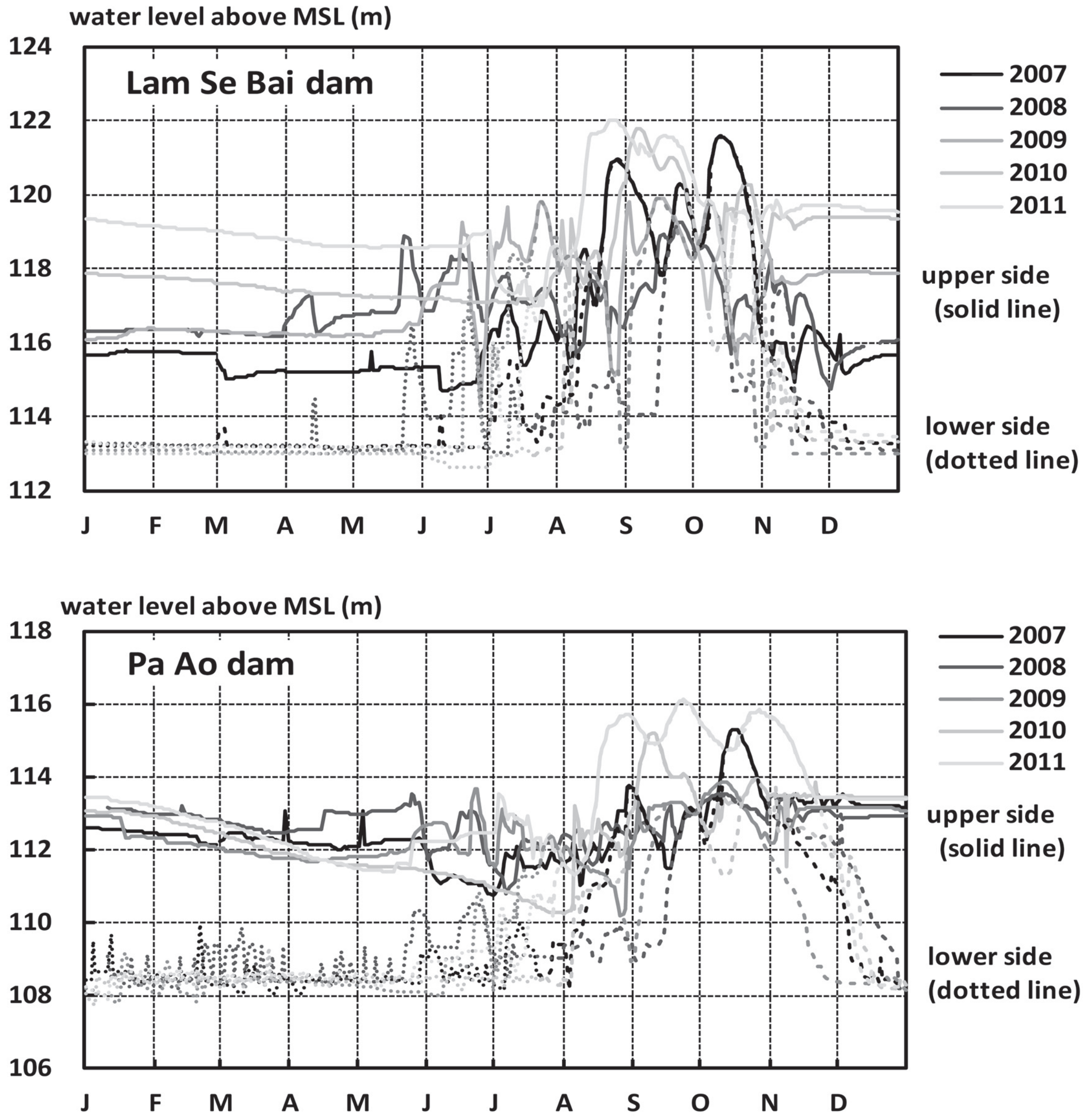

Figure 1 Water level of two irrigation dams of the middle Lam Se Bai basin.
Original data were obtained from the Irrigation Department offices.
Upper: Lam Se Bai dam ("Fai Lam Se Bai"), lower: Pa Ao dam ("Fai Pa Ao")
Solid line: upper (upstream) side, dotted line: lower (downstream) side

In the dry season from November to May, water level was considerably stable and the difference between the upper side and the lower side of each dam was distinct because the most dam gates were closed throughout the dry season. Water level of lower (downstream) side of the Lam Se Bai dam ranged from 113.0 to 113.5 m above mean seawater level (MSL), which was very close to that of the upper (upstream) side of Pa Ao dam. This result represented that there were little difference in elevation between the Lam Se Bai dam and the Pa Ao dam and therefore the river stream and the riparian swamps around our survey site were topographically very flat.

Whereas, in the rainy season, the water level fluctuated largely due to the difference in daily rainfall. The water level of the peak of the rainy season from August to October ranged about 116-122 m above MSL in the Lam Se Bai dam and about 112-116 m above MSL in the Pa Ao dam. Water levels of both the upper side and the lower sides represented frequently the identical values because all dam gates were completely opened during the peak of rainy season. When the water level exceeded 118 m above MSL at the Lam Se Bai dam and 114 m above MSL at the Pa Ao dam, dam gates were usually opened to avoid flooding in the upper areas of each dam.

Current velocity and direction of the Lam Se Bai stream and the riparian floodplain were shown in Figure 2. The data of the rainy season (measured on 10th September, 2010) were redrawn from the original data of Kuwahara *et al.* (2011) for comparison. In the dry season, only two layers of surface and 1 m deep could be monitored because most observation points were shallower than 2 m deep and partially dried up. In the dry season, the current velocity ranged between 0.6-6.1 cm/sec at the surface layer and between 0.6-4.0 at the 1 m deep, representing the water was almost stagnant. Only the surface water flowed downward due to wind drift and submerged currents were exclusively slow and multidirectional.

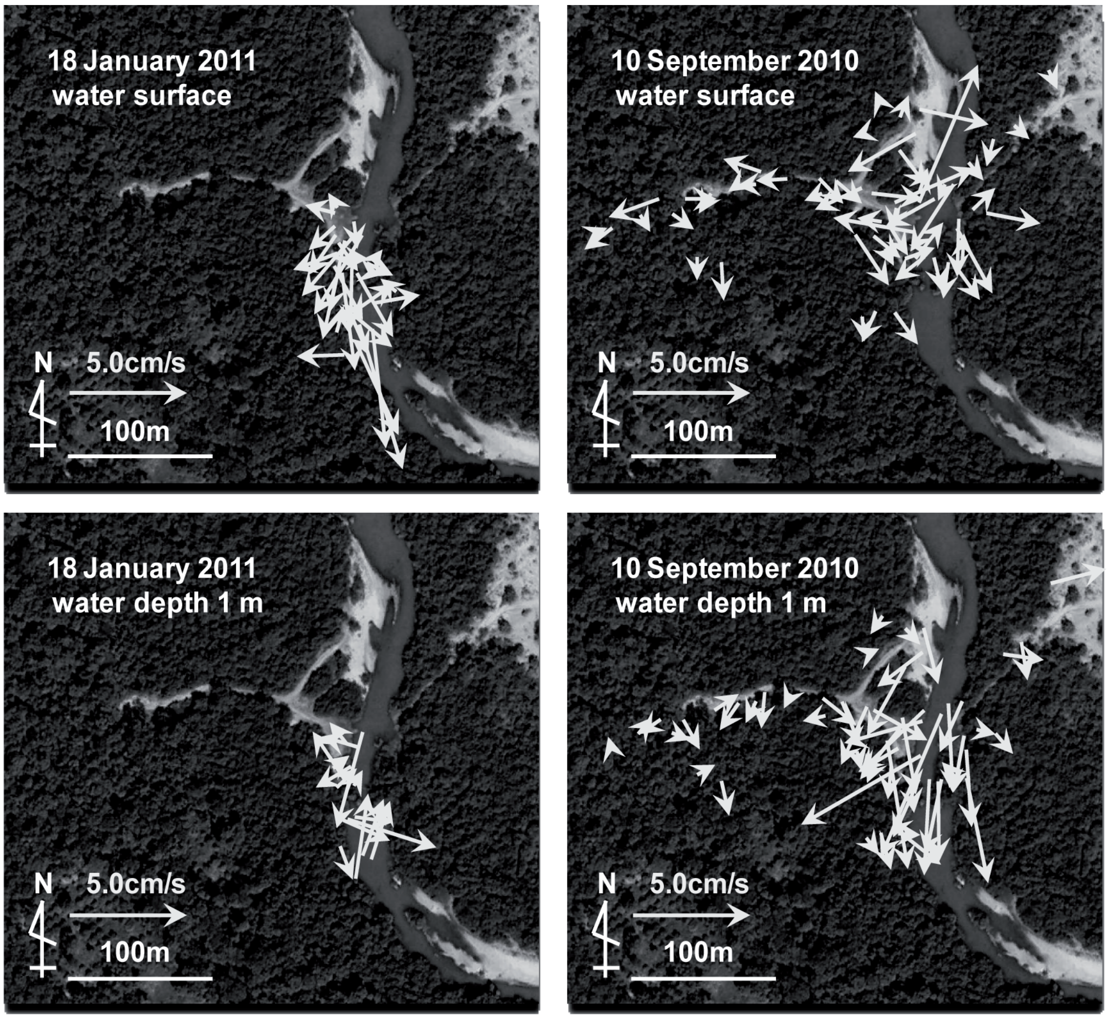

Figure 2 Current velocity and direction of the Lam Se Bai stream and the floodplain. Left: dry season (18 Jan 2011), right: rainy season (10 Sep 2010) The figures of the rainy season were redrawn from Kuwahara *et al*. (2011)

Similarly under the flooded conditions in the rainy season, water was also stagnant and flowed slowly into various directions within the riparian floodplain (right figures of Figure 2). The current velocity ranged 0-6.4 cm/sec at the surface layer and 0-5.8 at the 1 m deep, but mostly less than 1 cm/sec.

We hitherto demonstrated only two set of data about water current, but they were informative to understand the physical characteristics of the middle Lam Se Bai basin. Water current might be frequently stagnant both in the dry season and in the rainy season because the water levels of two irrigation dams were very close each other as mentioned above (Figure 1). It was considered that the stagnant conditions were caused by the reasons that the riparian swamps were topographically very flat and the river meandered through them and that the variations in current velocity were attenuated locally by the topographical nature of the riparian swamps. Strong currents were sometimes observed in our survey site during the rainy season (personal observation) but they were restricted almost exclusively to the opportunities of the heavy rainfall or discharge waters from the upper dam (Lam Se Bai dam).

Same as other Mekong river basin (MRC, 2002), water of the Lam Se Bai was ocher or light brown in color during the rainy season because fine particles of silt/clay and detritus were suspended into the water. Under the stagnant condition of the flooded periods of the rainy season, dissolved oxygen (DO) in the water decreased suddenly near the bottom layer (Fujioka *et al.* 2011a). However the water became clear in the peak of the dry season even under the stagnant conditions. This might be due to purification by waterweed which was grown on the bottom of the river, and as a result, the nutrient condition (Higano, 2011) and plankton population (Srithong *et al.,* 2011) were diminished and dissolved oxygen was increased.

Thus, water level and current velocity were predominantly determined by water control system of irrigation dams in addition to the topography and rainfall amount, and therefore they were predictable to some extent. In the Mekong river basin, a lot of fish species living in the trunk of the Mekong river migrated to the tributaries during the rainy season for breeding and nursing (Paulsen *et al.*, 2002). Local inhabitants of the Na Kae village understood empirically the seasonal fluctuations of waters and the fish migrating behaviors in the Lam Se Bai basin. They used seasonally a lot of different kinds of indigenous fishing gears in relation to the water conditions (Fujioka *et al.,* 2011b). In the peak of the rainy season, they operated stake net trap “pong pang”, branch weir trap “luan loub” and some other unique fishing gears along the stream of the Lam Se Bai and the floodplains (Fujioka *et.al.,* 2011a). The efficient use of indigenous fishing gears depended on understanding of fish behaviors, habitats and seasonal environmental conditions, such as water level and current velocity, of the rivers and the floodplains.

CONCLUSION

In the tributary of the middle Mekong river basin, water level and current velocity were predominantly determined by water control system of irrigation dams in addition to the topography and rainfall amount. Water current might be frequently stagnant both in the dry season and in the rainy season because the riparian swamps were topographically very flat and the river meandered through them. The efficient use of indigenous fishing gears by local inhabitants depended on understanding of fish behaviors, habitats and seasonal environmental conditions, such as water level and current velocity, of the rivers and the floodplains.

ACKNOWLEDGEMENTS

We are grateful to the Irrigation Department offices of Amnat Charoen and Ubon Ratchathani, for kindly providing monitoring data of dams. This study was supported by the Global Environment Research Fund (D-0902) of the Ministry of the Environment, Japan.

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Characteristics of Water Quality in Lam Se Bai Basin, Thailand

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ABSTRACT

Seasonal measurements of water quality were carried out in Lam Se Bai Basin, Northeastern Thailand. The water level of Na Kae station was the lowest in May 2010 almost dried and the highest in September 2010 about 9m in depth at the center of the river. In rainy season, water-soluble parameters such as nutrients, hardness and conductivity, are equalized by a flood. On particulate substances, turbidity tends to be higher in rainy season by hydraulic condition whereas chl.a fluctuated. In September 2010, there was stratification between surface and 1m below the surface. Under this condition, dissolved oxygen (DO) in the river water was 3mg/L on the surface and 0.4mg/L on the bottom. On contrary, DO on the surface was 1.08mg/L in the forest. Turbidity in the forest was lower than the river center. With the analysis of the similarity of water quality for the stations along the river, there are quite different dendrograms among the seasons. With the pattern of clustering, the connectivity and division of the basin system are presumed.

Key Words: water quality, swamp forest, low oxygen, Lam Se Bai

INTRODUCTION

Riparian freshwater swamps are important for nursing aquatic organisms by supplying potential source of food and act as breeding sites or shelters. They provide diversity and productivity of fisheries resources through the ecosystem in the watershed. Especially river-floodplain ecosystem plays an important role on enhancing the production through a variety of processes during the flooding cycle (Bayley, 1995). However, as forest decreased drastically from 50 % by 20 % in the past half century in Thailand, capture fisheries production decreased in coastal areas and inland areas (FAO 2010). Moreover, by various measures of human impacts such as the separation of floodplains from the river for intensive agriculture, the dam constructions for

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irrigation and hydroelectricity, degradation of the river-floodplain ecosystem would be of particular concern.

In this study, we aimed to describe characteristics of water quality in the river and the flood plain located in North-eastern Thailand and to evaluate the mass transportation in the system obtaining the water quality parameters.

MATERIALS AND METHODS

The study area situated along the river of Lam Se Bai, connecting to the Mun River which is one of the main tributaries of the Mekong River (Figure 1). The streams of the Lam Se Bai, start from the northern hillside, and flow into the Mun river in Ubon Rachathani Province. Along the Lam Se Bai River, 17 sampling stations were selected according to accessibility. Stations were separated into the bimonthly monitored floodplain area and the temporally monitored/upstream areas (Table 1). The main survey site was set up as Na Kae Station (No.15, 15°35’23”N, 104°27’44”E) on the floodplain of the middle in Na Kae village, Kham Khuan Kaeo district, Yasothon province, northeastern Thailand. Only at Na Kae (no.15), small rowing boats were used for the work of the water quality measurement, although the work at the other stations was conducted over the bridges or riverbanks.

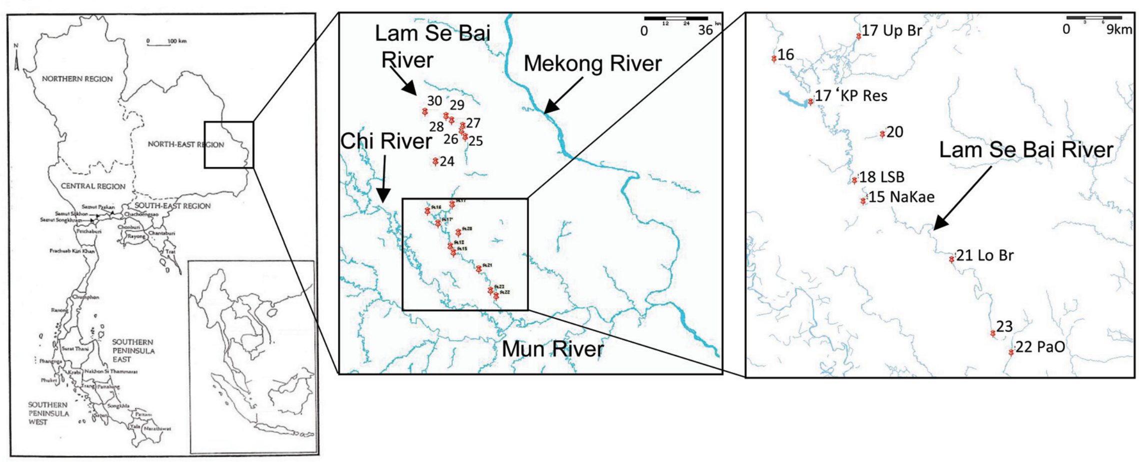

Figure 1 Location of study site and sampling stations along the Lam Se Bai River, Thailand

Table 1 List of the sampling stations with the coordination

No.	Abbr.	Area	Latitude	Longitude
Bimonthly monitored stations				
17	Up Br	Bridge on Route No. 202 between Yasothon and Amnat Charoen	15°50'23.6"N	104°27'21.2"E
17'	KP Res	Kutpeng Reservoir	15°44'27.5"N	104°22'58.4"E
18U	LSB-U	Lam Se Bai Dam (North)	15°37'18.1"N	104°26'56.2"E
18D	LSB-D	Lam Se Bai Dam (South)		
15	NaKae	Lam Se Bai at Nakae village	15°35'24.4"N	104°27'44.6"E
21	Lo Br	Bridge on Route No. 2383	15°30'10.9"N	104°35'43.4"E
22U	PaO-U	Pa Ao Dam (North)	15°21'41.2"N	104°41'05.3"E
22D	PaO-D	Pa Ao Dam (South)		
Temporally monitored stations				
20		Lotus pond	15°41'29.6"N	104°29'28.8"E
23		Bridge on Route No. 2409	15°23'25.0"N	104°39'25.0"E
Stations upper stream of Lam Se Bai				
24		Huai lam poan	16°03'56.8"N	104°22'11.2"E
25		Sawat - east	16°11'44.0"N	104°31'32.5"E
26		Sawat - north	16°13'35.5"N	104°30'26.3"E
27		Kut hae	16°15'10.1"N	104°30'41.5"E
28		Kut Chiang Mi	16°16'52.4"N	104°27'19.2"E
29		Kut Chiang Mi - west	16°18'13.9"N	104°25'32.9"E
30		Nam Yoi Cave (River origin area)	16°19'43.8"N	104°18'57.6"E

The water quality parameters are measured at eight stations bimonthly and at seven upstream stations and two stations beside the main stream temporally (about four month intervals) along the Lam Se Bai River (Table 1). Water temperature, pH, DO, Conductivity, and Turbidity were measured every one meter depth interval with Water quality meter WQC-24, TOA Co. Surface water samples were collected by casting bucket. Immediately after the filtration of water by cartridge membrane filter with 25mm disc and 0.45μm pore size, hardness, ferrous and ferric ions, ammonia, nitrite, orthophosphate and COD were measured using Simple pack test kit, Shibata Co. For chlorophyll and phaeopigment analysis, 20 to 50 ml of water samples were filtrated with glass fiber filter (Whatman GF/F), soaked in five ml of n-dimethyl formamide and detected with Turner Design Chlorophyll meter U-10 followed by fluorometric method (AWWA *et al.*, 1992). In order to obtain more accurate data for the nutrient and productivity indices, water samples of eight stations (listed in upper part of Table 1) were preserved in ice, then nitrite, nitrate, ammonia, orthophosphate, total phosphorus, BOD and COD were subsequently analyzed according to the standard methods (AWWA *et al.,* 1992) in the laboratory.

In order to compare the similarity of water quality parameters in each station along the Lam Se Bai River, Horn's measurement of overlap, R0 (Horn, 1966) was calculated. The obtained R0 in each station were proceeded to cluster analysis by Mountford's method (Kimoto, 1976). For the calculation of R0, some water quality parameters, namely, pH, DO, Conductivity, Turbidity, WT, Hardness, Fe (II+III), NH4, NO2, COD and Chl.a were selected. Due to the lack of complete data sets for the calculation, nine stations (no.30, 28, 26, 24, 17, 18U, 15, 20, 22U) were selected out of the 17 stations.

RESULTS AND DISCUSSION

Seasonal changes in water quality

The water levels at the center of the River of Na Kae research site (no.15) on May 10th, September 10th, October 27th, November 10th 2010 and January 20th 2011 were 0.8m, 9.1m, 8.6m, 2.1m and 1.6m, respectively. The river water in May 2010 was almost dried out, although the water level in September 2010 reached more than nine meter in depth and no water flow was observed. So, September and October corresponded to rainy season although May, January and November corresponded to dry season in this research period.

For eight stations listed in Table 1 as bimonthly monitored areas, year round changes of water quality parameters were demonstrated in Figure 2. Water temperature rapidly fell in November while it has exceeded 30 ºC from May to October at almost all stations. The temperature started to rise again in March 2011. In any station pH was higher than 6, so there was no acid soil problem around the basin. In September pH showed small different among sites ranging from 6.17 to 6.66 while considerable variation in pH were found in May and July ranging from 6 to 8.5. Dissolved oxygen (DO) in September showed the lowest from 1.1 to 3mg/L (except upper stream bridge) even in surface water. Conductivity in Na Kae was the most fluctuated and showed the highest value in July. It is considered that nutrients and some other soluble materials were flowed into the River through swamp forest and large floodplain area around Na Kae station.

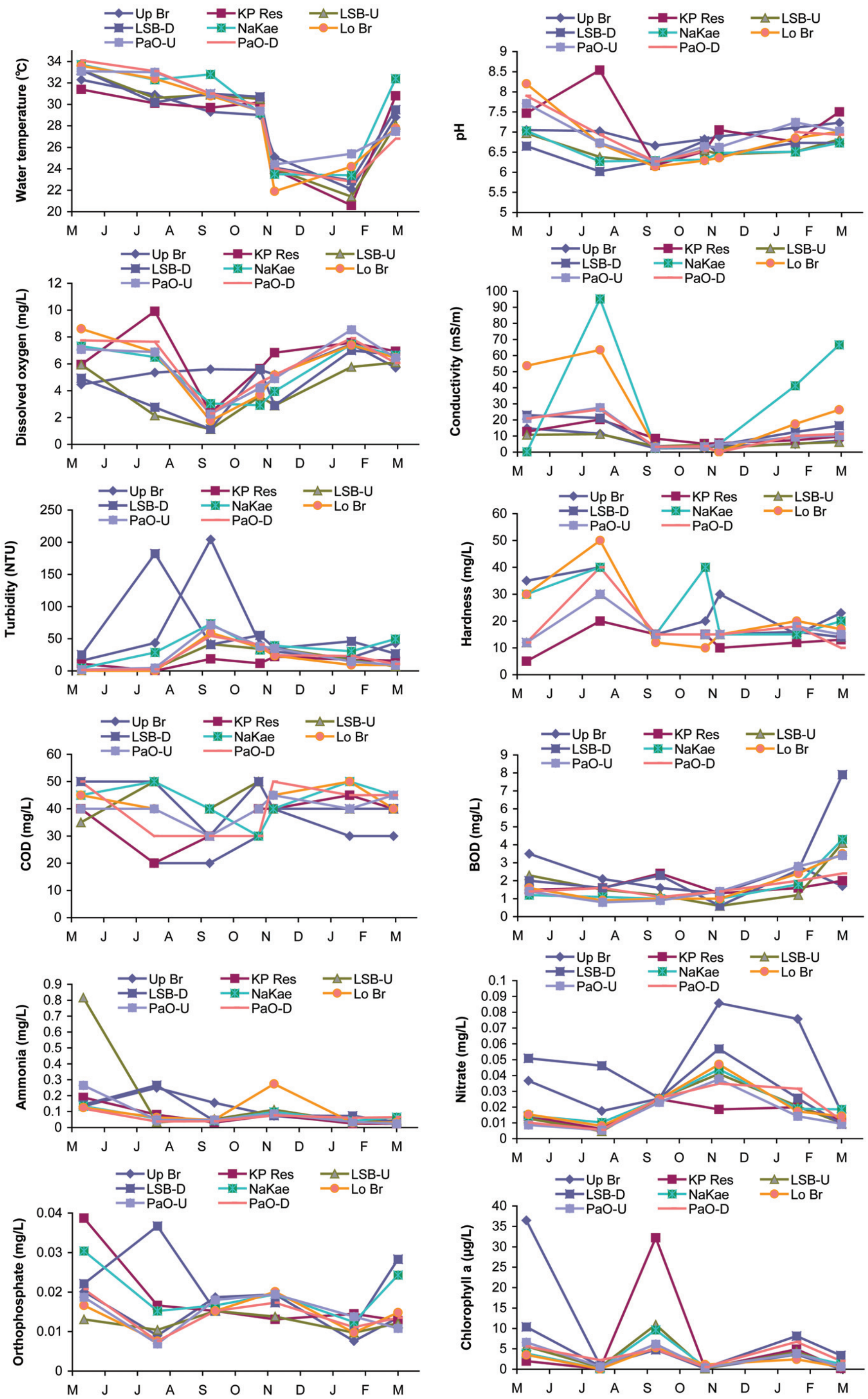

Figure 2 Water temperature, pH, conductivity, dissolved oxygen, turbidity, hardness, COD, BOD, ammonia-nitrogen, nitrate, orthophosphate and chlorophyll a on surface water in eight bimonthly monitored stations from May 2010 to March 2011

Turbidity showed lowest value in May (dry season) and increased from July to September (rainy season). This is explained as resulting from water runoff. Especially, the highest value of turbidity was recorded at Up Br (no.17) with strong water flow in September (rainy season). Hardness was different among stations in May and July, but became less diverse in rainy season. COD ranged 20 to 50mg/L while BOD ranged 0.6 to 7.9mg/L. The fact showed that chemical consumption was higher than biological consumption of oxygen.

Total ammonia was ranged from 0.02 to 0.27mg/L without significant difference among the season except 0.82mg/L at upstream of LSB dam in May. The high ammonia concentration may be explained by stagnant state of water. However no remarkable phenomena was recognized at the above situation. Nitrate was ranged from 0.005 to 0.0085 mg/L and lesser than total ammonia. Without Up Br and LSB-D the ranges of nitrate at each time were narrow, and it tended to show lower value in very low water level, but increase with the water level risen. Orthophosphate showed relatively constant throughout the year in each station between 0.01 and 0.02mg/L. Chlorophyll a concentration showed higher in May, September and January whereas lower in July, October and March.

In general, high values of DO and pH are caused by photosynthesis of phytoplankton (Boyd, 2000) or aquatic plant (Lambers *et al.,* 2008). In fact, very high pH and DO at KP Res in July were observed. It was presumably due to aquatic plants rather than phytoplankton because chl.a in surface water was very low at the period. On the other hand, DO in September was lower than the other months. However, ammonia did not represent high level in September. One explanation might be that ammonia already had been absorbed by phytoplankton because higher chl.a concentration was recorded in September. At the same time, oxygen in the water was consumed by the decomposition of organic material during the flood (Bayley, 1995).

Through the year round survey, it is characterized that in rainy season water soluble parameters (e.g. nitrate, ammonia, orthophosphate, hardness and conductivity) are equalized provably by a flood with gathered water. On the particulate substances, turbidity tends to be higher in rainy season by hydraulic condition whereas chl.a greatly fluctuates perhaps influenced by sunshine and consumers for phytoplankton.

Vertical profiles of water quality in Na Kae

Only at Na Kae station, the survey was conducted by boats so the water depth was exactly measured in this station. Figure 3 showed vertical profiles of water temperature, pH, conductivity, dissolved oxygen and turbidity at the center of Lam Se Bai River of no.15 in September 10th, October 10th, 2010 and January 20th, 2011. In September the vertical profiles inside the floodplain forest, ca. 50m apart from the center of the river, were also demonstrated. In September, river water was spread out the floodplain and the river flow was stagnant. The surface water temperature was 32.8 ºC and ca. 2ºC higher than lower layer. There was stratification between surface and one meter below the surface. Under this condition, oxygen in water body was consumed and stratified DO profile was observed, e.g. 3.05mg/L on the surface, 0.56mg/L in one meter and decreased to 0.4mg/L as it reached the bottom. On the other hand, there was no difference in temperature in the forest and the turbidity was lower than in the center of the river. In the forest, the canopy plays a role of sunshade and the branches submerged under the water acts as screen to nullify water current. In contrast, DO in the forest was much lower than the center of river, for example DO at the surface layer showed 1.08mg/L in the forest against 3.05 in the center of the river. This is one of the facts that the vegetation plays an important role on controlling water quality. In October the water level was ca. three meter lower than September. In this period, the river water resumed to flow. There was no stratification in the temperature and DO profiles. DO in October was recovered up to 3mg/L, so anoxic condition might be lasted only stagnated period. In January the water level was less than two meter and the water flow was slight. The water in January showed very high DO and ten times higher conductivity than in rainy season.

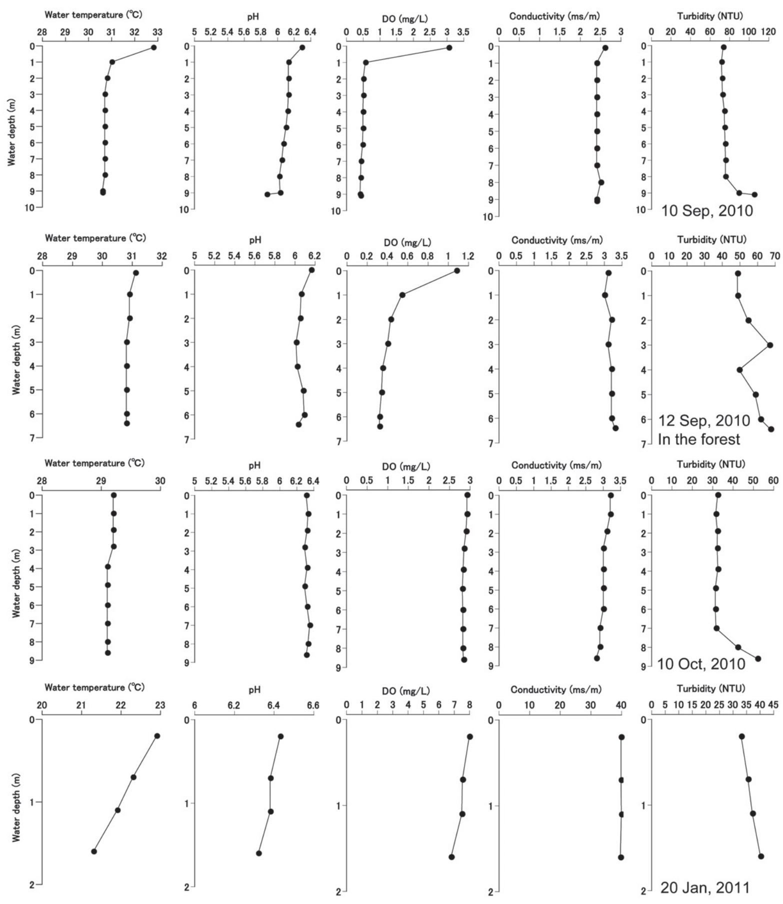

Figure 3 Vertical profiles of water quality parameters in the river water of Na Kae station (Station no.15)

It is considered that the low oxygen during inundation brings about two kinds of impacts for river-floodplain ecosystem. One is a negative impact for aquatic and terrestrial organisms (both animals and plants) after prolonged period of low oxygen (Junk *et al.*, 1989). Another is a positive impact for supplying nutrients eluviated from soil and degraded organic materials under the anoxic condition to algae and phytoplankton (Junk et al., 1989; Bayley, 1995). However we could not find any evidence to show these phenomena in our limited survey. It is necessary to perform more intensive monitoring during rainy season, such as daily fish catch record, occurrence of mass mortality of benthic organisms, measurements of primary production, ammonia and orthophosphate monitoring in bottom water, etc.

Connectivity of the river through the similarity of water quality

In Figure 4, R0 (Horn's measurement of overlap) of nine stations were separated into three clusters in May and four clusters in September 2010. The difference was strongly related to the connectivity of river water. In dry season, river water of the Lam Se Bai was divided in several/many parts, so similarity of water quality must be diverse. In fact, station 15 and 30 were isolated from each other, but both showed transparent in river water. It is presumably due to the consumption of nutrient by vegetation and aquatic plant. Moreover, the water at station 30 was the water come from the fountainhead that was filtered in the mountain area. In rainy season (Sep 2010) the river water was basically connected, so similarity of the water quality parameters was high. It is understandable that the cluster depended on the river flow, such as upstream (no.22U, 15, 18U) and downstream (no.28, 26, 24, 17), besides the headwaters of the river (no.30) and the tributary reservoir (no.20, Nong Sam Kha Reservoir). On the other hand, clusters were obscure in January 2011 except the origin of river water at Station 30.

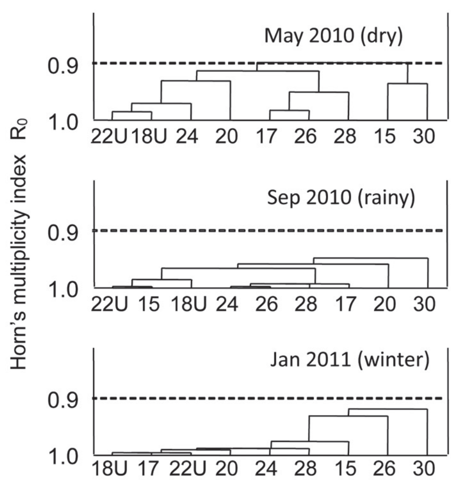

Figure 4 Dendrograms derived from Ro: Horn's measurement of overlap, based on surface water quality items in dry (May and Jan.) and rainy (Sep.) seasons

CONCLUSIONS

Measurement of water quality in the river and the flood plain provided the following information. The water level and river flow make an effect on water quality, especially low oxygen was observed under the stagnant water. Vegetation of floodplain forest plays an important role of water quality control as well as supplying nutrient. With the analysis of the similarity of water quality, connectivity and division of the basin system are presumed. It is important to consider the functional roles of floodplain in the ecosystem of river basin on altering the river regime such as dam management, dike construction, excavation of irrigation canals, cutting riparian forest, etc.

AKNOWLEDGEMENTS

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Plankton Community in Swamp Forest : Study Case at The Lam Se Bai Basin

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Junya Higano[2] Hisami Kuwahara[3]

ABSTRACT

Qualitative aspect of the plankton in Lam Se Bai was studied one year, during April 2009 to March 2010, every two months. Plankton samples were collected by towing plankton nets of mesh size 21 µm, from 8 stations at the middle depth of canal. A total of 187 species in 3 division of phytoplankton recorded comprised of 15 species of Cyanophyta, 141 species of Chlorophyta, 31 species of Chromophyta and a total of 76 species in 3 phylum of zooplankton recorded comprised of 17 species of Protozoa, 49 species of Rotifera, 10 species of Arthropoda. The genera of phytoplankton as Chroococcus sp, Oscillatoria sp, Eudorina elegans, Pandorina morum, Euglena acus, Phacus ranula, Mallomonas splendens and Peridinium sp. and the genera of zooplankton as Anuraeopsis navicula, Polyarthra vulgaris, Hexathra sp., Bosminopsis deitersi, Copepod nauplius and Calanoid copepod were frequently found in large number.

Key Words: plankton community, riparian, floodplain, swamp, Lam Se Bai, Mekong River

INTRODUCTION

Plankton is the crucial part of aquaitic food chain. As the primary producer, phytoplankton converts inorganic matters into organic compounds though photosynthesis, enabling transfers of energy and nutrients to zooplankton and other aquatic animals in the food chain. Each species of plankton inhabits in different evironments. Some live in areas with high concentration of organic matters, others are found in reservoirs with moderate concentration of organic matter while a number of species thrive in environment with little organic matter. Some phytoplankton species can thus be used } as water quality index. Most plankton has short life cycle and can quickly respond to changing environment. (Hanpongkittikul and Wongrat. 2005); (Pradissan, 2000); (Reynolds, 1984)

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Lum Se Bai is a small branch of the Mun river which is one of the Mekong river, The total length of Lum Se Bai is 233 km , Water level of Lam Se Bai is controlled by two small irrigation dams, that is, Lam Se Bai weir in the upper area and Amnat Charoen weir in the lower area. They were constructed to supply water for irrigation. Along Lam Se Bai have many riparian freshwater swamp forests, where are nursing fisheries resources with supplying potential source of food and breeding sites or shelter even though they have different frequency and period of flooding. Fisheries products are the important natural resources and fisheries activities of fishermen from every village that located along Lam Se Bai.

The purposes of this study are to investigate the species composition of plankton in Lam Se Bai, and whether there are temporal and spatial variations of phytoplankton and zooplankton community in the study area. Results of this study can be used as baseline for future diversity and ecological studies. And also qualitative of the plankton from this studies are used for indicator of primary productivity in Lam Se Bai

MATERIALS AND METHODS

Study sites

Lam Se Bai is a small branch of the Mun river, origin from border of Mukdaharn province and pass though Yasotorn, Amnat Jaroen and joint with Mon river at Ubol Rattanee province. Lam Se Bai have two small irrigation dams, that is Lam Se Bai weir in the upper area and Amnat Charoen weir in the lower area. Eight sampling stations were used in the study to ensure proper coverage from upstream area to downstream area (Figure. 1). These stations selection is based on 4 reasons; near main survey site (Na Kae village), near dam or reservoirs, easily sampling (mainly on bridge) and moderate distance each other.

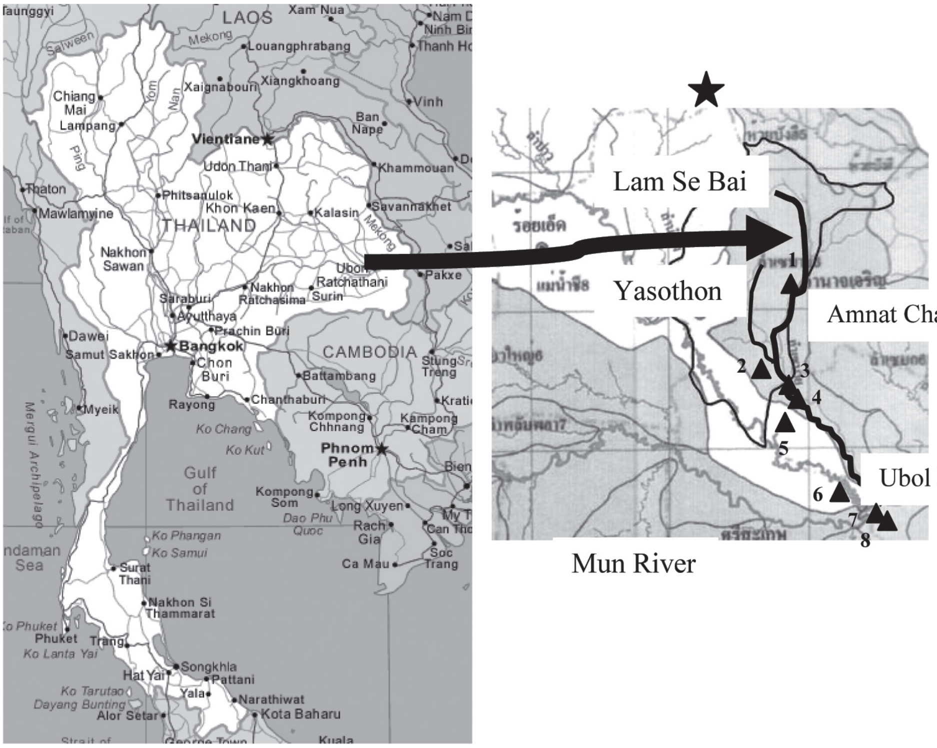


Figure 1 Study site in Lam Se Bai

Samples were collected during 2009, April to 2010, March (before raining season when water from upper stream flood over the riparian freshwater swamp forests along Lam Se Bai.) Samples were collected at every two months. Plankton net with mesh size 21 µm were used in collecting samples with oblique tow technique. Plankton samples were preserved with 4% formaldehyde solution. Olympus CX31 microscopes and Sedgwick-Rafter slides were used in studying species indentification. Species classsification of the samples was mainly based on Wongrat (1999a and 1999b)

RESULTS AND DISEUSSIONS

The study of phytoplankton community in Lam Se Bai, we found 3 division phytoplankton, 6 class, 74 genera, 187 species. Most of species found belonged to Class Chlorophyceae (green algae) which had the highest number of species with 37 genera 112 species (59.89%), followed by Class Euglenophyceae (euglenoids) with 5 genera 29 species (15.51%), Class Bacillariophyceae (diatom) with 16 genera 18 species (9.63%), Class Cyanophyceae (blue green algae) with 9 genera 15 species (8.02%), Class Chrysophyceae with 4 genera 8 species (4.28%) and Class Dinophyceae (dinoflagellates) with 3 genera 5 species (2.67%) respectively (Figure 2) The most diverse genus was Staurastrum which was frequently occurred throughout the study with 19 species followed by Trachelomonas, 10 species, *Cosmarium*, 9 species and *Closterium*, 8 species

For zooplankton, we found 3 phylum, 7 class, 42 genera, 76 species. Most of species found belonged to Class Eurotatoria which had the highest number of species with 21 genera 49 species (64.47%), followed by Class Crustacea with 10 genera 10 species (13.16%), Class Lobosa with 3 genera 9 species (11.84%), Class Ciliata and Class Oligohymenophorea with 3 genera 3 species (3.95%), Class Filosia and Class Heliozoa with 1 genera 1 species (1.32%), respectively (Figure 3) The most diverse genus was *Lecane* which was frequently occurred throughout the study with 10 species followed by *Brachionus*, *Trichocera Keratella* and *Difflugia* with 5 species.

The species of phytoplankton as *Chroococcus* sp, *Oscillatoria* sp, *Eudorina elegans*, *Pandorina morum*, *Euglena acus*, *Phacus ranula*, *Mallomonas splendens* and *Peridinium* sp. were the most common species being found in every investigate sites and time.

As the species of zooplankton as *Anuraeopsis navicula*, *Polyarthra vulgaris*, *Hexathra* sp., *Bosminopsis deitersi*, Copepod nauplius and Calanoid copepod were the most common species being found in all investigate sites.

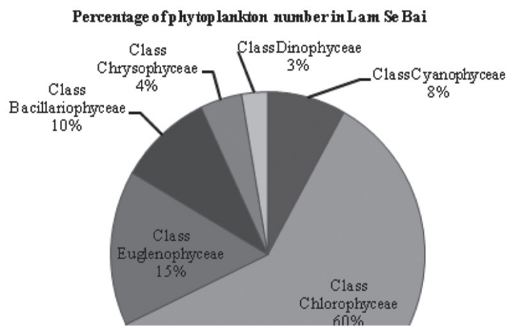


Figure 2 Taxonomic structure of the phytoplankton in Lam Se Bai

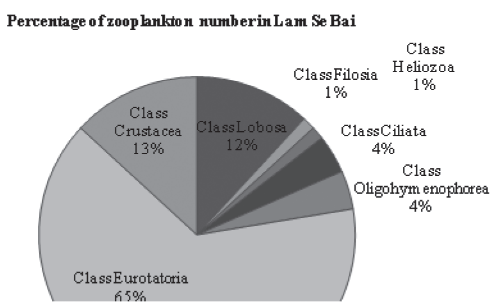


Figure 3 Taxonomic structure of the zooplankton in Lam Se Bai

The season effective on the community of plankton in Lam Se Bai

The variation of phytoplankton that were found each investigate time was not strong, unless the variation of phytoplankton were found in September was highest (123 species, 21%), follow with (Figure 4.) And also class Chlorophyceae was dominant phytoplankton group in each investigate time (Figure 5). As zooplankton that were found each investigate time was not strong, unless the variation of phytoplankton were found in April was highest (62 species, 20%), follow with figure 4, class Eurotatoria was dominant zooplankton group each investigate time (Figure 6).

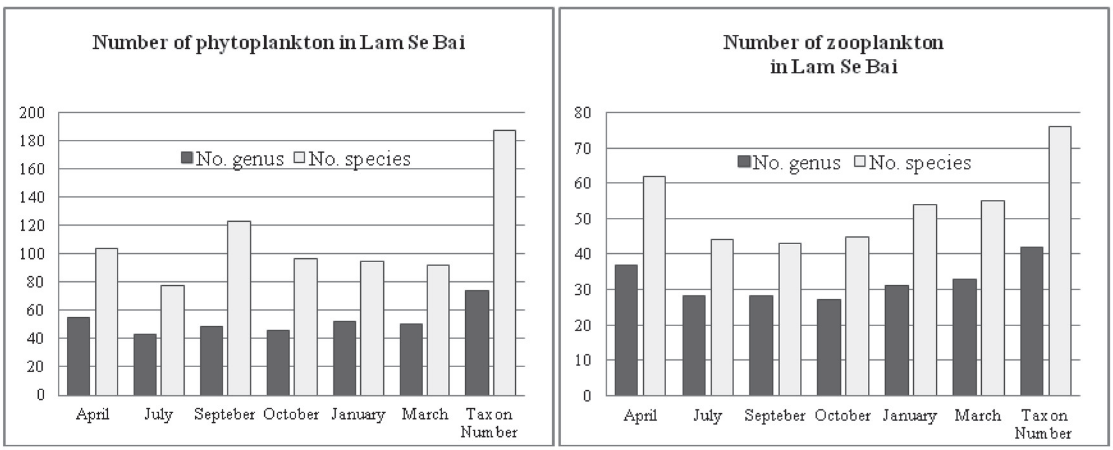
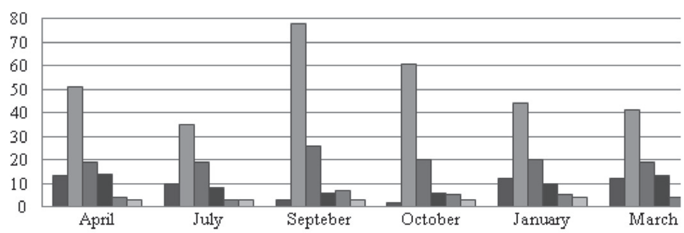
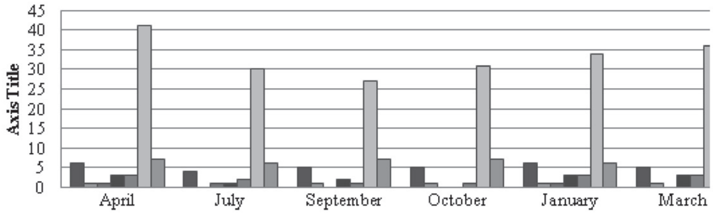


Figure 4 Number of plankton found each investigate time in Lam Se Bai



	April	July	Septeber	October	January	March
Class Cyanophyceae	13	10	3	2	12	12
Class Chlorophyceae	51	35	78	61	44	41
Class Euglenophyceae	19	19	26	20	20	19
Class Bacillariophyceae	14	8	6	6	10	13
Class Chrysophyceae	4	3	7	5	5	4
Class Dinophyceae	3	3	3	3	4	3

Figure 5 Taxonomic structure of the phytoplankton in investigate time in Lam Se Bai



	April	July	September	October	January	March
ClassLobosa	6	4	5	5	6	5
ClassFilosia	1	0	1	1	1	1
ClassHeliozoa	1	1	0	0	1	0
ClassCiliata	3	1	2	0	3	3
ClassOligohymenophorea	3	2	1	1	3	3
ClassEurotatoria	41	30	27	31	34	36
ClassCrustacea	7	6	7	7	6	7

Figure 6 Taxonomic structure of the zooplankton in investigate time in Lam Se Bai

The variation of phytoplankton found in each the investigate site along Lam Se Bai (Upstream to down stream) is similar (Figure 7), unless Kud Chum and Kud Peng, upstream site, the highest group of phytoplankton (class Chlorophyceae) was found in October, as Lam Sae Bai Weir, Khueang Nai, Amnat Charoen Weir was found in September, both investigate time were raining season in study site, higher nutrient was dissolved along Lam Se Bai in this season, appropriately grown of Chlorophyceae for this periodical. After the water level in Lam Se Bai was decreased in cool season (November to February) and in drying season (March to May), the number of phytoplankton group each investigate site was not too differently (Figure 8).

Similarly, the highest zooplankton group (class Eurotatoria) was found in raining season (Figure 9), effect on number of phytoplankton, source of food for zooplankton (Reynolds, 1984)

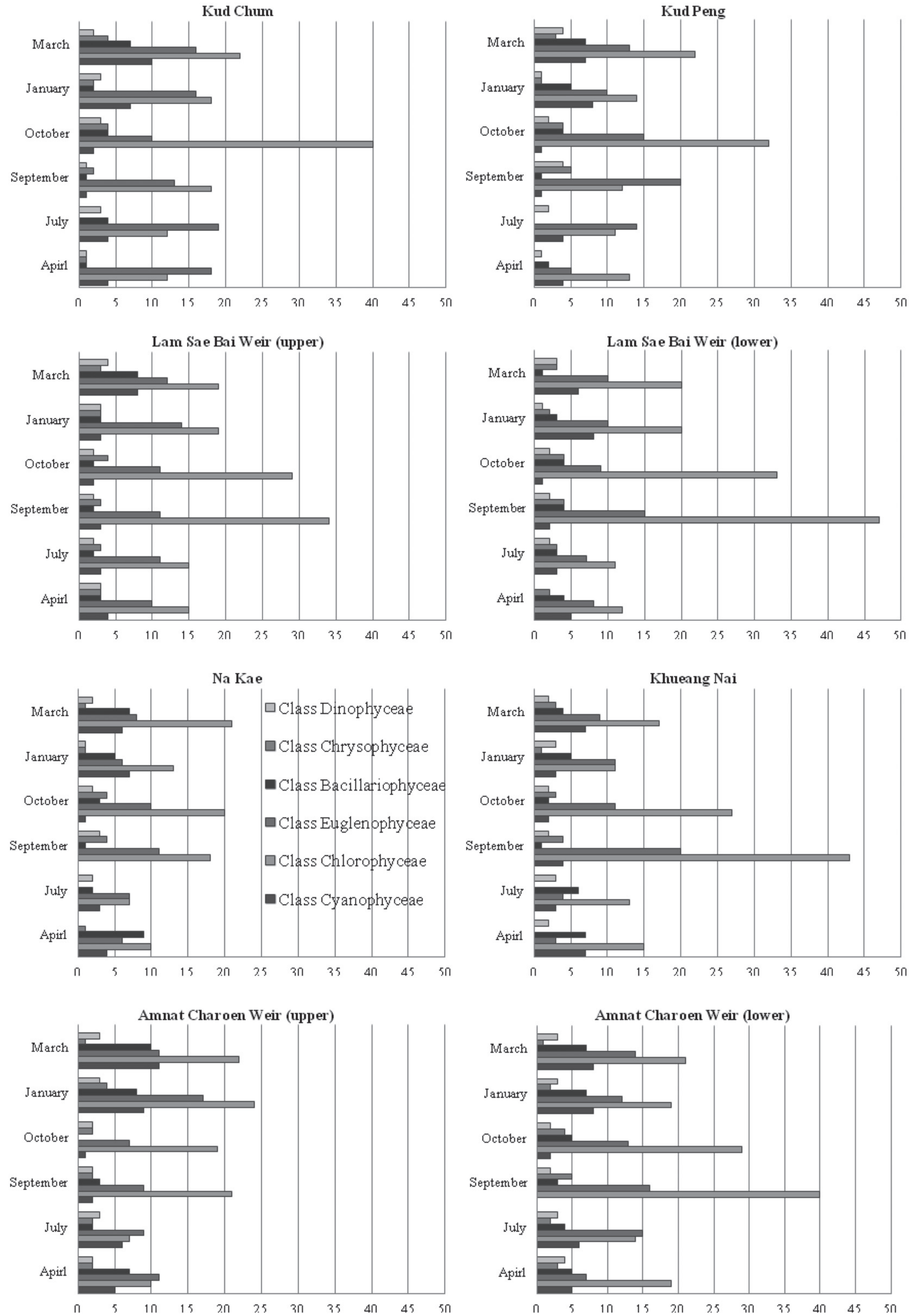


Figure 7 The variation of taxonomic structure of the phytoplankton in investigate site in Lam Se Bai

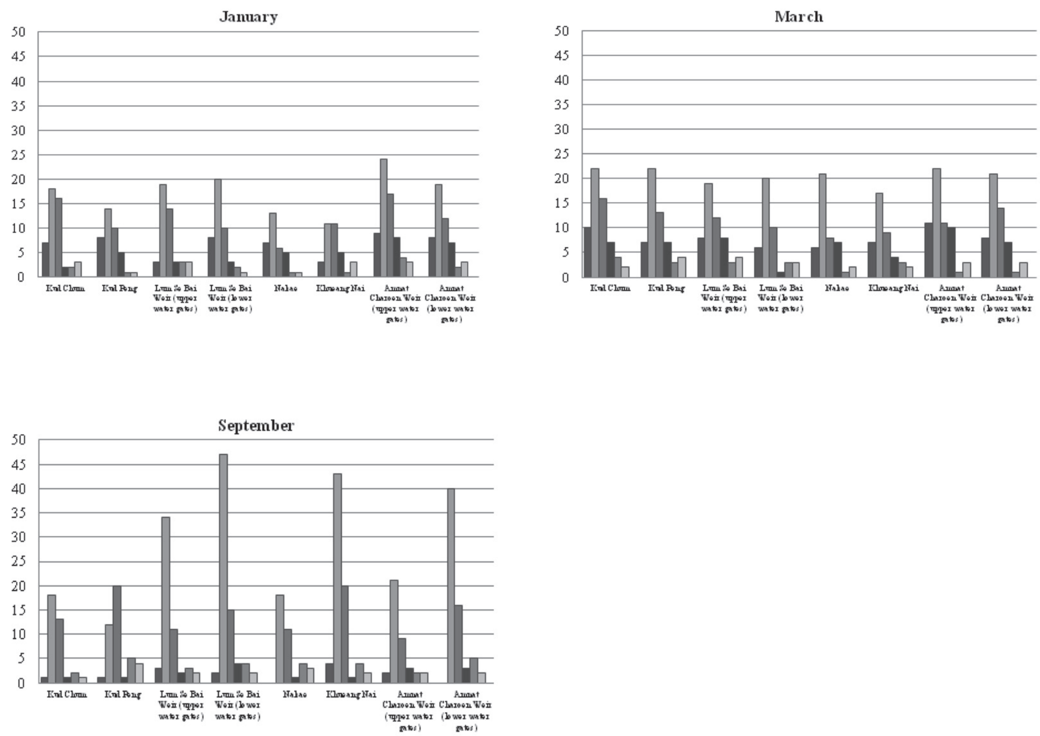


Figure 8 The variation of taxonomic structure of the phytoplankton in investigate time in Lam Se Bai

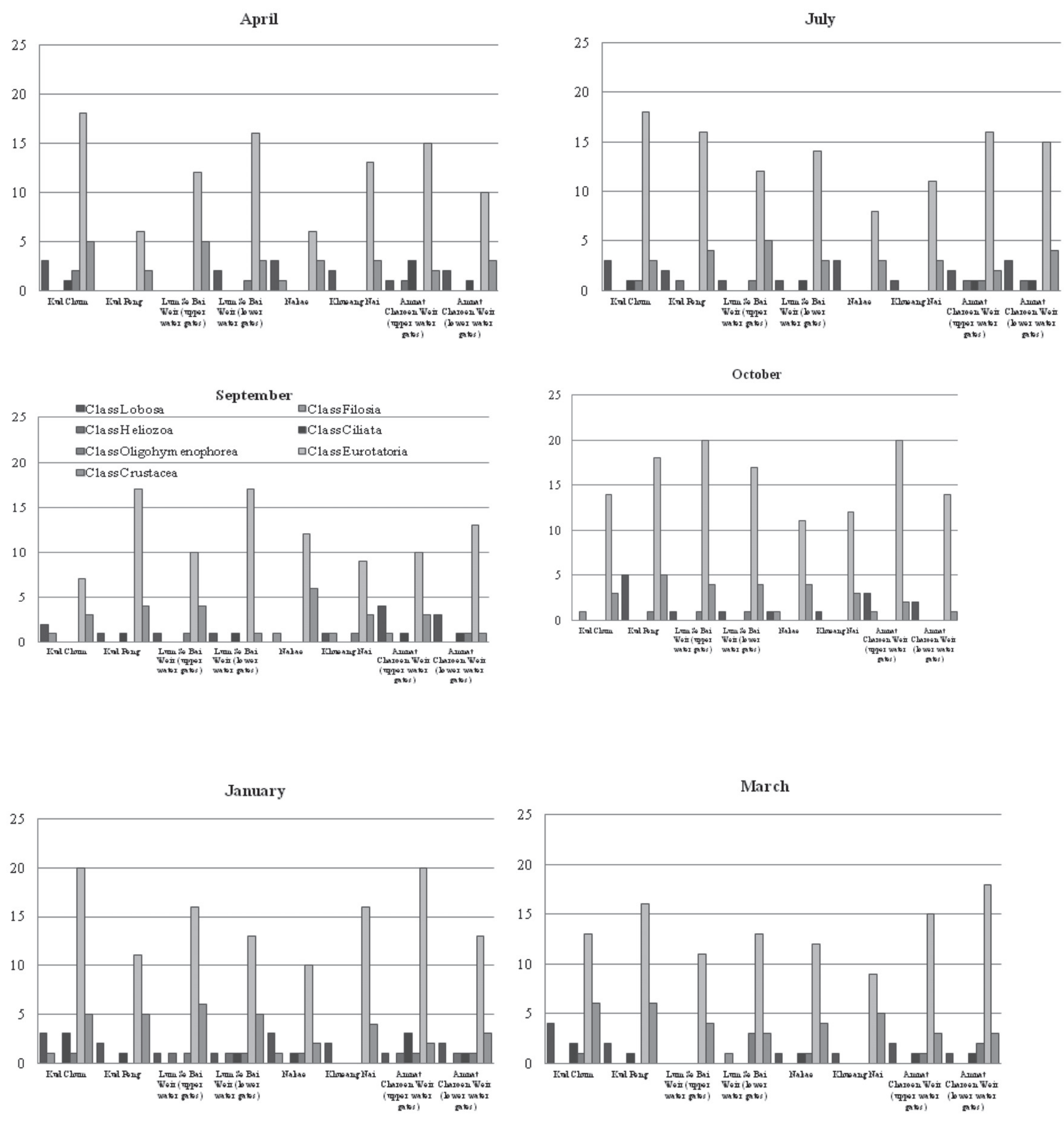


Figure 9 The variation of taxonomic structure of the zooplankton in investigate time in Lam Se Bai

The water nutrient (nitrate, total ammonia and orthophosphate) that were found in each the investigate site along Lam Se Bai (Upstream to down stream) is similar (Figure 10), unless total ammonia value that collected in April, July and October, the values was higher than investigate time. Normally, the land used of villagers along Lam Se Bai is planting, paddy field or annual crops, so the villagers always use fertilizer such as urea, ammonium nitrate etc. for their production, so some nutrient from fertilizer from field was released to Lam Se Bai when raining beginning season. And dissolved oxygen value along Lam Se Bai was very low (less than 2 mg/Liter), clause by fermentation of organic matter in swamp forest area after water level increased, especially in October, that was effected on higher ammonia value, because of nitrification is very low, ammonia is oxidized to nitrate is not occurred in low dissolved oxygen condition (Boyd and Tucker, 1998).

Water quality data (nitrate, orthophosphate) that shown in figure is small value, because of some nutrient is absorbed by macrophytic algae that appeared along Lam Se Bai.

CONCLUSIONS

The taxon number of 187 species in phytoplankton, with the follow percentage: 59.89% Chlorophyceae, 15.51% Euglenophyceae, 9.63% Bacillariophyceae, 8.02% Cyanophyceae 4.28% Chrysophyceae and 2.67% Dinophyceae. And 76 species in zooplankton, with the follow percentage: 64.47% Eurotatoria, 13.16% Crustacea, 11.84% Lobosa, 3.95% Ciliata, 3.95% Oligohymenophorea, and 1.32% Filosia and 1.32% Heliozoa. The dominant species of phytoplankton were *Chroococcus* sp, *Oscillatoria* sp, *Eudorina elegans*, *Pandorina morum*, *Euglena acus*, *Phacus ranula*, *Mallomonas splendens* and *Peridinium* sp., as zooplankton were *Anuraeopsis navicula*,

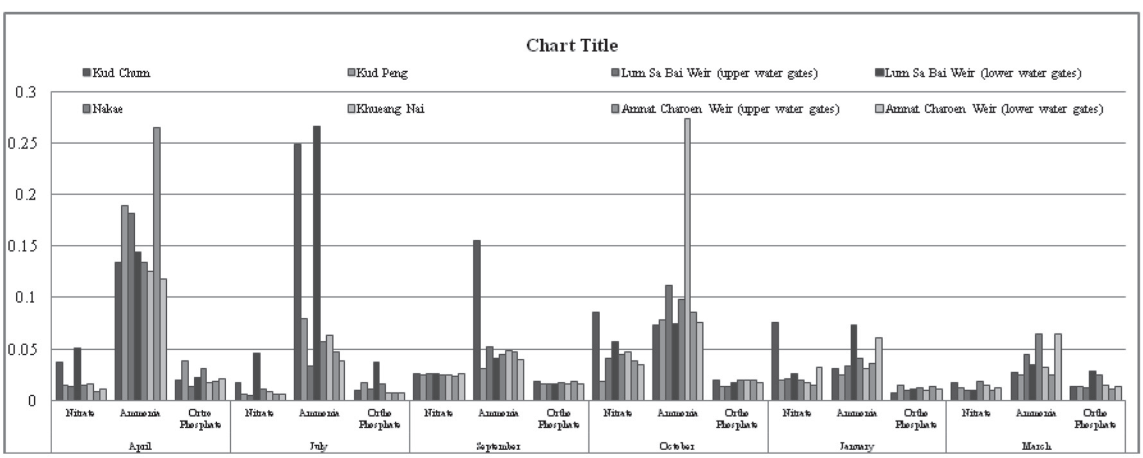


Figure 10 The variation of water nutrient in Lam Se Bai

Polyarthra vulgaris, *Hexathra sp.*, *Bosminopsis deitersi*, Copepod nauplius and Calanoid copepod were the most common species being found in all investigate sites.

The results provide useful knowledge on plankton community for further study (Raining season) in Lam Se Bai, The studying on fluctuation of abundance of plankton all round year in Lam Se Bai lead to provide useful knowledge for primary productivity of this swamp area.

ACKNOWLEDGEMENT

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Exploring Villagers-Resources Network : Differences in the Pattern of Natural Resource Use in Yasothon, Thailand

Fumikazu Ubukata[1]

ABSTRACT

For rural villagers, the nature is an important livelihood sphere. The utilization of these various natural resources thus consists one integral part of their economic activities. This "natural economy" or "villagers – resources network", however, had long been underestimated both in terms of rural development and natural conservation. By examining the status and trends of resource use by the villagers in the two villages of Yasothon, Thailand, this study tried to explore the seasonal, spatial and household-wise variations and trends of this network. The study revealed that the resource endowment is not the sole factor affecting the extent of resource use. This implies the importance of the concept of "resource activation" mediated by the villagers' preferences and skills.

Key Words: Thailand, Yasothon, resource, network, natural economy

INTRODUCTION

For rural villagers, the nature is an important livelihood sphere. They largely live on natural resources, such as abiotic resources (i.e. water, land) and biotic resources (i.e. forest, plants, animals) (Daly and Farley, 2004). The utilization of these various natural resources thus consists one integral part of their economic activities. This "natural economy", however, had long been underestimated both in terms of rural development and natural conservation. In the former context, it was only partly included into economic calculations, which had caused an underestimation of natural capital (Daly, 1996). In the latter, the consideration was in many cases fragmented into one particular type of resources (i.e. forest, fish, water, land etc.). As the relationship between nature and people is comprehensive and complex, the specific focus on the particular part of the

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relations may sometimes fall into danger of misunderstanding the status and trend of natural economy.

This paper therefore regards this nature – people relationship as a set of comprehensive actor networks among various natural resources and villagers. Here "the actors" include both natural and human actors, for the author believes that both can mutually affect each other within the existing network. In addition, it is important to identify the set of mediating factors which affect the creation, maintenance, and change of the network patterns. The attribution of households, resource types and ownership/domain (i.e. private ownership, public ownership, commons etc.) and exploitation techniques are more or less considered as elements of such factors.

In Thailand, some studies examined villagers' natural resource use patterns (Shibahara, 2002a, 2002b) and some aspects of such villager – resources network. Their focus, however, were more or less limited to a particular resource type and/or domain. It is thus important to examine how the multiple networks among villagers and resources are created and what influence the creation and change of the networks. By examining the status and trends of resource use by the villagers in the two villages of Yasothon, Thailand, this study tried to explore the seasonal, spatial and household-wise variations and trends of this "villagers – resources network". Then finally, the author also considered influential factors affecting the network.

METHODOLOGY AND STUDY AREA

Interviews and questionnaire surveys were conducted during the following three durations in NG and KN villages, K district, Yasothon province of northeast Thailand (Figure 1).

1) Fourteen days from 12 October 2005 (for NG village, fourteen days from 13 Oct. 2005)

2) Seven days from 7 March 2006

3) Eleven days from 16 June 2006.

In the questionnaire survey, the author selected 10 households for each village in accordance with the economic status[2] , and asked their daily resource takings: *who took what and how much resources from where for what purposes*. The resources here include three categories: fish, wood (especially fuelwood), NTFP and others. Here the author analyzed the seasonal, spatial, and household variations in resource use frequency[3].

The brief comparison of NG and KN villages are shown in Table 1. It is obvious that their resource endowments and economic status are different. In general, NG village has larger forest area, while KN villagers are richer in paddy fields. Table 2 provides household-wise basic data. It seems that KN villagers are slightly better off and have clearer social stratification.

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2 Three categories (high, middle, and low). The criteria are based on villagers' subjective evaluations.
3 The author also obtained data on resource value, though the data is still under processing.

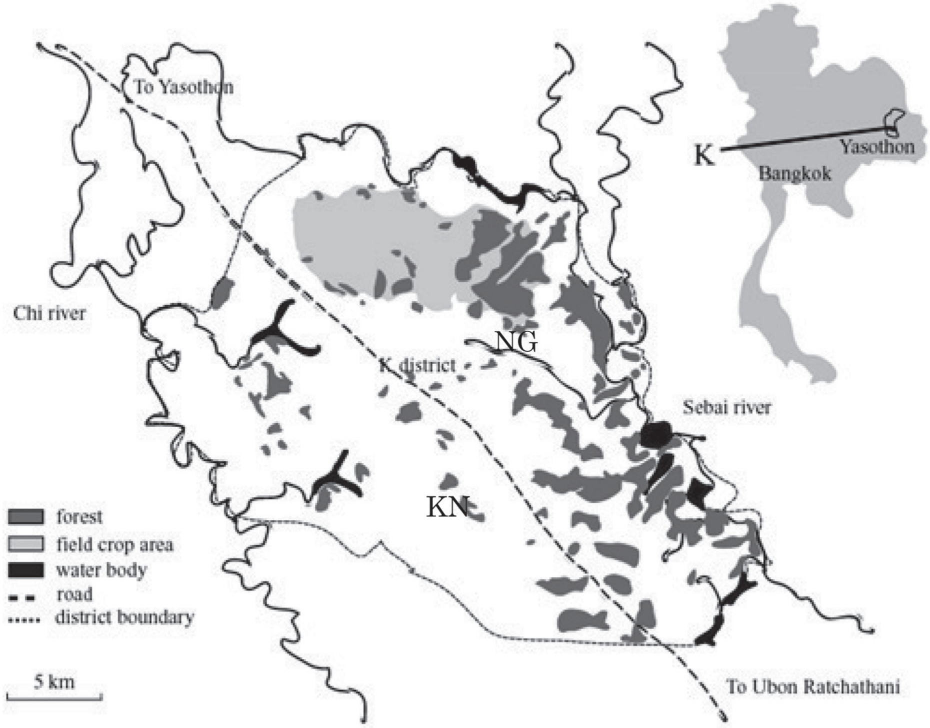

Figure 1 Study area
Source: ETM L andsat 2000.

Table 1 General statistics of the studied villages (2005)

	NG village (no.4 and 8)	KN village (no.1 and 2)
Total HH	256	329
Population	1,086	1,635
Paddy fields (rai)	3,166	5,335
Field crop area (rai)	77	65
Cultivated land/HH(rai)	12.7	16.4
Communal land (rai)	570	310
Communal land/HH (rai)	2.3	0.9
Number of cars	25	43

Sources: Documents from District Office, District Agricultural Office and my field surveys
Note: HH means household(s). One rai = 0.16 ha.

Table 2 Basic data on sample households

	NG village (10 HH)			**KN village (10HH)**		
HH economic status	High	Middle	Low	High	Middle	Low
	(4HH)	(3HH)	(3HH)	(3HH)	(5HH)	(2HH)
HH members	5.8	4.0	4.3	5.3	4.8	3.0
Agricultural Labors	2.8	2.7	3.0	2.0	2.0	1.5
Non-agricultural Labors	1.3	0.7	1.0	2.0	1.4	0.5
Land owned (rai)	20.0	31.7	6.0	30.7	17.8	8.5
Number of Cattle	0.0	1.7	0.0	0.7	1.4	1.5
Number of Buffaloes	0.0	1.7	1.3	0.0	0.0	0.0
Number of Cars	0.8	0.0	0.0	2.5	0.0	0.0
Number of Motorcycles	2.0	1.3	0.3	2.0	1.0	0.0

Sources: field surveys.

RESULTS AND DISCUSSIONS

Status of Resource Use Frequency

Table 3 indicates the summary of resource use frequency during the survey periods. In two villages, compositions of resource categories are similar, but the total frequency (and frequency/HH/day) is larger in KN village. It is interesting that even in wood and NTFP the frequencies are larger in forest-scarce KN village. Moreover, it is likely that KN villagers' resource use is more diversified than that of NG villagers (Table 4).

Table 3 Summary of resource use frequency

Fish	Fuel wood	NTFP and others	Total	Frequency/day/HH	
NG village	53 (49)	16 (15)	39 (36)	108 (100)	0.34
KN village	103 (53)	15 (8)	76 (39)	194 (100)	0.61
Total	156 (52)	31 (10)	115 (38)	302 (100)	0.47

Sources: field surveys.

Note: the percent share of the total frequency in parenthesis.

Table 4 Some major natural resources used in the villages during the surveys

Category	Sub-category	NG village	KN village
Fish	Fish	*pla mor, pla chon, pla khao, pla thaphiang*	*pla duk, pla chon, pla mor, pla khao, pla salit, pla nang, pla tong, pla khayeng, pla siam*
	Others	*kop, kiat*	*kop, pu*
Fuelwood		Not specified	Not specified
NTFP and others	Mushrooms	*het din, het than, het puak,*	*het puak, het nomai, het than, het takrai, het phung, het ko,*
	Insects	*chinglit, meng khinun, takaten, meng khison, meng kheng*	*meng khinun, khai mot daeng, meng khison*
	Plants	*khilek*	*mai phai, nomai, tiu, yanang, huaman, dok kae, kok, top chawa*
	Others	resin	

Sources: field surveys

Note: listed in local name.

Table 5 Spatial compositions of resource use firequency

Main resource domain	Private		Communal			Outside	Total
Village	Paddy field	Other private land	Stream	Pond, reservoir	Communal land	Outside village area	
NG	41 (39)	15 (15)	14 (14)	6 (6)	26 (25)	2 (1)	104 (100)
KN	124 (66)	17 (9)	0 (0)	0 (0)	21 (11)	25 (13)	187 (100)
Total	165 (57)	32 (11)	14 (5)	6 (2)	47 (16)	27 (9)	291 (100)

Sources: field surveys

Note: the percent share of the total frequency in parenthesis. In several cases the author could not identify the actual spatial composition of resource use, which caused the inconsistency in terms of the total frequency with Table 3

This suggests an important theoretical implication: resource endowments do not necessarily reflect villagers' resource use, though they are still strong in creating the differences in terms of spatial composition (see Table 5 and discussion below). Something should be mediated between resources and natural economy (or utilization of resources). In other words, some resources are "activated" by the households and then integrated into the villagers – resources network. In the existing literature, property right is a theoretical concept to play this role (Demsetz, 1967). Here in Yasothon, however, property right alone is not an important factor because both villagers are granted similar rights (including de facto ones)[4]. Another related theoretical concept is the notion of access which is defined as "the ability to derive benefit from things" (Ribot and Peluso, 2003: 153) or a concept of resource/environmental entitlements (Leach *et al.,* 1999). According to these concepts,

[4] The rights of resource use here are multi-layered ones. Villagers are generally allowed to exploit resources in their communal land (thi satharana) in their community (village/villages) as well as in their own private property. In most cases they set up community rules in using communal resources. In communal domain, outsiders are generally excluded but they are allowed to take some resource flows such as NTFPs. In addition, a part of private land, such as paddy field, becomes open field during the off-farm season.

power relationship among various actors greatly affects the patterns of resource use. When we recognize this definition, resource activation can be deeply associated with villagers' resource access. So what factors actually affect resource access, and hence the activation of resources? The further examinations on variations of resource use frequency highlight some of these factors.

Seasonal, Spatial and Household Variations in Resource Use Frequency

Seasonal variations in terms of resource use frequencies are shown in Figure 2. These are, of course, fluctuated according to the seasonal availabilities. The variations between the villages indicate both the differences of resource taking and that of resource processing activities. For instance, taking resin and grasshoppers (takaten) were only observed in NG village, while taking *kok* grass (Cyperaceae) for mat making was only seen in KN village (Table 4). In addition, some inter-household transactions were identified in KN village, though the resource use in both villages were basically for subsistence needs.

Table 5 indicates spatial compositions of resource use. Here the author can point out three important results. First, paddy fields and private domain are the most important sources in both villages, though the share is larger in paddy-rich KN village. This is not to say, however, that the communal area is unimportant. The second point is that resources from communal area are also of considerable importance. Reflecting the resource endowment, larger share of communal resources can be

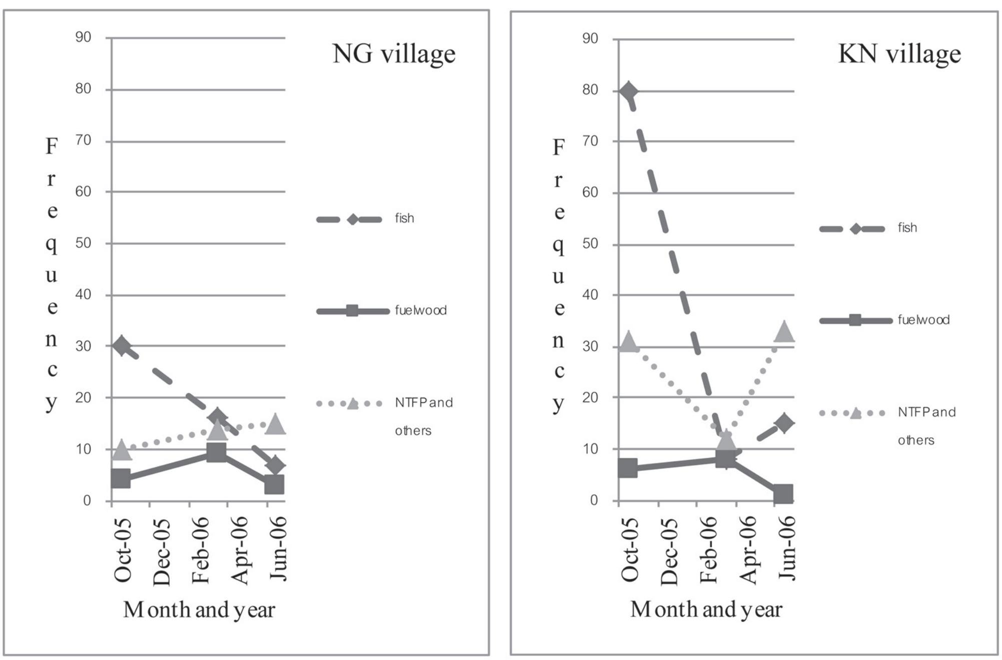

Figure 2 Seasonal variations of resource use frequency
Source: field surveys

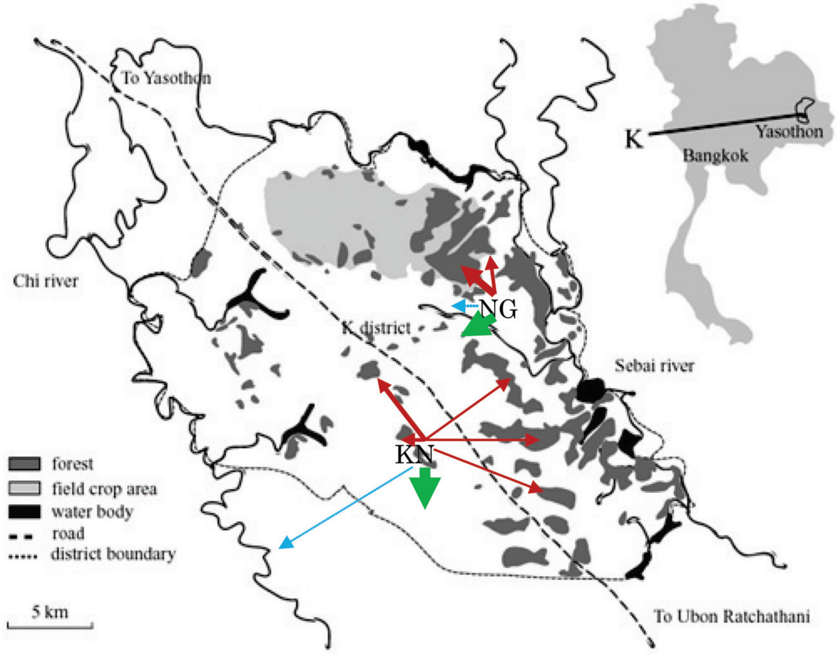

Figure 3 Spatial patterns of villagers - resources network

Sources: ETM Landsat 2000 abd field surveys.

Note: thickness and color of the arrows indicate frequency and place of resource respectively.

observed in NG village. In addition to the share shown in the table, it is also significant to note that the villagers sometimes rely on specific type of resources from the communal domain, such as certain type of mushrooms, resin and fish. Third, KN villager relies more on the resources outside the village. This is typically seen in case of taking mushrooms and certain type of fish. In other words, KN villagers have wider ranges of villagers – resources network than NG villagers (Figure 3).

In terms of variations among households, the author could not identify the clear and statistically significant patterns of resource use frequency except some village-specific trends, for instance, larger frequencies of taking fuelwood among the households with low economic status in NG village (Figure 4)[5]. Another interesting village-specific trend is that the households with middle economic status in KN village seem to take NTFPs more frequently than that of high and low economic status.

[5] The results are statistically tested both parametrically and nonparametrically.

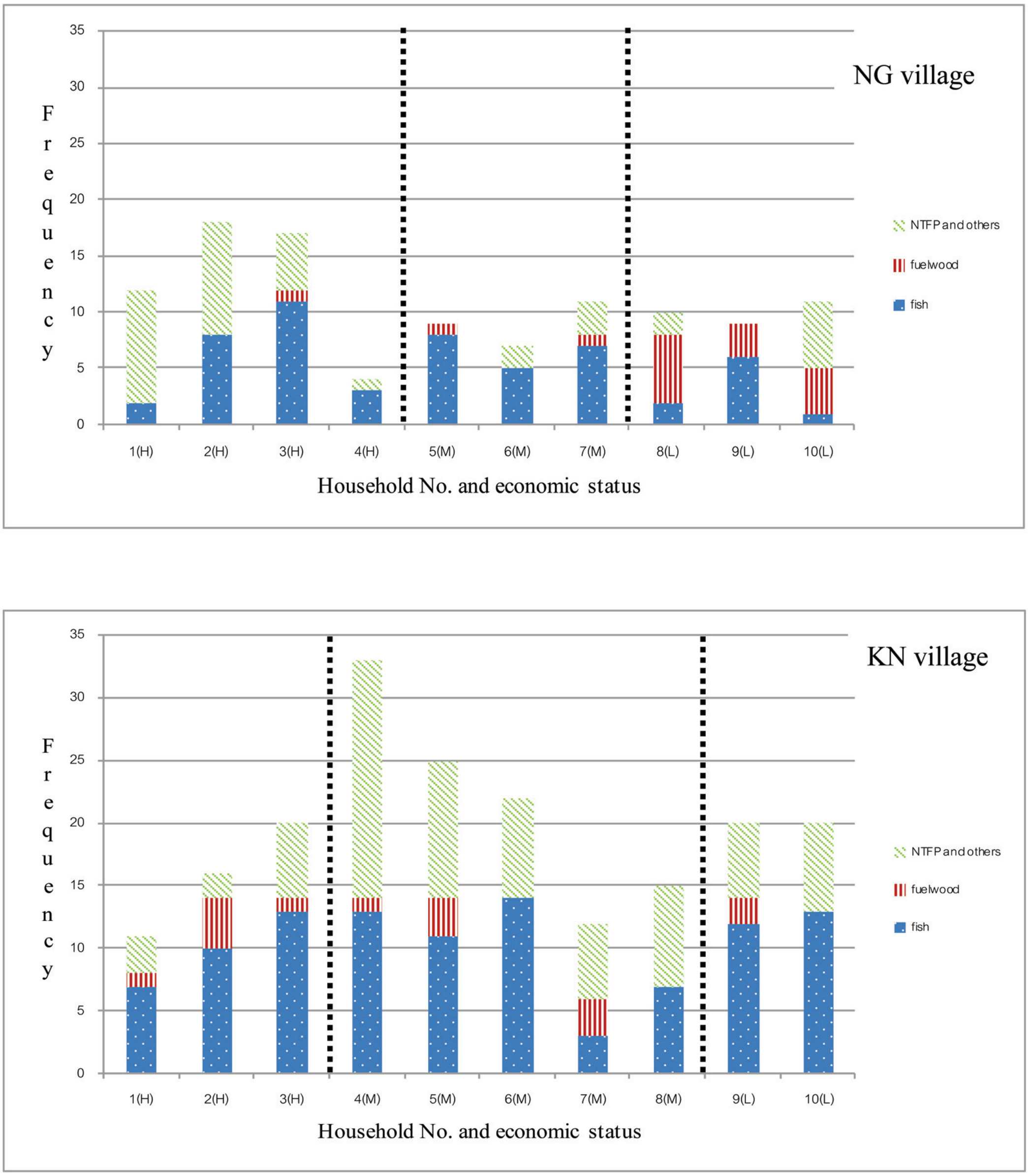

Figure 4 Household variations of resource use frequency

Sources: field surveys

Note: H, M and L in household No. meam high, medium and low economic status, respectively.

This trend, however, was statistically insignificant. After all, it was hard to say the resource use frequency is associated with the household economic status or power status. In other words, resource use was highly individualized in household level. Though the number of the sample is small, this is rather contrary results against the well-known fact that the poor tend to rely more on natural resources. It may even suggests that the better off can exploit more resources than the poor, if we can neglect the differences of the amount of resource taking per each occasion.

This does not deny the view of "resource activation (hence network activation)" thesis, for the household access to resources can still be considered as a direct factor that enables resource activation. In the study area, however, it is more appropriate to say that the access is important not because of social and economic power but because of the villagers' personal preferences and skills toward natural resources which are not directly associated with these power. Here the villagers do not regard natural economy as a source of economic power, as the rural economy here has been already commercialized. Of course, commercialization of some natural resources may lead to link economic power and resources. The market may stimulate the exploitation and processing of some natural products, while it may discourage the exploitations of the others because of resource substitutions. In the study area, mushrooms are one important natural commodity. However, the village survey could not find remarkable significance of this commodity during the survey period[6].

On the other hand, the villagers neither regard it as a symbol of sociocultural power nor a symbol of inferiority. Rather, it seems that natural economy here still meets minor but important subsistence needs for villagers. For example, one neighboring villager explained that he will not starve to death with plenty of natural resources in his village life (Ubukata, 2008). Moreover, it is likely to say that village culture (local customs associated with the resource use) may bare the notable differences in resource activation by creating household differences in preferences and skills, and vice versa. For instance, the use of *kok* grass in KN village is closely associated with the existence of non-commercial local handicraft.

Here the two-way analysis is possible when we examine the indirect factors activating the network. As stated above, from villagers' side personal preferences and skills, or village culture (local customs associated with the resource use) seem to be very important in this sense. Then, from resource side, what factors made villagers being "effective activators"? Two characteristics of resources seem to be significant. One is that resources here are largely accessible to villagers, and their existence, usages,

[6] Some mushrooms, such as het puak in local dialect, are highly valued and traded. But most villagers regard them as an occasional (especially at the beginning of rainy season) source of income.

and values are well recognized. Another is that there are relatively few options to replace the use of certain resources or resource taking activities. Market goods have not been able to fully substitute these natural products, although some of these products have become less important in villagers' daily life than in the past. In addition, activities to take particular resources themselves may also have some cultural meanings (for instance, socializing among villagers, maintaining skills etc.), which are not replaceable with the simple purchase of the commodity.

Some Recent Trends of Resource Use

Apart from the quantitative analysis, the author would like to point out several important trends of resource use found during the survey, though some of them are still in the process of examination. All of them are associated with the recent social change in the villages. First, villagers have formed local rules in resource use. In many cases this has happened in communal domain (Ubukata, 2008). Both the villagers and government agencies play important roles in rule formations.

Second, as a result of aged society and depopulation, most resource takers in the villages are older persons. Younger generation may not have interests in this activity and thus are losing capabilities and village culture that affect resource activation. Third, market penetrations may result in two opposite directions. On the one hand it may activate certain kind of resources (i.e. certain kind of mushrooms) through the high market valuation. On the other, it may shrink natural economy at large by replacing it with market economy. These changes may also affect the spatial pattern of villagers – resources network. In Tambon KJ (the sub-district where NG village is located), for example, a good market for mushrooms expanded outsiders' network into the Tambon territory. This had caused resource conflict between Tambon villagers and the outsiders, and finally led to the introduction of new Tambon rules on resource management in 2005 (*ibid.*).

For conservationists, these overall trends may sound blessing. But are they really socially and ecologically "desirable" in the longer term? In Japan, for instance, it has been regarded that the problems in terms of rural resource management are not the problems of resource overuse but the ones of resource underuse (Takeuchi, *et al.* 2001). In addition, there is also a danger of resource depletion for a few marketable products. If the trend is true, is it likely that the Thai society will shift the resource problems from overuse to underuse in the future? What happens to the natural resources and societies during the transitional phases? Further examinations on the changing process of villagers-resources network can highlight these issues.

CONCLUSIONS

By examining the patterns of villagers' resource use in Yasothon, this study tried to explore the "villagers – resources network". Here the variations and status of the network were, though it is partly, qualified and quantified. Among them, perhaps the most important finding is that resource endowment is not the sole factor affecting the extent of resource use. This implies the importance of the concept of "resource activation” or resource access mediated by the villagers’ preferences and skills. By this concept, we can identify the factors affecting both sustainable and unsustainable resource use by focusing on villager’s life, resource characteristics, and their spatial relationships. It also enables to comprehensively consider the possible potential options within the existing network when certain natural or social changes happen.

Of course the network itself changes in the longer term. Through data analysis and theoretical considerations, this paper also identified some of the important factors that affect resource activation and hence the change of the network. According to this, the author also considered how the recent social changes have affected the process.

The work has not finished yet. It is obvious that still many things have to be done in understanding the complex relationship of resources and society. For instance, how can we understand the composite effects among multiple resources use? Further research both from natural and social sciences may gradually open the door.

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A Review of Shrimp Based Farming Systems in Bangladesh with Reference to other South and Southeast Asian Countries

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ABSTRACT

A lot of research works have been done on the issue of shrimp farming including its environmental and socioeconomic aspects in worldwide and especially in Southeast Asia. But few attempts have been made to explain the remarkable variation in shrimp farming systems among the south and Southeast Asian countries including Bangladesh. This paper tries to compare the history of shrimp farming, its farming technical variation among the above countries, impact on mangrove forests and integration of shrimp with rice farming systems with Bangladesh and other Southeast Asian countries. It has been found that Bangladesh has a unique shrimp farming system consisting of rice cultivation in winter season and shrimp cultivation in monsoon season. This will give some ideas for future shrimp farming system research on Bangladesh.

Key words: Shrimp cultivation, Farming systems, Bangladesh, South and Southeast Asia

INTRODUCTION

Asia has been called the cradle of aquaculture where the culture of fish in freshwater probably began about 500 B.C. and in brackishwater ponds later in 1400 A.D. (Primavera, 1994). From Java in Indonesia, brackishwater culture spread to the Philippines and other Southeast Asian countries (Hora and Pillay, 1962). Traditional shrimp culture has been characterized by low-density stocking of wild fry (entering ponds during passive tidal water exchange or purchased from fry collectors) generally in Polyculture with fish. Weidner and Rosenberry (1998) cited that modern shrimp farming can be traced directly to Motosaku Fujinaga, a Japanese scientist who laid the groundwork for hatchery technology with his pioneering research on the spawning and larval rearing of Kuruma shrimp (*Penaeus japonicas*) in 1930s.

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Shrimp (*Penaeus monodon*) farming is growing in almost all regions of the globe and it has a long history also in Bangladesh. Between 2002 and 2008, global shrimp production has increased by 34 percent (FAO, 2008) as a result of industrial transformation and intensification of production patterns (Lebel et al. 2002). About 75% of the world production of farmed shrimp comes from Asian countries; the two leading nations being China and Thailand (Figure 1), closely followed by Vietnam, Indonesia, and India (FIGIS and FAO, 2007). In terms of world Market Occupation Ration (MOR) among the Asian major shrimp producers from 1990-2003, it has been found that Thailand had the largest market occupation ratio (21.9%) of the world shrimp market, followed by Indonesia, India, and China of 8.8%, 7.5% and 4.9% (Xinhua, 2008). The data has been shown in Table 1 Bangladesh also occupies a portion of world shrimp market (2.5%). Thailand exports nearly all of its production, while China uses most of its shrimp in the domestic market.

Table 1 Market Occupation Ration (in percent) of Asian major shrimp producing countries

Year	Bangladesh	China	India	Indonesia	Malaysia	Philippines	Thailand	Vietnam
1990	2.2	10.0	4.9	9.4	1.7	3.2	14.4	1.6
1991	1.9	6.9	6.3	9.9	1.9	3.7	17.9	2.3
1992	1.8	7.7	5.9	9.3	1.7	2.8	20.5	2.8
1993	2.2	4.9	7.3	10.0	1.5	2.8	23.2	3.3
1994	2.8	3.9	8.3	9.5	1.5	2.6	25.7	3.4
1995	2.8	3.4	6.8	8.9	1.5	2.1	26.6	2.9
1996	2.9	2.2	7.5	8.8	1.4	1.6	25.5	2.7
1997	2.4	2.7	7.9	8.6	1.6	1.3	24.7	3.9
1998	2.5	2.3	7.7	8.7	0.9	1.3	23.4	4.6
1999	2.5	2.5	8.3	8.0	0.9	1.5	24.3	5.1
2000	2.9	3.5	8.5	8.9	0.9	1.4	25.4	6.2
2001	3.2	4.4	7.8	8.6	1.1	1.2	21.5	7.5
2002	2.6	6.1	9.1	7.9	2.0	1.6	17.3	9.2
2003	2.7	8.1	8.2	7.2	1.1	1.2	15.8	9.7
Average	2.5	4.9	7.5	8.8	1.4	2.0	21.9	4.7

Source: Calculated through the data from FAO, Fish stat plus, 2004

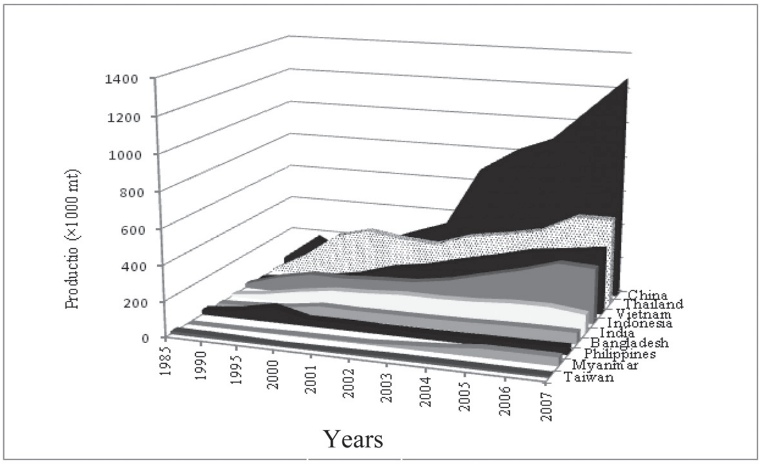

Figure 1 Production (thousand metric tons) of cultured shrimp in leading Asian countries
Source: FAO, 2007

There are several studies have been done on shrimp aquaculture in different Asian countries. Those studies have either treated shrimp farming as a whole, blurring distinction between and within countries, or else taken up its development in one country (Hall, 2004). While variation between or within countries has been noted, discussion has generally been limited to pointing out quantitative differences, such as variances in the rations of extensive to semi-intensive to intensive farming or in farm sizes. Different shrimp producing countries followed their different types of shrimp farming technique with some little variance among the countries. The shrimp based farming systems also varied from country to country.

In Bangladesh, the shrimp can be alternatively cultured with rice in the same field and in some area in Vietnam and India the same system could be found while in Thailand, Indonesia, China or Taiwan shrimp is mainly cultured as monoculture or sometimes with mangrove forest ecosystems. As yet, little effort has been made to explain this diversity (though see Stonich and Vandergeest, 2001; Lebel *et al.* 2002).

Thus, the present paper tries to give a review on following topics of shrimp cultivation in Bangladesh and other South and Southeast Asian countries; a) history of shrimp farming b) Shrimp cultivation system c) impact of shrimp cultivation on mangrove forest and d) the shrimp based farming systems. At the final remarks, future research approach has been discussed.

HISTORY OF SHRIMP FARMING

With minor differences in timing, a boom in export-oriented shrimp aquaculture swept across much of coastal Asia during the 1980s. The more or less simultaneous turn to the industry in so many countries has led observers to focus on general rather than country-specific factors in explaining the boom. The introduction of technological innovations, a rapid drop in the price of hatchery fry, the increasing scarcity of wild-caught shrimp brought on by over fishing, rising international prices and the support of national governments and international donor institutions have all, rightly, been seen as helping to bring about the shrimp farming boom (Chua and Tech,1990; Stonich *et al.* 1997). However, there were important differences in the genesis of shrimp farming both within and across countries. In particular, the industry emerged in the Philippines earlier and with less state support than in Indonesia and Thailand, where it was promoted more aggressively as a source of foreign exchange and economic diversification. However, in this section I would like to briefly describe about the history of shrimp farming and its emergence in Bangladesh with some other Southeast Asian countries.

In Bangladesh, the traditional *bheri/gher* (*bheri/gher* is the modified rice field having high dikes to keep water inside to cultivate shrimp/prawn) aquaculture had been practiced in the coastal areas of Bangladesh to grow shrimp and fish long before the introduction of current shrimp culture practices (DDP, 1985). In the early 1960s, the government constructed a large number of coastal embankments to protect agricultural land in the coastal areas from tidal waves and saline water intrusion. This process brought an end to traditional shrimp aquaculture in these areas. However, since the 1970s, strong international market demand and high prices for product have encouraged farmers to resume shrimp farming in polders within the embanked areas. Equally important was the fact that it was no longer financially viable to cultivate rice because the polders had become water logged due to poor drainage. These two factors together provided a catalyst to the process of accelerated shrimp farming (Karim 1986). The government of Bangladesh recognized shrimp farming as an industry under the Second Five-Year Plan (1980-85) and adopted measures necessary for increased shrimp production (Haque 1994). In 1979-80, slightly more than 20,000 ha were under shrimp cultivation (Ahmad, 1988). According to an estimate by the Master Plan Organization (MPO, 1986), the total area under shrimp culture was expected to rise from 96,048 ha in 1990 to 135,000 ha in 2005. But as of 1995, there were already about 140,000 ha of shrimp farms (Wahab, 2003), exceeding the projection for 2005. However, the recent statistics shows that the total area for shrimp cultivation is about 240,000 ha across the country in the shrimp cultivation area (DoF, 2010).

For Philippines, The culture of penaeid shrimps in brackish water ponds is probably as old as the culture of milkfish since they always occur together especially when the fish farmers were still merely dependent on the entry of wild fry. Normally it will be a mixed harvest milkfish, tiger prawn (*Penaeus monodon*), the white shrimps P. *indicus* and P. *merguiensis* and perhaps the greasy-back shrimp, *Metapenaeus ensis*. But because only a relatively small quantity can be harvested with the milkfish, it was always considered only a secondary species. It was only in 1951 when the culture of P. *monodon* as a primary species was first advocated by Villadolid and Villaluz (1951). Rabanal

(1955), made the first documentation on their growth and their culture in brackish water ponds. Even after that, P. *monodon* remained in its position as a secondary species to be stocked with milkfish. The industry just could not develop fully with the meager supply of wild-caught fry. Its full commercialization has to wait for the development of hatchery technology. This was not to happen until the mid 1970s after the successful reproduction of P. *monodon* in captivity (Villaluz, 1972). However it was during the 1980s that the industry really took off. Fueled by a booming Japanese market, large business concerns, many with no prior exposure to aquaculture, ventured into hatchery and grow-out operation.

The story of the introduction of modern shrimp aquaculture to Thailand is better known. State support for shrimp farming in Thailand began in 1973 with the promotion of hatcheries. Semi- intensive shrimp farming expanded rapidly in the late 1970s and early 1980s, in part because of promotion by the Asian Development Bank (ADB) from 1981 (Kikuchi 1993). Government assistance increased in the late 1980s, while most of the intensive technological package was introduced by CP (Charoen Pokphand) in a joint venture with Mitsubishi from 1986 (Goss *et al.* 2000). The initial boom in intensive farming took place in the inner Gulf of Thailand around Bangkok. While the details of farm ownership and integration into corporate networks are unclear (Goss *et al.* 2001; Vandergeest *et al.* 1999), participants included a mix of urban elites and rural farmers and fishers. Kongkeo and Davy (2010) mentioned that the outbreak of Yellow-head virus disease in Thailand starting in 1990 did not lower overall production due to good management practices and efficient small scale operations. White spot disease outbreak slightly affected the production during 1994–1997, before launching again in 1998, because the technologies on intensive closed system and on-screening of brood stock and PLs by PCR test were well adapted by farmers. These technologies were simplified and locally adapted to suit local conditions and farmer capabilities. However, the present production was maximum in 2000-2001 of about 300000 tons and declined to about 200000 tons in the year 2003-2004 (Kongkeo and Davy, 2010)

Indonesians farmed shrimp for centuries, using traditional low-density methods. Indonesian brackish water ponds, called *tambaks*, can be traced back as far as the 15th century. They used small scale ponds for monoculture or polycultured with other species, such as milkfish, or in rotation with rice, using the rice paddies for shrimp cultures during the dry season, when no rice could be grown (Ronnback, 2001). Such cultures were often practiced in coastal areas or on river banks. However, State promotion began in the early 1980s in the context of a ban on trawler fishing for prawns and the decline in oil prices. The government looked to aquaculture as a way of halting the slide of export earnings from shrimp and reorienting the economy away from the oil sector. Programmes were launched with the aim of intensifying production in the large areas of existing, traditional fishponds, or tambak, and extending production to new areas of the country. One programme, funded by the World Bank and ADB, sought to establish 100,000 ha of new ponds outside Java by 1989 (Suzuki, 1997). The government also established credit programmes and a Research Institute for Coastal Aquaculture within the Ministry of Agriculture. While Muluk and Bailey (1996) are surely right in attributing the rise of Indonesian shrimp aquaculture primarily to the private sector, government policies were key preconditions. The Indonesian boom of the 1980s was centered in North and East Java (and, to a lesser extent, Sumatra and Sulawesi), and this location had important implications for the development of Indonesian shrimp farming. Java differed from both Thailand and Negros (but not from central Luzon; see Dannhauser 1986) in already having extensive areas of tambak, the histories of which stretched back centuries in some cases. At present, the intensive form of shrimp farming is concentrated in the large shrimp farms on the south coast of Sumatra island. There are three major activities in that region. Charone Poppand owns major shrimp operations there and also in Aceh.

Shrimp cultivation has been started over 100 years in Vietnam, but modern shrimp culture has just been started in 1987. In 1970s, shrimp culture was still mostly extensive with low production and attributed by natural seed and without feeding. However, the popularity of shrimp farming in Vietnam was catalyzed by the impact the Doi Moi reforms in 1980s had on the fisheries sector together with successfully breeding of P. monodon brought the opening of a new era of shrimp culture in Vietnam (MoF, 2004). Since Doi Moi, fisheries exports have increased and national aquaculture development programs have spurred the growth of aquaculture. Export targets of 2 million tons by 2010 have been set. In 1990, aquaculture export levels were 310 000 tons and by 2002 it was 976 000 tones (MoF, 2004). Shrimps fetch a higher selling price compared to other agricultural crops commonly grown in Vietnam. For example in 2002, frozen shrimps fetched US$5940 per ton (FAO, 2004a) whereas rice fetched US$188 per ton (FAO, 2004b). The lack of alternative livelihoods in the rural regions, together with the abundance of cheap unused land, free water, cheap labor and favorable climate were the ideal conditions for shrimp farming to expand. Shrimp farms are now found in mangrove, coastal and inland areas.

In India, commercial shrimp farming started gaining roots only during the mid-eighties. It was a relatively late start in India; by this time, shrimp farming had reached peak in most of the neighboring Asian countries, especially China and Taiwan; in some the disease and poor farm management practices had already taken a heavy toll (Yadava, 2002). India was one of the world's larger shrimp exporters with an estimated annual production, in 1987/88, of 245,000 tons. Approximately 215,000 tons of this was sea-caught shrimp, the remaining 30,000 t coming from brackish water culture in West Bengal, Andhra Pradesh, Kerala and Goa (Chong Kee-Chai 1991). Shrimp yields from pond culture in India are, however, low, averaging 500 kg/ha/year, although this is comparable with yields from extensive culture in other countries such as Indonesia or the Philippines. The boom period of commercial-scale shrimp culture in India started in 1990 and the bust came in

1995-96, with the outbreak of viral disease. The fact that most of the coastal States in India were new to commercial-scale shrimp farming, the general ignorance of good farming practices, and the lack of suitable extension services, led to a host of problems (Yadava, 2002).

SHRIMP CULTIVATION SYSTEMS

Farming technique

Shrimp aquaculture has expanded from the south-eastern to the south-western parts of the coastal areas of Bangladesh. Initially, the pond area under shrimp aquaculture comprised 20,000 ha in 1980, growing rapidly to approximately 240,000 ha in 2009 (DoF, 2010). This expansion of shrimp aquaculture in the country is ascribed to its suitable climatic conditions and the availability of resources such as feed, seed, water and a cheap labour force (Islam, 2003). The swift increase after the 1980s is mainly due to the high profits obtained, high demand for shrimps on the international markets, employment generation, and earning of foreign currency (Deb, 1998). The private sector initiatives include the involvement of multinational corporations, which attracted both national governmental and international development agencies to expand shrimp aquaculture in the country (Deb, 1998). This same notion has been articulated by scholars of several Asian countries (Bailey, 1988; Bailey and Skladany, 1991; Stonich and Bailey, 2000). In the 1970s, shrimp aquaculture in Bangladesh was started in *ghers*, (Islam *et al.,* 2005). Generally, a *gher* is used to grow rice between the months of August and December/January, and shrimp culture is practiced during the months of February to July/August (Deb, 1998; Ahmed, 2003; Islam *et al.,* 2005). Tidal water exchange is important in the *gher* system for trapping wild seeds and natural food as well as for maintaining water quality (Islam *et al.,* 2005; Ahmed et al., 2008). However, this system has evolved over time and today, Bangladeshi shrimp aquaculture is classified into four categories: traditional, extensive, semi-intensive and intensive (Table 2) (Deb, 1998; Islam *et al.,* 2005); vary from country to country (Primavera, 1993, 1998; Dierberg and Kiattisimkul, 1996; Rönnbäck, 2002).

The Bangladeshi classification is fully based on the intensity of the culture pattern such as stocking density, inputs (feed and fertilizer) and water quality management (Table 2). The stocking rate is low and any kind of sophisticated management is almost absent in traditional culture practices (Islam *et al.,* 2005). Therefore, smaller size ghers and improved management practices are encouraged to obtain sustainable production and profits (Wahab, 2003). In Bangladesh, 70% of the shrimp farms use traditional and/or extensive, 25% semi-intensive, and 5% intensive culture techniques (Hussain, 1994).

Though these four types of shrimp cultivation system have been seen among the shrimp cultivation countries of south and Southeast Asia, all these system are not simultaneously practiced. In Thailand about 80 percent of the farmers have developed an intensive operation while the rest are mainly semi-intensive (Somsak and Ayut, 2000), whereas in Philippines, extensive and semi-intensive farms produce most of the shrimp

Table 2 Four different types of shrimp aquaculture practices.

Criteria	Intensity of farming systems			
	Traditional	Extensive	Semi-intensive	Intensive
1) Pond (gher)size (ha)	5-10 or >	5-10 or >	1-10	< 1
2) Stocking	Natural	Natural + artificial	Artificial	Artificial
3) Stocking density (seed/m2)	1-1.5	2-10	20-40	40-60
4) Seed source	Wild	Wild	Wild + hatchery	hatchery
5) Survival rate (%)	50-60	60-80	70-80	70-90
6) Feed used	Natural	Natural, little low cost feed	Natural and pelleted feed	Formulated complete feed
7) Water exchange	Tidal	Tidal, minimal pumping	Tidal, pumping	Pumping, reservoir, filter
8) Aeration	No	Little or no	Yes	Yes
9) Yield (t/ha/yr)	0.1-0.5	0.6-1.5	2-6	7-15
10) Production cost (US $/kg)	No data	1-3	2-6	4-8
11) No. of crops/year	1-2	1-2	2-3	2-3
12) Diversity of species	Polyculture	Polyculture	Monoculture	Monoculture
13) Lime used (kg/ha/yr)	Little or no	< 100	250-400	500þ
14) Fertilizers used (kg/ha/yr)	Little or no	Cowdung-500, little or no urea/TSP	Cowdung-2000þ, Urea-300+, TSP-100+	Cowdung-4000+, Urea-500+TSP-200+
15) Chemicals used	No	No or little	Used	Widely used
16) Employment (Persons/ha)	No data	< 7	1-3	1
17) Disease problems	Rare	Rare	Moderate to frequent	Moderate
18) Operational costs	Little or no	Low	Moderate to high	Extremely high
19) Development costs	Little or no	Low	Moderate to high	Extremely high
20) Environmental impact	Little or no	Relatively little	Moderate to high	Relatively little
21) Social implications	Little or no	Relatively little	Moderate to high	Extremely high
22) Economic proliferation	Subsistence	Subsistence	Commercial	Entrepreneurial
23) Sustainability concerns	High	Moderate to high	Moderate to low	Relatively low

Source: Primavera (1998), Dierberg and Kiattisimkul (1996), Deb (1998), Rönnbäck (2002), Islam *et al*. (2005).

(Weidner and Rosenberry, 1992). Approximately 90% of production come from extensive farms in Vietnam with a few from recently developed super-intensive farms (Khang, 2008). Four major types of shrimp farms are used in India, ranging from traditional to intensive systems. Traditional shrimp aquaculture on a significant scale has only been practiced in the states of West Bengal and Kerala (Alagarswarmi, 1995). Most of the shrimp farms present in the other states in 1990 were extensive and semi-intensive farms developed in the 1980s.

Farmed species

Although there are many species of shrimp only few of the larger ones are actually cultivated, all of which belong to the family of penaeids (Rosenberry, 2004a) and within it to the genus Penaeus (Rosenberry, 2004b). Many species are unsuitable for farming as they are too small to be profitable. However, among the leading cultured penaeids species the *Penaeus monodon* (Black Tiger Shrimp) is account for about 80% of the Asian shrimp production (Josueit, 2004). There are some other species of shrimp which are being cultivated are Chinese white shrimp (P. *chinensis*) which occurs along the coast of china and the western coast of Korea and is being farmed in China. The Indian white shrimp (P. *indicus*) is a native of the coasts of the Indian Ocean and is widely bred in India. In Indonesia, Banana shrimp (P. *merguiensis*) is also cultivated in some area. However, *Penaeus vannamei* was introduced into Asia in the 1990s (Briggs *et al.* 2004). In the 2000s, commercial production of *Penaeus vannamei* overtook the production of P. *monodon* in China, Taiwan and Thailand due to a number of favorable factors. Thailand freely permits the commercial culture of P. vannamei, but has official restrictions due to fears over importation of exotic diseases and thus only SPF (Specific Pathogen Free) broodstock may be imported.

IMPACT OF SHRIMP FARMING ON MANGROVE FOREST

The transformation of the naturally multifunctional mangrove ecosystem into privately-owned, single-purpose shrimp aquaculture systems is destroying the ecology of the coastal zone (Folke and Kautsky, 1992). Destruction of mangroves due to shrimp aquaculture has been reported by several scholars in different parts of the world (Dierberg and Kiattisimkul, 1996; Hein, 2002). The enormous growth of shrimp production from 1,600 tons in 1950 to close to 4.5 million tons in 2006 at a value of just under US$ 18 billion (FAO, 2009) has been achieved with a concurrent reduction in mangrove area in some countries of between 50-80%, leading to considerable loss of biodiversity and coastal ecosystem function (Valiela *et al.* 2001; Alongi, 2002; Manson *et al.* 2005).

In Bangladesh, mangrove wetlands are still being converted to ponds/gher for shrimp aquaculture (Chowdhury *et al.,* 2006). The exact rate of mangrove destruction due to the construction of ponds in the south-western parts of Bangladesh is not yet known. Nevertheless, in the south-eastern parts of Bangladesh an area of 18,200 ha of mangrove (*Chokoria Sundarbans*) has almost completely been destroyed to make place for shrimp

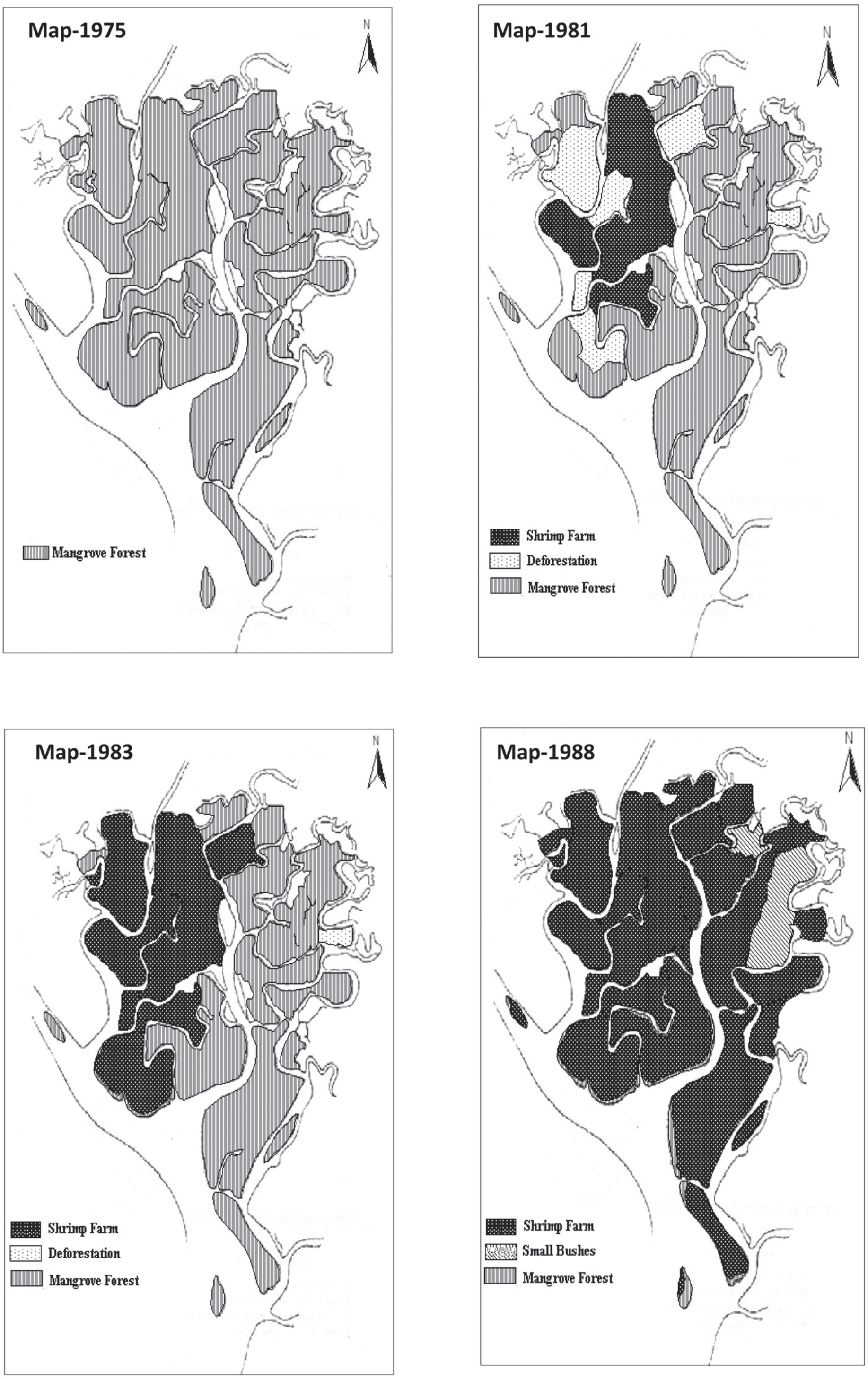

Figure 2 The map showing the Chronological changes of Chakaria Sunderban ($21^0 38'$ and $21^0 50'$N and $91^0 56'$ and $92^0 08'$ E) to Shrimp Farming from the year 1975 to 1988

aquaculture (Akhtaruzzaman, 2000). A chronological change of Chokoria mangrove forest to shrimp farm has been shown in the figure 2. The government-led development projects for shrimp aquaculture, patronized by the Asian Development Bank (ADB) and the World Bank, might have caused massive destruction of the forests (Deb, 1998). However, shrimp aquaculture is not the only reason for mangrove degradation; other land uses such as rice production and salt production have also played a substantial role in the destruction of mangrove forests in Bangladesh (Deb, 1998).
In India, part of the shrimp pond construction took place in mangroves, and shrimp aquaculture has been an important cause of the conversion of mangroves in the last decade (Krishnamoorthy, 1995; James, 1999). A recent survey by the aquaculture sector found that about 5 percent of the shrimp aquaculture farms in India have been constructed in former mangrove areas (ADB/NACA, 1998). Mangrove conversation has been undertaken by both small-scale extensive farms and by larger-scale semi-intensive and intensive farms (Vivekananda *et al.* 1997).

In the Philippines approximately half of the mangrove loss of 279,000 ha from 1951 to 1988 resulted from the development of shrimp culture pond (Primevera, 1995). Min Hai province, with the largest mangrove area in Vietnam, has lost forests at an average of 5000 ha/yr (Trinth, 1993). Over the period of 1961-96, mangrove loss was approximately 86,628 ha (83.9% of the total area) along the Gulf of Thailand and about 98,496 ha (42.5% of the total area) along the Andaman sea (Aksornkoae and Tokrisna, 2004). According to the 1996 survey, mangrove conversion on the Eastern Peninsula was largely due to shrimp ponds (55%) followed by other land uses (42.5%) and resettlement (2.5%) (Charuppat and Charuppat, 1997).

SHRIMP BASED FARMING SYSTEMS

Shrimp based rice farming systems

The pattern of shrimp culture in the south-western coastal region of Bangladesh is often in rotation with agriculture and reflects the ambient seasonal salinity fluctuation in response to monsoon (Farmer, 1989). From time immemorial, tidal waters carrying post-larvae of shrimps and fin-fishes were trapped in the *'gher'* which were allowed to grow for a period of about 6 months. The same land was used for paddy culture after repeated flushing at the onset of monsoon. In the early 1970s, coastal shrimp farming took a new turn and began to expand in the mangrove and polder areas with dramatic expansion in the 1990s (Deb, 1998). However, in the southwestern coastal areas (i.e. greater Khulna region), the cropping pattern for brackish-water shrimp culture is dry months (December-July), followed by transplanted Aman rice (rainy season rice) during July through to December. In some areas, shrimp farming is characterized by monoculture. In the south-eastern coastal areas (i.e. Cox's Bazaar region), shrimps are grown from May to November and for the rest of the year, the land is used for salt production. In some parts of the south-eastern tidal area, rice alternates with shrimp and fish production (ESCAP, 1988). In the south-western part of Bangladesh, Ali (2006) found that over the last 5-6 years, growing household population demand for rice and world market demand for shrimp production have induced farmers to cultivate both rice and shrimp following one or more of the three common rice-shrimp rotation systems. He found that in type I (one-cycle shrimp) system, the land is inter-cultured in July with rain-fed HYV (High Yielding Variety) Aman rice and fresh water fish viz. Nilotica, Tilapia, Silver Carp, and Prawn (Macrobrachium resnbergii) those are harvested in November; after that shrimp and saline water fish are produced during December until June. In type II (cone-cycle shrimp) system, rice field are transformed into shrimp ponds in June and shrimp and saline water fish are produced till November; the land is dried out in December and cultivated to irrigated HYV Boro rice (dry season rice) to be harvested in May. In type III (two-cycle shrimp) system, rice fields are transformed into shrimp ponds to produce shrimp and saline water fish year-round (December-October) leaving no room for rice cultivation. However, the type II (one cycle shrimp) system also has been documented by Rahman and Ando (2010) in the south-western part of Bangladesh.

Various combinations of coastal rice with shrimps and fishes have been reported from Vietnam with the corresponding farming schedules. The Mekong Delta has about 2,000,000 hectares of rice fields, 41% of the total rice field area in the country. The freshwater prawn *Macrobrachium rosenbergii* and other shrimps and fishes are produced in rice field aquaculture systems, rivers, canals, and brackishwater areas in the Mekong Delta (Mai et al. 1992, Lin and Lee 1992). Three types of shrimp based farming systems dominate in the Mekong Delta (Mai et al. 1992). One is year-round rice with freshwater prawn or fish, e.g., in Thanh Loc in Thot Not District and Cai Con and Mang Ca in Phung Hiep District. Another is year-round rice with brackishwater shrimp or fish, e.g., in Giong Co in My Xuyen District. A third system is rice rotated about every six months with shrimp or fish, e.g., in Long Thoi Commune, Nha Be and Duyen Hai Districts. In the third system, rice is grown during the wet season when freshwater is available and shrimp or fish is cultured when the rice fields turn brackishwater (Le 1992). When salinity remains lower than 10 ppt in the dry season, farmers can raise a second crop of *Macrobrachium* without rice. Where salinity is 10 ppt or higher, marine shrimps (*Penaeidae*) migrate into tidal flats at spring tides. Farmers use fallow rice fields to trap and grow shrimps. Data collected from 55 rice-prawn farms in Duyen Hai District indicated that 55% had yields of 100-300 kg/ha-crop and 23% had yields of more than 300 kg/ha-crop (Le 1992). Farmers with prawn yields lower than 100 kg/ha had net benefits less than US$400/ha-crop. Yields of more than 300 kg/ha netted higher than $l,000/ha-crop (Le 1992).

There is also evidence in India about the cultivation of shrimp with rice in the same field. Ghosh (1992) reported on integrated culture of coastal rice with marine shrimps and fish in West Bengal, Kerala, Goa and Karnataka in India. During the monsoon, coastal rain-fed fields are planted with rice; during the summer months when salt content is high, the fields are used for fish farming. The *'pokkali'* system involves the trapping of shrimps such as *Metapenaeus dobsonii, M. monoceros, Penaeus monodon, P. indicus, P. semisulcatus* from the tidal water that entered the ricefields. Lately, the system has been modified to include selective stocking of desired shrimp species.

The rice fields are desalinated after the shrimp crop in time for the rice crop. The *'pokkali'* plots have crisscross trenches to quickly drain the runoff water and wash away the surface salts from the shrimp culture phase. The topsoil is scraped to better remove the salts and is then heaped away from the plots. After these heaps have been washed by the rain, the desalinated soil is again spread over the rice plots. With the 'pokkali' system, production amounts to 785-2,135 kg/ha-year (80% shrimps), whereas traditional plots normally produce 500-600 kg/ha-year of aquatic crop (Ghosh 1992).

A slightly different farming system, the improved *'bhasabadha'*, involves selective stocking of fishes (tilapia, mullets, and others) and marine shrimps. Production from the *'bhasabadha'* system could be 600-1,000 kg/ha-year. The return on capital investment could be 29% in the traditional *'pokkali'* and 56% in the improved *'bhasabadha'* systems (Ghosh 1992).

Farming systems based on Shrimp with other species

Extensive cultivation of Gracilaria *verrucosa*, G. *gigas*, and G. *lichenoides* can be done with tiger shrimp (*Penaeus monodon*) with a rate of 10,000-20,000/ha in the same pond simultaneously in Taiwan (Gomez, 1981). These species also have been grown successfully with tiger shrimp, mudcrub and milkfish in brackishwater ponds in the Philippines, Thailand, India and China (Gomez and Azanza-Corrales, 1988). In Thailand, fish farmers harvest the Gracilaria that grows on the polyethylene net and bottom of cages stocked with the seabass *Lates calcarifer*. Total yearly production of seaweed and fish is 50-100 kg per 10 m^{-2} cage (Tachanavarong, 1988). *Gracilaria* culture has been carried out in shrimp pond effluents (Chadrakrachang *et al.*, 1991).

The integration of shrimp, Artemia, and salt also well established venture in Thailand. A study revealed that annual per hectare production is about 23 kg wet Artemia cysts, 8300 kg wet *Artemia biomass*, 62 tons salt and 1, 125 kg fish and shrimp (Tarnchalanukit and Wongrat, 1985). In the Philippines, several experiments on the culture of *Artemia* in salt ponds have proven it feasible (Santos *et al.* 1980). The monthly per hectare production from these trials were 7.45-20 kg dry *Artemia* cysts and 2-7 tons wet *Artemia* biomass, and 100 tons salt (Jumalon *et al.* 1987). Salt and *Artemia* are produced during the dry season in ponds with salinities higher than 90 ppt; fish or shrimps are produced during the wet season in ponds with much lower salinities.

DISCUSSION AND FUTURE RESEARCH APPROACH

According to the commercial point of view the beginning of shrimp (P. monodon) farming in different Asian countries is more or less same period with a little difference in India. The 1980s is the peak time of increasing the shrimp farming and its production in this region. The china and Thailand is now the leading shrimp exporting countries in the world shrimp market. It is believed that a viral disease outbreak caused the collapse of the shrimp exports from Taiwan to Japan in 1987-88. This led Thailand, encouraged by extremely high prices in the Japanese market due to supply shortages, to replace Taiwan as the world's leading producer of farm-raised P. *monodon* in 1988 (FAO, 2006-10).

However, although the South and Southeast Asian countries share many common features in shrimp farming systems, we can find some differences also. For example, in Bangladesh the commercial shrimp farming starting from the 1980s still now the 70% of the shrimp farms use traditional and/or extensive culture technique (Hussain, 1994), in Vietnam 90% of production comes from extensive farm (Khang, 2008) whereas in Thailand 80% of the production comes from intensive shrimp farm (Somsak and Ayut, 2000) that makes the Thailand to contribute more in world shrimp market. The differences also found in the intensity of mangrove forest loss in this region. The mangrove forest loss in Thailand is 87%, in Bangladesh it is 73% due to shrimp farming whereas in Indonesia and Philippines the mangrove loss are low as 45% and 50%, respectively. Obviously, it is true that these countries established shrimp farming systems in expenses of mangrove forest loss. Though the intensity of destruction is different but its impact has a common aspect. Destruction of mangroves along the Philippine coastline accounts of 20 typhoons and tsunamis each year around 3000 deaths in Zamboanga province in 1976, 1000 in northern Panay in 1984 and 7000 in Ormoc and other Leyte towns in 1991. In the Chokoria Sunderban in Bangladesh, mangroves protected villagers from a 1960 tidal wave but a cyclone caused thousands of deaths and enormous property damage in 1991 after the installation of shrimp farms (Choudhury et al. 1994).

Another important discussion aspect of shrimp farming is disease outbreak. The disease outbreak of shrimp is one of the most important drawbacks of shrimp farming during 1988 to 1995. The disease outbreak first noticed in Taiwan in 1988 and the production dropped to an estimated 20,000 tons (Weidner and Rosenberry, 1992). Just after two years i.e. in 1990, the disease outbreak found in Thailand and this caused a decrease of shrimp farming area along the south east coast. By 1998, it had recovered but the area on the Andaman sea coast gradually increased. From 1996, there is a steady increase of shrimp farm away from the coast to the inland rice growing area. However because of the disease, Taiwan switched to other shrimp species like the red-tailed shrimp (P. *penicillatus*) and Kuruma shrimp (P. *japonicus*). In Thai case, the farmers returned to extensive aquaculture and in some are mangrove reforestation was done. In Bangladesh, the disease outbreak occurred in 1996 a bit later than Thailand and this is probably diseased post larvae (PL) import from Thailand. This caused approximately 90% of shrimp farms in the south-western area being affected by white spot viral diseases, resulting in shrimp production being reduced by 20% at a national level (Chowdhury and Muniruzzaman 2003). But there has no evidence that the farmers either change the shrimp farming system or switched to any new species of shrimp. Because of the environmental and social problem the Indian supreme court decided to ban non-traditional shrimp aquaculture in 1996 (Hein, 2000). Thai government also announced the Cabinet Resolution in 1998 to ban the shrimp cultivation in inland which was thought of as the rice bowl of Thailand (Somsak and Ayut, 2000.). But, in Bangladesh, the Government did not take any step to ban the shrimp farming practices elsewhere within the country.

The most important differences of shrimp farming system of Bangladesh with other southeast Asian countries is the shrimp is grown alternately with rice crop. In Thailand, or Indonesia or Taiwan or Philippine shrimp is grown as monoculture or in some area shrimp is cultivated as an integrated system with mangrove tree species known as aqua-silviculture (De la Cruz, 1995). In southern coast of Vietnam and in some area of India, shrimp alternate with rice has been found to cultivate. In this case, the rice is grown in monsoon season when there is enough rainwater comes and make the area suitable for rice cultivation and in winter season cultivation of brackish water shrimp starts. This pattern also found in Bangladesh. However, recently the inland shrimp cultivation in the rice field occupies most of the south-western part of Bangladesh where shrimp is cultivated in monsoon season (May to November) and the rice is cultivated in winter season (Dec-April) using the groundwater irrigation.

Several researchers have studied different technical and socio-environmental aspects of shrimp culture as monoculture in different countries of Southeast Asia including Bangladesh. But very little or no work has been so far done on the issue regarding shrimp based rice farming system (where shrimp is grown in monsoon season and rice in winter season). Thus it is necessary to do an in depth research about this issue- includes- the development of such shrimp farming system, its impact on micro environment (soil salinity and other soil nutrient elements) which will give some idea about the sustainability of such shrimp based rice farming system.

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Enterprise Development for Sustainable Management of Forests: Some Lessons from SMEs

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ABSTRACT

This paper presents some lessons to support forest-based enterprises, including swamp forests based from earlier external interventions for the development of small and medium enterprises (SMEs) in other industries. The lessons were collected primarily through a review of literature. Interventions could be classified as non-financial services or business development services (BDS), financial services and policy support. In general, favorable interventions mimic the market, where market-distortion should be minimized. Interventions should encourage the participation by the private sector or existing players in the industry. External interventions are most effective as facilitators, in contrast to the direct provision of services. Interventions may include capacity building of existing BDS providers or the facilitation in the establishment of providers of important business services that do not yet exist. Intervention may also be directed to creating a market for BDS, through the organization of small enterprises. Enterprises can be organized following cooperative and collaborative forms of association. Organizing informal enterprises may involve designing proper ownership models. Enterprise ownership models could be designed such that the targeted clients could be better protected from fraud or unfair deals given their inherent weaknesses in various aspects of business. The provision of financial services such as credit also follows these principles where service should be passed on to commercial providers, not government agencies or not-for-profit organizations. For existing credit providers, the next challenge is the provision of financial services other than credit such as insurance and money transfers. Policy recommendations generally go back to minimal or regulatory role of the state in promoting economic activities. Generally, policy should clarify rules, encourage the institution of property rights, enforcement of contracts, and formalization of the informal sector.

Keywords: enterprise development, sustainable livelihoods, small enterprises, forest products

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INTRODUCTION

Various studies have documented the high-incidence of poverty within most of the remaining "rich" forests (Sunderlin and Huynh, 2005; Sunderlin, *et al.* 2005), which include still "undeveloped" swamp forests and mangroves. In most cases, the widespread poverty in these forest resource-rich areas is their inaccessibility to market which is further due to the lack of transport infrastructure. The people dependent on these forest resources lack market for their products which in turn limited their income and their capacity to improve their productivity. Efforts towards poverty alleviation in these resource-rich but poor communities have thus included the development of enterprises that utilize these forest resources (Scherr, *et al.* 2004).

We define enterprise development as the (establishment) of businesses that utilize available resources (i.e. forest resources such as trees and various NTFPs and in the case of swamp forests, including fisheries) to generate and. Forest- or fishery-based enterprises are basically the same as any other business enterprise: they aim and need to make a profit. Achieving profitability, however, is not easy due to inherent weaknesses in the market competitiveness of forest communities, and due to constraints unique to forest-based enterprises. In fact, this appealing agenda of alleviating poverty through forest-based enterprises is quite recent. Having said so, various enterprise development programs have been implemented to develop small and medium enterprises (SMEs) in various industries in other sectors and from which lessons can be drawn. This paper compiles these lessons for the purpose of guiding enterprise development initiatives in swamp forest communities or livelihoods improvement programs in forest communities in general.

FOREST ENTERPRISES AND SMEs

Forest enterprises as SMEs

Small and medium enterprises (SMEs) are differentiated from large enterprises because of their smaller number of employees and levels of capitalization. Moreover, micro-enterprises are recently also being made distinct from SMEs mainly due to their informality and ineligibility for formal credit. For our purpose, the term SMEs here would include micro-enterprises since forest enterprises are mostly characterized by high informality. Most forest enterprises also have few or even no hired employees – relying on family labor - and small amount of capitalization. Many forest enterprises are similar with other SMEs due to their small size, thus, they have a disadvantage based on economies of scale, higher transaction costs, limited access to credit, low level of technology, limited production capacity and more.

Unique characteristics of forest enterprises

One feature of forest-based enterprises is, in most cases, the resources (i.e. land, water, and the various "products" in them such as trees, medicine, wild animals, fishes.) have poorly defined property rights. This feature makes many forest enterprises, dependent on extractive harvesting, making many forest enterprises prone to unsustainable supply of raw materials. Poorly defined property rights also affect the eligibility of forest enterprises to engage in formal transactions including accessing formal credit and support services. Furthermore, forest enterprises generally lack market and physical infrastructures. They generally have low value, low barriers to entry and exit, and mostly engaged by poor people (Belcher, 2005). High value forest products tend to be controlled by the elites or highly regulated by the state.

Objectives in forest enterprise development

The development of forest enterprises is appealing because it has the potential to achieve multiple objectives, other than *economic* objectives. Many promoters of forest enterprises are conservation organizations who have *ecological* objectives and hope that the establishment of a forest enterprise could lead to the protection of the resource base – and not lead to overexploitation of the resource. With emerging issues of inequality and recognition of indigenous people's rights, the development of forest enterprises could even achieve social objectives when they enable marginalized groups such as indigenous forest communities to interact (economically, socially, and politically) with the wider society - with self-esteem and confidence (de Haan and Zoomers, 2005). Forest enterprises could also play an important role in *preserving cultural practices* when they utilize certain species that are part of their cultural identity or are 'cultural keystone species' (Garibaldi and Turner, 2004).

A number of studies have documented the potential of achieving profitable and ecologically sustainable forest enterprises (Salafsky *et al.* 2001; Paredo 2003; Schreckenberg, 2003; Antinori and Bray 2005; Wheeler, *et al.* 2005). These success stories are, however, outweighed by many more studies of forest 'enterprises' that failed to make profit (Wells, *et al.* 1999; Salafsky, *et al*. 2001). It is generally accepted that in order for a forest enterprise to succeed in achieving other objectives, it needs to succeed first economically by producing sustained profit, just like any other business enterprise.

Areas of enterprise development support

In general, support for small enterprises varies in scale and scope. Depending on the available resources (i.e. budget) and objectives, enterprise support could vary in terms of number of targeted beneficiaries, duration of intervention, etc. An intervention could be focused on finance, marketing, human resource or production and channeled through enterprise organizations such as SME associations or their federations. Interventions could also be less direct such as through policy support that targets business environment of enterprises such as incentives and taxes and other related regulations. The critical importance of finance, however, makes interventions on it usually distinct from the other support services. These support services could be generally classified under three areas: *business development services (BDS) or non-financial services, financial services* and *policy support*. These are illustrated in Table 1 with some examples of services and at various stages of enterprise growth.

Table 1 Potential areas of intervention at different stages of enterprise development

Stages of enterprise growth	**Potential areas of intervention**		
	BDS	***Finance***	***Policy***
Pre-start up	• Pre-start up support (e.g., industry and market research)	• Pre-start up costs	• Property rights (e.g., security of land tenure)
Start up	• Organizational capacity building	• Fixed & working capital generation	• Business regulations and legal requirements
Growth & expansion Operations & Maintenance	• Managerial, technical, and financial capacity building • Market information	• Working capital (for expansion) • Debt financing	• Legal requirements • Incentives (e.g., subsidies, industry support)
New technology	• New technology use • Technical skills development	• Equipment acquisition costs	• Incentives (e.g., tax exemptions)
New product & new market	• Product development and marketing plans	• New venture capital	• Business regulations, export requirements
Federation, networking, mergers	• Linkaging; negotiating profit sharing & business ownership models	• Acquisition costs	• Incentives (e.g., incentives related to scale)

The above table illustrates not just the distinction in types of enterprise interventions but also the different stages of enterprise growth. Interventions that aim to start and enterprise will surely cost more, take more time and even have higher risk of failure than interventions that aim at already operating enterprises. Likewise, it would take more effort, time and money to support enterprises in remote swamp forests inlands of Mekong River or in other mangrove areas that have limited infrastructure, no existing industry or unorganized producers compared to similar areas that are closer to transport infrastructures and already have a thriving industry with an organization of farmers, fishermen or local producers.

Trends in enterprise development

The trend in enterprise development follows the trend in government services provision which is moving towards the achievement of greater efficiency in services provision through market–based policy instruments. Ideally, business support services should not be dole outs and not be given free. However, the existing enterprises may be too poor to afford to pay business service. Moreover, viable enterprises may not even exist especially in poor forest communities. In cases where enterprises already exist, market-based intervention implies supporting the provision of business services by the private sector. This implies that external intervention has to recognize that some business services are already being provided by existing players in the market chain such as by buyers, suppliers and traders (Anderson, 2000). Thus, instead of competing against private providers of business services, which used to be the case, the new approach is for intervening donors and their implementing organizations to support these existing providers. Donors through their implementing organization then take the role as facilitator instead of direct provider of such services, where market distortions are minimized (Figure 1).

LESSONS LEARNED IN BDS PROVISION

BDS is a broad term to include any support service outside of finance such as marketing assistance, commercial entities development, technology and product development, information services, and business linkages (ILO, 1999; Mikkelsen, 1999; UNECE 2000; Committee of Donor Agencies for Small Enterprise Development, 2001). The following lessons include insights regarding the selection of appropriate enterprise development program models, selecting program partners which would continuously provide services to target entrepreneurs or enterprises, capacity building activities, and designing enterprise associations and ownership.

Program models of BDS intervention

Enterprise development programs are always constrained by budget and objectives. Based on given constraints, three program models could be followed: services facilitation/provision, direct business involvement/marketing and (market) infrastructure support - based on program models by McVay (2000). Each model differs generally in terms of cost, sustainability, outreach and impact.

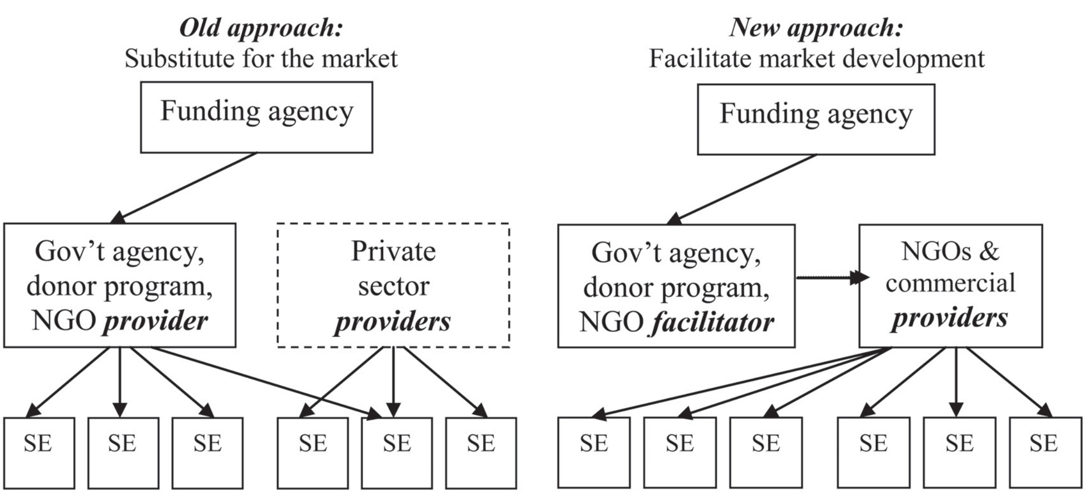

Figure 1 Trend in enterprise development
(Adopted from the Committee of Donor Agencies for Small Enterprise Development 2001)

Services facilitation/provision

An enterprise development program/ project could function as a facilitator or as a supplier of services. As a facilitator, support services are channeled to SMEs through BDS providers (e.g. commercial providers or NGOs) (UNDP, 1999a, 1999b). This is the ideal business support provision model as illustrated earlier in Figure 1. However, in cases where there are no existing BDS providers, the project management organization may have to directly provide the services to SMEs, while at the same time, paving the establishment of separate BDS providers. As "facilitators", the challenge is to identify important business services as well as attract commercial providers to provide these 'viable' services. As direct providers of business services, the challenge is to "sell' their services (e.g., training, marketing consultancy, etc.) to the SMEs whereby SMEs should be able to handle full or partial cost of service delivery. In practice, service providers often have difficulty achieving sustainability because many services are difficult to 'sell' to SMEs. Service provider organizations often have to rely on grants and subsidies for continuous operation, but then problem arises when continuous external funding is not guaranteed.

Direct business involvement/marketing

This model provides services to SMEs by getting directly involved into the business such as marketing clients' products and acting as middlemen. This model may be appropriate in cases when an important function in the enterprise value chain is not being provided or when the market is too monopolistic - where middlemen are using their market power to limit competition to SMEs. It should aim to encourage competition among intermediaries with a conscious aim to eventually pass the business to the private sector, after demonstrating its feasibility. It should start with a careful analysis of the value chain, identifying where best to intervene (Kaplinsky, 2000).

Compared to other models, this is the most sustainable because it generates income and recovers cost faster. It would also have greater impact to target beneficiaries because intervention is more direct and assessment of impact is easier. However, it would have limited outreach because it would involve limited clients. Extreme care should be observed before following this model since any intervention, especially, direct intervention, is market distorting thereby causing distorted signals to market players – both producers and traders. It could leave an industry worse off after the project intervention exits.

Market infrastructure support

This model differs slightly with the services facilitation/provision, such that the services provided are not inclusive to particular SMEs - and can hardly be "sold". It targets market infrastructures affecting broader SME organizations. Services include supporting the establishment of market information services, market trade fairs and expositions, research for product development, and industry-wide interventions that may even be for both small and large-scale enterprises. This model includes schemes such as establishing 'special economic zones' and 'business incubation units' where huge and focused investments are made in particular location. However, services and business support under this model are usually expensive and mostly done by or in close collaboration with government line agencies. It has broader outreach but since it targets institutions and so its impact is not easy to measure. It can be made more sustainable through financing from fees and levies.

Following these three models, however, does not prevent implementing another. These can be illustrated in the experience of Traidcraft Exchange, a relatively large donor-funded NGO based in the UK which started an overseas business development service in 1986 (Redfern and Snedker, 2002). In order to reduce cost, it helped establish local BDS provider organizations to provide marketing services to its target clients of small enterprises. In 2002, it was reaching out to around 400 businesses. Several of these BDS providers, especially in Africa, got involved in the supply chain (or following the direct business involvement model). This was due to the limited number of marketing intermediaries. Traidcraft Exchange acted both as a facilitator - by developing local BDS providers; and a service provider - by providing a range of BDS including export marketing training and export facilitation through buyer linkages, trade fair facilitation, sales tours, design inputs, and provision of market information. Some important lessons include: a) focusing support on one BDS provider organization is risky especially when such organization fails; b) newly "facilitated" BDS providers struggle to reach a high degree of sustainability mainly because they are servicing very small businesses in underdeveloped markets; c) developing the market for new business services, particularly the more general business advisory services is a long-term venture that could even take more than 10 years.

Types of BDS provider organizations

In any program model, there is a need for locally based organizations to deliver the services to SMEs, thus, choosing the appropriate service providers is important. BDS provider organizations can be distinguished according to their ownership. *Membership organizations* are composed of SMEs themselves such as cooperatives and their federations and associations. *Service delivery organizations* are outside agents providing services to SMEs. The latter vary in ownership, management and source of funding and these could be a) government or quasi-government organizations; b) not-for-profit or NGOs; and c) commercial private sector organizations which are privately owned and provide services for profit such as consultancy firms, private training institutes and even suppliers and business partners (ILO, 1999).

Membership organizations

Generally, membership organizations have least potential in providing services to their members mainly due to their low quality human resources especially for smaller organizations with poorer membership (which is why they needed the services in the first place). Membership organizations also often lack funds for such support services especially when members fail to pay their membership contributions. On the other hand, membership organizations are prone to domination by powerful individuals who may be pursuing self-serving interests and not of the general membership (Havers and Gibson, 1994 as cited in ILO, 1999).

Service delivery organizations

The ideal BDS providers are commercial ones because they are established without external funding, make profit and are sustainable. They are evident among larger enterprises but are rare for SMEs again mainly because SMEs often cannot afford them. Governments and semi-government organizations are least successful at being "business-like". On the other hand, NGOs are prone to have a charity orientation, often not properly accounting for costs making their service unsustainable without continued donor support. BDS provision should start by surveying existing institutions and supporting effective organizations particularly commercial providers and NGOs. Without existing providers, donor programs may need to facilitate their establishment.

Capacity building of BDS provider organizations

Assuming the existence of an association of enterprises (i.e. farmers, households) or better, an already existing provider of services to these membership organizations, intervention could be directed to capacity building. Capacity building is more than just the provision of training. According to Henriques (1994), capacity building has four main areas. *Organizational capacity* is the ability of an organization to articulate and generate commitment for its vision and objectives for its clients. *Managerial capacity* is the ability to realize its vision demonstrated in its organizational structure and management systems and staff (e.g. administrative, production, financial systems). *Technical capacity* is the ability to meet the needs of its clients through particular instruments or methods while *financial capacity* refers to the ability of an organization to obtain funding to deliver its services; be it through self-financing or external support.

These are some lessons learned for the capacity building of BDS providers as well as business organizations in general. In order to improve *organizational capacity*, BDS organizations should define their target group and set a clear vision, determining who and how many clients they are going to serve given available and expected flow of funds. To improve *managerial capacity*, organizations should have a legal personality, a decentralized structure that is free from non-business-like influence of politicians and bureaucrats and a management system that generally simulate the market as could be shown through the charging of fees for services as well as incentives linked to staff performance. In addition, management should have focus but at the same time have flexibility to modify services according to changing needs of clients. *Technical capacity* building generally should assist enterprises in their core area of expertise or product. For BDS providers, specialization can be in the areas of technical training, managerial training, counseling, marketing assistance, and information (Mansour, 2001). If a certain service is not the specialization of an organization, then it should contract or subcontract this out to the appropriate one. Profit oriented-activities such as forest product processing should be handled by commercial organizations while development activities such as trainings could be handled by separate and more specialized organization (Schreckenberg, 2003). Financial capacity could be improved through the promotion of transactional relationships where fees are charged for services through price mark-up, commissions or service charge. Organizations should also have a diversified source of funding and may engage into income generating activities that could finance their provision of non-income generating services.

Formation of small enterprise associations

Small enterprises lack the economies of scale that larger enterprises have. This then makes many business transactions relatively expensive for smaller enterprises. The same is true for the transaction costs of BDS providers that try to service these small enterprises. Smaller enterprises should be organized not just to make it easier to access BDS, but consequently and more importantly, for them to achieve economies of scale in their common business transactions, be it buying inputs, selling products, or collective bargaining. By forming associations, SMEs could have some advantages of being large-scale yet retaining their flexibility for being small.

Types of associations

Efficiency through joint actions arises from *collaboration* and *cooperation* between business enterprises in pursuit of market advantage (Macqueen, 2004). *Collaboration* is the direct and usually contractual participation between vertically related firms i.e., between producers and buyers. Cooperation is between enterprises in an industry or horizontally related firms such as between or among producers themselves for various purposes such as sharing of information, training, marketing or for accessing BDS. Both collaborative and cooperative relationships result to different types of associations (Polenske, 2003, in Macqueen, 2004). Collaborative relationships include contractual production and contract buying (e.g., between farmers and wholesalers or retailers) while cooperative relationships include cooperatives, unions and cartels.

Associations for the poor

Within associations, there is the possibility of unequal relationships among the membership of associations. To promote an association for the poor, it is important to design organizations such that potential imbalances are anticipated and provided upon appropriately in contract agreements or organization by-laws. These may include representation of the poor in the decision-making body of the organizations. In the case of “collaborative relationships”, the pro-poor provisions should be embedded early on in the contracts with business partners. In facilitating the formation of associations, supporting agencies must be clear of the vision and objectives of such association and must invest to overcome lack of trust among potential members who may be competitors (Rosenfeld, 1996). This can be achieved through planning and pilot projects that have strong participation of the target enterprises. Again, there is emphasis for external support for these pro-poor associations to ultimately aim for self-management (Cegilie and Dini, 1999, in Macqueen, 2004). In addition, Doner and Schneider (2000) point out that the formation of enterprise associations would be more successful given: a) high membership density as percentage of total numbers of firms within a particular sector; b) extensive selective benefits brought about by membership in the association; and c) effective internal interest mediation such as voting weighted by size, transparency and opportunities to discuss issues among members.

Enterprise ownership models

Given focus on poverty alleviation and especially in remote forested areas, enterprise development support may need the establishment or incorporation of a new business. In this case, an important issue is the ownership of such an enterprise since this would determine the profit sharing arrangements as well as the profitability of such business. The formal business sector already offers several models of business ownership such as sole proprietorship, partnership, corporation and cooperatives, or a mixture of these through innovative contracts such as contract growing, joint venture or licensing. Each ownership model provides flexibility with regard to how much risk or liability owners are willing to take, which is influenced by their size of investment and the level of formality required in an industry. For small forest enterprises, the investment and formality required usually increase as the product goes along from producers to final retailers. Cooperatives may work well at producer level because of their informality and limited production capacity. Processing and trading may be better managed by individual entrepreneurs. Cooperatives could also be more appropriate especially for communities having a communal form of control or ownership of the resource base be it land, forest or mangroves.

Lessons from forest enterprise development

Some of these lessons have already been applied in forest enterprise development and there are specific lessons that could also be learned from these earlier experiences.

● *Product development:* Product developers should invest in a product with the highest potential in terms of value, and feasibility. This would require understanding the market of forest products and careful analysis of the feasibility of forest products. A manual to conduct this feasibility study, called the market analysis and development (MA&D), was already prepared and includes an assessment of the existing situation by understanding the forest product market, identifying problems and opportunities, selecting products with highest potential and formulation of business plan (Lecup and Nicholson 2000).

● *Start-up investment and time:* Enterprise development based on a new product normally undergoes the three stage process of a) testing its potential for becoming a business; b) developing the project to the point where it can become an independent business; and c) balancing business goals of profitability with other related objectives (i.e. equity, longer-term ecological goals). From earlier initiatives, establishing profitable business from forest products takes time, even years especially those involving research and development such as pharmaceuticals (Schreckenberg, 2003).

● *Resources access and property rights:* Starting a forest enterprise is also difficult especially when access to forest resources is limited, not secured or not effectively enforced (Peluso, 1992). It is easier when there is already an existing community organization governing the forest resources. In this case, a transition from a community-based organization (CBO) that manages the forest to a business/enterprise organization is more possible; although with a precaution that a CBO may be appropriate in forest management but not necessarily in managing an enterprise (Pandit, Albano and Kumar, 2008).

● *Product/service specialization:* Specialization implies efficiency and competitiveness and should be a primary objective of enterprise development interventions (Helmsing, 2003). Following the value chain, enterprise development interventions should not immediately engage in various enterprise activities (e.g. production, processing, marketing) but partner with other enterprise organizations involved in some of these activities (Schreckenberg, 2003). Business organizations should focus on their "core competencies" namely the activities for which they have relatively unique resources or skills, and leave other activities to other actors in the value chain (Kaplinsky and Morris, 2001). Producers do not have to forward integrate in doing the processing or trading of their products if they are not competent to maintain quality or meet the formal requirements required by the buyers.

● *Diversification:* Specialization in a forest product may pose a higher risk if the industry is volatile such as when price is unstable for various reasons (e.g. weather, seasonalities, changeability of consumer preferences, policy). In this case, it would be less risky to diversify markets such as targeting broader market including local, national, and international market, not just a niche market (Shackleton, 2005). A related strategy is to diversify forest products not just depending on one species; or even diversify investments to include businesses other than from forest products.

Commercializing "subsistence" products: There is lesser risk in promoting products that are also being consumed by the people because if price goes down, the producers could still consume or use them. In relation to this, it makes it ideal to promote the commercialization of plant species that provide more than one product such as wood, bark, fruit, oil, etc.

FINANCIAL SERVICES PROVISION

In general, the same principles in BDS provision apply to the provision of financial services. Due to the importance of finance and more recent popularity of microfinance, there is a rich literature on lessons in financing small business. (For example, see Consultative Group to Assist the Poor (CGAP) website at www.cgap.org). Some particularly important lessons for forest enterprise development are given below.

● *Role of donors and government agencies.* The donor provision of loans, grants, and equity should be temporary and should be used to build the capacity of providers as well as regulatory agencies, rating agencies and credit bureaus. Government should not get involved in direct provision but focus on regulation, ensuring policies that stimulate financial service and avoiding fraud.

● *Market development and sustainability.* Most poor people cannot get good financial services that meet their needs because there are not enough strong institutions that provide such services. Strong institutions need to charge enough to cover their costs and be able to operate sustainably beyond the duration of donor funding. In this regard, policy should move away from interest rate ceilings to enable microlenders to charge interest rates that are well above average bank loan rates since their costs are more compared to banks.

● *Transparency and standards of operation.* Financial service providers must be trained to produce accurate, standardized performance information. Accurate records and accounting would guarantee that the savings of the people are being managed properly and far from the risk of swindling or bankruptcy. This is considering that in many rural and forest communities, financial cooperatives may be the only available institution for the poor to build cash savings.

● *Other financial services.* Enterprises may also need services such as savings, cash-transfer services and even insurance. On the other hand, very poor people such as those engaged in collection of forest products may not need or want credit, at least initially, due to their limited use of cash or because they just are very poor. In such cases, other services may be more appropriate-for instance, small grants, employment and training programs, or infrastructure improvements. Similarly, provision of credit would be risky if the enterprise is not viable. Ideally, financial services should be preceded by effective provision of BDS which includes technical assistance to production and processing, and market assistance. Successful financial services show a close linking of credit with BDS (Sievers and Vanderberg, 2004).

● *Innovations in microfinance:* Innovations in financial services are not just in provision of micro-credit but also in savings, money transfers, and micro-insurance which could also be appropriate for forest enterprises and forest communities in general. As successfully demonstrated in micro-credit schemes, the group-lending model based on peer guarantees could further be replicated. Other innovations would include embedded or 'forced' savings (e.g., built-in savings from enterprise sales to cooperatives or regular savings). Savings could be in cash or in kind where the savings in kind are later sold to realize the cash value. Credit retailers or microfinance providers could also be supported to use their advantage of location to partner with banks, money remittance companies, insurance agencies, etc. to provide these services to target clients in remote areas.

POLICY SUPPORT

In general, the establishment and growth of business-whether large or small enterprises-depend on policies that affect investor (including farmers and ordinary individuals) confidence, encourage entrepreneurship and rule of law. These policies then include national economic platforms and monetary policies down to localized laws concerning trade, taxation, resources ownership, and business registrations. To a degree, external actors especially large donor organizations may directly influence these policies by setting conditions in their grants or loans or indirectly by working with private sector organizations for advocacy. Other than the specific policy support mentioned in the provision of BDS and financial services, policy makers need to be influenced to formulate clear rules and regulations that would protect market contracts and prevent fraud, provide public goods which may include infrastructure support to areas with high incidence of poverty including forests and mitigate negative externalities from economic activities in forests. Although it is beyond the scope of this paper, there must be caution with public infrastructures for their possible negative consequences to the targeted local as well as communities the forest resources.

Clear rules and the informal sector

Certainty in the business environment will encourage investor confidence to invest for longer-term business ventures. Government policy should encourage such confidence in the market, generally through encouraging transparency in business transactions and accountability of regulating offices and businesses, preventing corruption, fraud, business malpractices, and other market distortions. Clarification of rules should be followed by their strict enforcement.

Many small enterprises operate informally for various reasons such as the lack of regulatory bodies or the over-regulation of the industry, high cost to comply with the rules, illiteracy, or lack of awareness of the entrepreneurs. While informal operation may have its advantages, it is generally disadvantageous especially with regard to the long-term potential of the enterprise to innovate and expand. Informal enterprises have to enter the formal market for them to be able to access cheaper and quality assured goods and services (e.g., credit, BDS) and for them to have more predictable business environment where contracts can be made and executed. Formalization can be done through formal organization of small enterprises, formulation and clarification of business rules and regulations, and strengthening the enforcement of contracts and property rights. Compliance cost should be improved to make sure that cost of formalization is cheap and the benefits are more compared to staying informal. Forest enterprises can better capture the 'green', 'fair', or 'certified' niche markets when they are formalized. Formalization also implies transparency in transactions and good recording - an important process in monitoring resource sustainability. On the other hand, resources access and business regulations should be reviewed to ensure that benefits are more than the cost of compliance (De Soto, 2000; Galal, 2004).

Property rights

The institution of property rights is fundamental to enterprise development as it enables people to access a property to use for productive activities; enabling the provision of incentives for innovative activities and entrepreneurship. Ideally, property rights should be secure, divisible and transferable. In order to secure property rights, they should be legitimized and enforced through policy. Divisible property rights means that holders of these rights should be free to create further rights out of these rights, as they desire. Owners of property should be allowed to invest or divest their property including transferring ownership of such property or part of the property, as they deem necessary. The more secure, divisible, and transferable a property is, the higher is its value and the more options and benefits it provides to its holders, and the wider economy (De Soto, 2000; Boudreaux 2005). This is particularly important in forest and fishery communities where property rights are less defined and less secure as prohibitive forestry and fishery policies are in conflict with actual utilization of these resources by local people.

The trend in forest policy is towards granting property rights to forest users, which is favorable, and which should further be expanded and secured. Many kinds property rights are emerging and are being traded in the free market but their potential to be used as a source of capital is limited by the lack of legislation or the presence of legislation that opposes their trade. Support should be keen in identifying these property rights to make sure they are formalized, secured, tradable in the formal sector; and thus, more profitable to the property holders. Caution, however, should be observed especially in granting property (i.e. land) rights to marginalized groups because granting them right to sell land could also lead to their landlessness. On the other hand, policies prohibiting land transfer generally lower the value of land, which would make the landholders worse off just in case they decide to sell their land (for any 'valid' reason such as for emergency use or investment in any enterprise), and would generally discourage external investment in the community. Moreover, granting rights to owners would not necessarily mean they will sell their land; they may actually protect and improve it more because the granting of exclusive ownership to them adds more value to their asset. In this case, policy needs to be more flexible based on the context of a certain locality.

It is also important to note that securing property rights does not necessarily mean individual ownership. In some cases especially in traditional communities, individual ownership may not be the social norms and communal property ownership could be more appropriate. In the same way, where government ownership is recognized by communities such as in long-declared protected areas, such government property must be secured along with clarification of local access rights. These said, the need for a particular property right institution has to be recognized and supported first by the constituency to ensure compliance. Furthermore, to protect and enforce these rights, there should also be efforts to improve judicial and police accountability in order to prevent unfair market transactions or fraud (De Soto, 2000; Boudreaux, 2005).

Other public goods and alternative income

Market and physical infrastructure are crucial for enterprise development but these are often lacking mainly because they are expensive. Some remedies include one or a combination of collection of fees from enterprises for such purpose of building the infrastructure or giving exclusive licenses to beneficiary enterprises in exchange of them investing in such infrastructure. As earlier discussed, small enterprises need services such as technical assistance and general capacity building, many of which are not 'commercial' by nature which more likely to have to be provided with subsidy. In many forest communities, forest enterprise development may be hampered by the lack of physical infrastructure and other ‘ such as transport, electricity, water, health services which then have to be addressed first or at the same time with enterprise development interventions.

There is evidently a potential for forest enterprises to grow and employ poor in forest communities. However, forest enterprise development is just one of the alternative strategies towards achieving poverty alleviation. This paper cited lessons how such potential could be achieved but it is also important to note that there are limitations in promoting forest-based enterprises, or livelihoods based on forest products in general (Belcher and Shreckenberg, 2007). Other alternatives could be more appropriate. Empirical evidence shows many people in forest or fishery communities are sourcing their income not just from forest resources or from forestland but increasingly also come from off-farm and non-farm labor within or outside the community. Interventions should not be limited to employment opportunities from forest products or within forest communities. This may include skills training programs for laborers who regularly migrate outside communities for work.

CONCLUSION

Part of strategies to sustainably manage the remaining rich forest resources has been livelihood improvement programs for the usually poor and forest-dependent people. Efforts towards poverty alleviation in these resource-rich but poor communities have thus included the development of enterprises that utilize these forest resources Forest enterprise development, however, is quite recent and there is a dearth in successful cases. On the other hand, enterprise development efforts have been done in other sectors, particularly in the development of small and medium enterprises (SMEs). The lessons learned from SMEs and from initial cases of forest enterprise development are presented in this paper; generally classified into business development services (BDS) provision, financial services provision, and policy support.

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General Allometric Equations For *Eucalyptus camaldulensis* and other Tree Species

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ABSTRACT

Eucalyptus camaldulensis, which originated in Australia, is widely planted on degraded land in many countries, because the species is adapted to deteriorated soil and tolerates fire, high temperatures and periodic inundation. It is important to gather basic data on the plant biomass of this species, because such data are relevant to calculations of carbon dioxide sequestration under the Afforestation or Reforestation for Clean Development Mechanism (AR-CDM) projects of the Kyoto Protocol. To estimate how much carbon dioxide trees can sequester, we need to monitor the tree size measurements such as DBH (diameter at breast height), which is a parameter in allometric equations. We compared two allometric equations for calculating the stem biomass of E. camaldulensis samples from two sites: a semi-arid area of Australia, and a tropical monsoon area of Vietnam. Using the data obtained from the sites, an allometric equation with the square of DBH multiplied by tree height (DBH2H) as the independent variable was developed. The solution to the equation indicates that changes in DBH2H account for 99% of the changes in stem biomass. We compare the allometric equation for stem biomass of E. camaldulensis and the allometric equation of evergreen broad-leaved species. There are no statistical differences between them, and the solution to the equation indicates that changes in DBH2H account for 98% of the changes in stem biomass when all data are pooled.

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The slope of the allometric equation for coniferous species is lower than that for *E. camaldulensis*. This could be a result of the low stem bulk density of coniferous species. The new allometric equation in this paper is effective in estimating the stem biomass of evergreen broad-leaved tee species in South East Asia.
Key Words: *Eucalyptus camaldulensis*, allometric equation, stem biomass, South East Asia

INTRODUCTION

In the last few decades, considerable effort has gone into developing allometric equations for estimating the biomass of individual trees and forests. Forest biomass information has recently become necessary for estimating not only the biomass production of woody products but also for estimating carbon dioxide (CO_2) sequestration in light of concerns over global warming. When there is a need to estimate the biomass of individual trees, the lack of predictive equations demands destructive sampling of trees for the purpose of developing a local allometric equation (Ter-Mikaelian and Korzukhin, 1997). However, destructive sampling is too laborious. For this reason, the development of unified allometric equations is desirable. In high-volume or old-growth forest, stems account for more biomass than branches and leaves do, and stems can be used for construction; however, destructive sampling is too laborious, so the first allometric equations to be developed were those for stem biomass. The allometric equations for branches and leaves vary by species, stand density and available space in the crown, whereas the allometric equations for stem biomass are less affected by such factors (Sato, 1962).

Eucalyptus camaldulensis, which originated in Australia, is widely planted on degraded land in many countries, including Thailand, because the species is adapted to deteriorated soil and tolerates fire, high temperatures and periodic inundation. The species shows high photosynthetic rate and adaptive water use efficiency, because of its high physiological plasticity (Tanouchi *et al.*, 2006; Utsugi *et al.*, 2006, 2009). It is important to gather basic data on the plant biomass of this species, because such data are relevant to calculations of carbon dioxide sequestration under the Afforestation or Reforestation for Clean Development Mechanism (AR-CDM) projects of the Kyoto Protocol (UNFCCC, 2006).

This paper compares the allometric relations for *E. camaldulensis* sampled in Australia with those for that species sampled in Vietnam. Australia has a dry climate, and Vietnam is in the same monsoon area as Thailand. Then we add extra data for relating stem biomass to the tree size characteristics of evergreen broad-leaved species, deciduous broad-leaved species and coniferous species. The paper aims to propose a comprehensive allometric equation for *E. camaldulensis* and evergreen broad-leaved species by comparing allometric equations for deciduous broad-leaved and coniferous species.

MATERIALS AND METHODS

This paper uses allometric equations of the form:

$$Ws = a\ D^{b} \qquad (1)$$

Where *W*s is the oven-dry weight of tree stem biomass (kg), D is the square of diameter at breast height (DBH; cm) multiplied by tree height (H; m) (DBH2H), and a and b are parameters.

The data of DBH, H and Ws for *E. camaldulensis* were obtained at a semi-arid area of Australia, Sturt Meadows Pastoral Station (STM; 28°53’S, 121°45’E) by us (Kojima et al., 2006, Suganuma et al. 2006) (n=11), and at a tropical monsoon area of Vietnam (Futan; 11°30’N, 106°50’E) by Yamada *et al.* (2000) (n=4). Annual precipitation and temperature are 200 mm year-1 and 21°C at STM and 1900 mm year-1 and 30°C at Futan. The DBH of sample trees ranges from 2 – 44 cm in Australia and 12 – 19 cm in Vietnam.

The data for evergreen broad-leaved species (n=119), deciduous broad-leaved species (n=194) and coniferous species (n=299) were obtained from numerous studies and bulletin reports published in Japan between 1955 and 2003, including those from the Japanese Journal of Forest Research (Japanese Forestry Society), universities, the National Forest Research Institute and prefectural forest research institutes. In the literature, we selected the data of *W*s, DBH and H in individual trees.

The data were logarithmically transformed, and Formula (1) was obtained by the least-squares method. Each regression was compared by ANCOVA (Poorter, *et al.*, 2008) using STATISTICA Ver.6 (StatSoft, Inc., Statistica for Windows, Tulsa).

RESULTS AND DISCUSSION

The relationship between DBH2H and Ws is shown for *E. camaldulensis* in Figure 1. The data obtained from Vietnam are within the 95% confidence interval for the allometric equation derived from the data of Australia. If all the data are combined, then parameter a, parameter b and the coefficient of determination (R^2) are 0.038, 0.9322 and 0.997, respectively. Furthermore, the allometric relationship between Ws and DBH obtained in Thailand (Thoranisorn *et al.*, 1990) is not statistically different from that obtained in Australia (Utsugi *et al.*, 2010). These same allometric relationships indicate that stem shape or bulk density is very close even among *E. camaldulensis* species that have a wide geographical distribution.

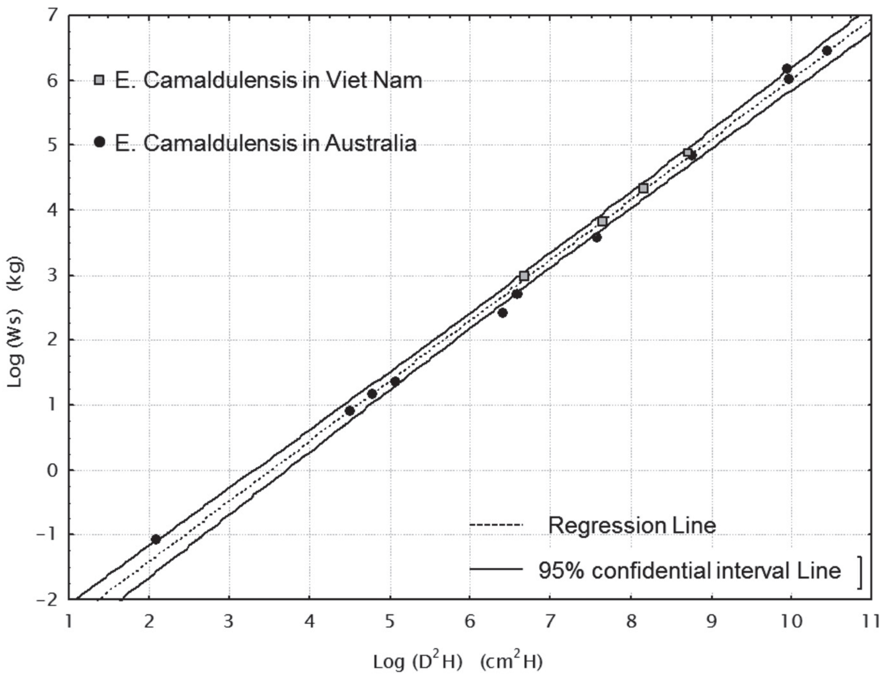

Figure 1 Relationship between DBH^2H and *W*s plotted for *E. camaldurensis* on logarithmic axes. Solid black circles are data obtained in Australia; solid gray squares are data obtained in Vietnam.

The allometric relationship for evergreen broad-leaved species is plotted over the allometric relation of *E. camaldulensis* in Figure 2. R^2 for the allometric relationship for evergreen broad-leaved is 0.986. The number of species sampled for evergreen broad-leaved is 24 (Table 1). The allometric equations between E. camaldulensis and evergreen broad-leaved are not statistically different ($p > 0.05$). When all the data are combined, parameter a, parameter b and R^2 are 0.0378, 0.9501 and 0.98, respectively. R^2 for all the data is equal to R^2 for the data of evergreen broad-leaved. Yoda (1972) found a unified allometric relationship between Ws and DBH2H using the data obtained in tropical forest in Thailand and evergreen broad-leaved forest in Japan. These things indicate that the stem biomass of evergreen broad-leaved species, including E. camaldulensis, would be able be estimated by a unified allometric equation with DBH2H as the independent variable.

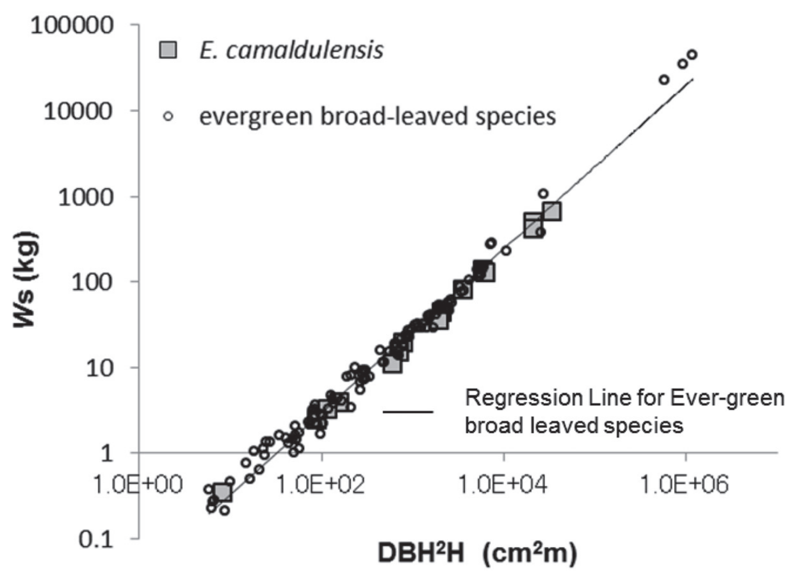

Figure 2 Allometric relationship for evergreen broad leaved species and *E. camaldulensis*. Black circles are evergreen broad leaved species; solid gray squares are *E. camaldulensis*.

Table 1 Evergreen broad leaved species used for developing the allometric equation

Species name	N	Species name	N
Machilus thunbergii	2	*Illicium anisatum*	1
Camellia japonica	4	*Machilus thunbergii*	1
Camellia lutchuensis	1	*Meliosma rigida*	2
Castanopsis cuspidata	3	*Pieris japonica*	2
Castanopsis cuspidata	4	*Quercus acuta*	1
Castanopsis sieboldii	20	*Quercus glauca*	1
Cinnamomum tenuifolium	1	*Quercus myrsinifolia*	57
Cleyera japonica	1	*Quercus phillyraeoides*	3
Distylium racemosum	2	*Quercus salicina*	1
Distylium racemosum	2	*Rapanaea neriifolia*	3
Eurya japonica	1	*Schefflera octophylla* □	2
Ilex pedunculosa	3	*Zanthoxylum ailanthoides*	1

The allometric relationship for deciduous broad-leaved species is plotted over the allometric relationship for *E. camaldulensis* in Figure 3. R^2 for the allometric relationship for deciduous broad-leaved is 0.967, which is slightly less than for evergreen broad-leaved. The number of species sampled for deciduous broad-leaved is 30 (Table 2). The allometric equations between *E. camaldulensis* and deciduous broad-leaved are statistically different (p<0.05). The deciduous broad-leaved species mainly distribute in the warm temperate zones of East Asia. The natural habitat would affect the difference in stem shape and bulk density between evergreen and deciduous broad-leaved species.

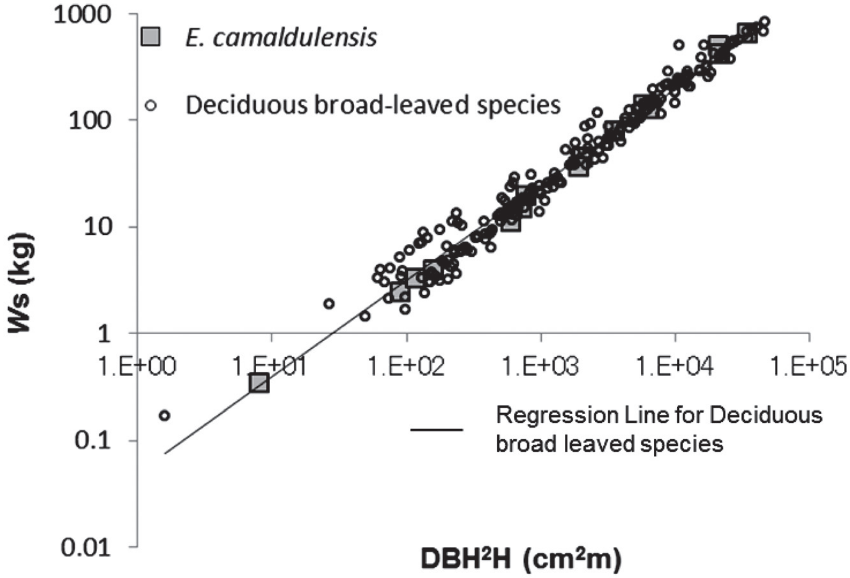

Figure 3 Allometric relationship for deciduous broad-leaved species and *E. camaldulensis*. Black circles are deciduous broad-leaved species; solid gray squares are *E. camaldulensis*.

Table 2 Deciduous broad leaved species used for developing the allometric equation

Species name	N	Species name	N	Species name	N
Acer amoenum	2	*Clethra barbinervis*	1	*Styrax japonica*	3
Acer mono	5	*Fagus crenata*	23	*Styrax obassia*	13
Acer rufinerve	1	*Ilex macropoda*	1	*Swida controversa*	3
Acer sieboldianum	5	*Kalopanax septemlobus*	5	*Swida macrophylla*	2
Albizia julibrissin	1	*Magnolia obovata*	5	*Tilia japonica*	1
Benthamidia japonica	3	*Peris japonica*	4	*Zelkova serrata*	3
Betula ermanii	9	*Prunus grayana*	2		
Betula maximowicziana	3	*Prunus jamasakura*	3		
Betula platyphylla	15	*Quercus acutissima*	2		
Carpinus laxiflora	2	*Quercus crispula*	15		
Carpinus tschonoskii	3	*Quercus serrata*	62		
Castanea crenata	3	*Sorbus alnifolia*	1		

The allometric relationship for coniferous species is plotted over the allometric relations of *E. camaldulensis* in Figure 4. R^2 for the allometric relationship for coniferous species is 0.979, which is midway between the values for evergreen broad-leaved and deciduous broad-leaved. The number of species sampled for coniferous species is 7 (Table 3). The allometric equations for *E. camaldulensis* and coniferous species are statistically different (p <0.001). The regression line of the allometric equation for coniferous species is clearly below those for the deciduous or evergreen broad-leaved species in this study. The coniferous species are mainly distributed in the warm and cool temperate zones of East Asia, and their bulk density of stem is apparently lower than that of broad-leaved species (FAO 2010). This is because of differences in the allometric relations between coniferous species and broad-leaved species.

The stem allometric equations for *E. camaldulensis*, which are able to live in a wider range environmental conditions, are able to be unified, and the stem allometric equation for evergreen broad-leaved is not different from the stem allometric equation for *E. camaldulensis*. We recommend the following allometric equations for estimating the stem biomass of evergreen broad-leaved forest, including *E. camaldulensis* forest.

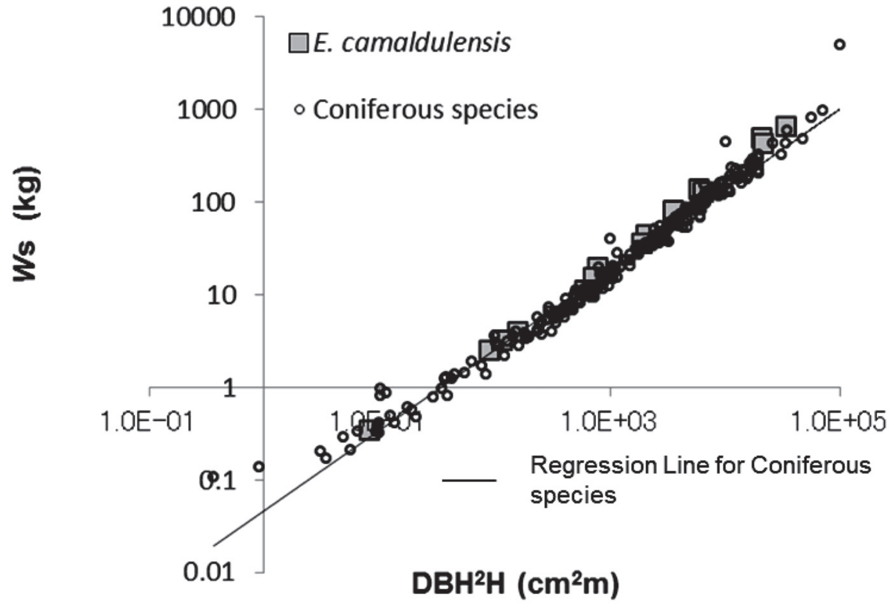

Figure 4 Allometric relationship for coniferous species and *E. camaldulensis*. Black circles are coniferous species; solid gray squares are *E. camaldulensis*.

Table 3 Coniferous species used for developing the allometric equation

Species name	N
Cryptomeria japonica	114
Chamaecyparis obtusa	34
Larix kaempferi	85
Tsuga sieboldii	7
Abies sachalinensis	13
Abies firma	24
Abies veitchii	16

*W*s = 0.0378 D 0.9501.....................(2)

The allometric equation in this study includes a parameter that is difficult to measure (tree height) as an independent valuable. Recently, a digital tree height measuring system with a laser rangefinder has been developed. The careful measuring protocol ensures accurate tree height measurement in the field. Given such accuracy, Equation (2) would be useful for estimating the stem biomass in evergreen broad-leaved forests where destructive sampling or other laborious research is difficult.

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Table 1 Evergreen broad leaved species used for developing the allometric equation

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