PRODUCTIVITY OF FLOODPLAIN FOREST AREAS UNDER DIFFERENT LAND USE SYSTEMS: A CASE STUDY BAN PAK YAM, SRISONGKRAM DISTRICT, NAKHON PHANOM PROVINCE

MISS NANTA SITTHIRACH

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Author: Miss Nanta Sitthirach

Approved by the Thesis Advisory Committee:

....(Chairman)

(Assistant Professor Dr. Sawaeng Ruaysoongnern)

....(member)

(Associate Professor Prasit Kunurat)

....

(Associate Professor Dr. Sommai Priprem)

Dean, Graduate School

Khon Kaen University

....

(Assistant Professor Dr. Assanee Pachinburavan)

Dean, Faculty of Agriculture

Khon Kaen University

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บทคัดย่อ

ป่าบุ่งป่าทาม เป็นพื้นที่ชุ่มน้ำที่สำคัญของภาคตะวันออกเฉียงเหนือ มีการใช้ประโยชน์โดยชุมชน มายาวนาน การศึกษา การเปลี่ยนแปลงผลิตภาพของป่าบุ่งป่าทาม ที่มีผลกระทบจากการใช้ประโยชน์ที่ดินในระดับต่างๆ กัน โดยทำกรณีศึกษา ป่าบุ่งป่าทาม บ้านปากยาม อำเภอศรีสงคราม จังหวัดนครพนม การศึกษามีวัตถุประสงค์ เพื่อ 1) ศึกษาปริมาณของอินทรีย์คาร์บอนที่สลายตัวได้ง่ายในดินป่าบุ่งป่าทาม 2) เพื่อประเมินศักยภาพผลิตภาพของพื้นที่ป่าบุ่งป่าทาม โดยใช้อินทรียคาร์บอนส่วนที่สลายตัวได้ง่าย 3) เพื่อประเมินระดับความเสื่อมโทรมของพื้นที่ป่าบุ่งป่าทาม ภายใต้การใช้ประโยชน์ที่ดินที่แตกต่างกัน การศึกษาใช้แนวคิดความสัมพันธ์ของมนุษย์กับทรัพยากร และตัวชี้วัดเชิงปริมาณของคุณภาพทรัพยากรดินด้านเคมี ประเมินสถานภาพของ soil carbon fractions ใช้วิธี $KMnO_4$ oxidation ที่นำเสนอโดย Blair et al (1995). ผลการศึกษาพบว่า ป่าบุ่งป่าทามมีความสำคัญต่อการใช้ประโยชน์ของชุมชนบ้านปากยามมายาวนาน การเปลี่ยนแปลงการใช้ประโยชน์ที่ดินป่าบุ่งป่าทาม เกิดจากการลดลงของทรัพยากรประมง ทำให้ชุมชนต้องหาทางเลือกในการดำรงชีพ การทำนาปรังในพื้นที่ป่าบุ่ง ป่าทาม ก็เพื่อให้มีข้าวบริโภคในครัวเรือน การวิเคราะห์ดินเพื่อประเมินศักยภาพของผลิตภาพ ภายใต้การใช้ประโยชน์ในระดับต่างๆกันพบว่า ในดินป่าธรรมชาติ มีปริมาณของ ฟอสฟอรัสที่เป็นประโยชน์ และโพแตสเซียมที่แลกเปลี่ยนได้ สูงกว่าดินทำการเกษตร การเปลี่ยนแปลงในส่วนของอินทรีย์คาร์บอน พบว่ามีความแตกต่างกันไปตามการใช้ประโยชน์ที่ดิน ปริมาณของ C_T, C_L,C_{NL} ในพื้นที่ป่าธรรมชาติมีค่าสูงกว่าในพื้นที่ทำการเกษตร ผลจากการใช้ประโยชน์เพื่อการเกษตร พบว่าปริมาณของ C_T, C_L, C_{NL} มีแนวโน้มลดลง การลดลงของ C_L เกิดขึ้นที่ 72-96 % เมื่อเทียบกับพื้นที่ป่า และพบว่าการลดลงของ C_L. เป็นส่วนที่เกิดขึ้นมากกว่า C_T, และ C_{NL} ค่าของ CMI ในดินป่าธรรมชาติมีค่าสูงกว่าในดินพื้นที่เกษตร ในพื้นที่ทำนาปรัง ค่าของ CMI มีแนวโน้มลดลงคือพบว่าลดลงเหลือเพียง 5-24% เมื่อเทียบกับพื้นที่ป่าธรรมชาติ การประเมินศักยภาพผลิตภาพของพื้นที่ป่าบุ่ง ป่าทาม ที่การใช้ประโยชน์ระดับต่างๆ กัน พบว่าพื้นที่ป่าบุ่งป่าทาม มีศักยภาพของผลิตภาพสูง โดยพิจารณาจากปริมาณของ C_L และปริมาณธาตุอาหาร และผลจากการใช้ประโยชน์ที่ดินในการเกษตรทำให้มีการลดลงของ C_L ซึ่งมีผลทำให้ศักยภาพของผลิตภาพลดลง การประเมินความเสื่อมโทรม โดยใช้สถานภาพของคาร์บอนในดินเป็นตัวชี้วัดพบว่า มีความเสื่อมโทรมเกิดขึ้นในระดับปานกลาง จากที่มีการลดลงของ C_T เกิดขึ้นที่ 49-79% การลดลงของ C_{NL} เกิดขึ้นที่ 41-74% และการลดลงของ C_L เกิดขึ้นที่ 72-96% เมื่อเทียบกับในป่าธรรมชาติ แต่ก็พบว่าระบบก็ยังสามารถรักษาถาวรภาพไว้ได้ ซึ่งอาจจะเนื่องมาจาก การที่พื้นที่ป่าบุ่งป่าทามเป็นระบบที่สามารถสนับสนุนธาตุอาหารให้กับการผลิตของระบบอย่างได้เพียงพอ การศึกษาพบว่าวิธี $KMnO_4$ oxidation สามารถใช้ในการประเมินสถานภาพของ C_L ในดินได้ การเปลี่ยนแปลงของ C_L สามารถใช้เป็นตัวชี้วัดศักยภาพของผลิตภาพ และระดับความเสื่อมโทรมได้ จึงน่าจะมีการศึกษาต่อไปในเชิงการติดตามการเปลี่ยนแปลงของระบบโดยใช้ C_L เป็นตัวชี้วัด ซึ่งจะให้ข้อมูลที่เป็นประโยชน์ในด้านการจัดการและฟื้นฟูป่าบุ่งป่าทามของภาคอีสานต่อไปในอนาคต

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Abstract

Floodplain with their natural vegetation are important wetlands that have supported the livelihoods of surrounding communities for a long time in the history of the Northeast Thailand. The objectives of this study are 1)To study soil labile carbon of floodplain forest areas under differences land use systems. 2) To assess potential productivity of floodplain forest areas by using soil labile carbon. 3) To assess degree of degradation of floodplain forest areas under different land use systems. The relationships between community and resources were considered. The analytical method in order to assess carbon fractions used in this study is the $KMnO_4$ oxidation technique that have been proposed by Blair et al. (1995). The potential productivity and level of degradation were assessed by the status of soil labile carbon in relation to different land use systems.

The relationships between floodplain forest and community indicated that floodplain forest is important resources base for community living of Ban Pak Yam. Due to decline in fisheries resources lead to changing in living style. Floodplain forest have been converted to agricultural forest for rice growing for consumption in their households. The result of soil analysis showed that changes in soil nutrients coincide with types of land use. Conversion floodplain forest to agricultural forest lead to decline in available P and exchangeable K. Changes in soil carbon fractions related to different type of land use systems. In remaining floodplain forest soil, C_T, C_L and C_{NL} appear higher than in agricultural forest soil. In remaining floodplain forest, C_T appear 33.7 mg/g, C_L 7.93 mg/g and C_{NL} 25.77 mg/g and remain 7-17.3 mg/g, 0.35-2.17 mg/g and 6.65-15.13 mg/g respectively in agricultural forest.

Due to conversion floodplain forest to agricultural forest, loss of soil carbon fractions taking place in total carbon, labile carbon and non-labile carbon. Loss of labile pool appear 72-96 %. Loss of labile carbon was more pronounced than total carbon and non-labile carbon. While carbon management index (CMI) in agricultural forest appear 5-24 % when compare with native state.

Based on status of soil labile carbon, indicated that floodplain forest areas have high relatively potential productivity. While, conversion floodplain forest to agricultural forest, potential of productivity tend to decline. In agricultural forest loss of total carbon occur 49-79% while loss of non-labile carbon occur 41-74% and loss of labile carbon occur 72-96% when compare with remaining forest.

In this study founds that loss of soil labile carbon could be indicator of soil degradation. Due to the status of soil labile carbon indicates that the degree of soil degradation appear moderately. Nevertheless, the system can continue to maintain it stable this might be due to floodplain forest areas have high potential of nutrients supplies from labile pool.

By using the $KMnO_4$ oxidation technique can provide useful results in monitoring of soil labile carbon status in soils. The C_L status in soil can be indicator of potential productivity and degree of degradation. This provides information in order to rehabilitate and sustain the remaining floodplain forest in the Northeast of Thailand.

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Nanta Sitthirach

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CHAPTER I
INTRODUCTION

Floodplain forests areas are very important wetland in Northeast of Thailand. Floodplain forest defined as vegetation where occurs in floodplain area. The forest founds along the river particularly in the Northeast. Mongkolsawat (1988) reported the area of floodplain in the Northeast is 5,929,100 rai or 5.62% of all cover areas. Their virtual important consists of ecosystem function and benefits to rural socio-economics. Communities have historically been used of floodplain for their living for long time period.

However, this obviously lacks of management policy and its are not able to harmoniously in practice. Such as, the cabinet resolutions also categories floodplain as watershed level five which is not relatively important area for protection and conservation. In 1998, the policy planing and action plan in wetland management were launched where include floodplain area in the Northeast. However, in practice the development policy that related to floodplain makes permanent degraded floodplain particularly dam construction or road construction in floodplain area (Department of Environmental Quality and Extension and Tammun Project, 1995).

As Davies and Claridge (1993) reported productivity of wetland ecosystem are higher than or equal to productivity from intensive agriculture. However, in the Northeast there is not directly study in floodplain forest productivity. According to Kunurat et al. (1991) study floodplain forest in the middle Mun river showed that floodplain forest is productive system there were plenty and high biodiversity. There were consists of 100 plant species, 57 fish species, 13 mollusk species, 2 shrimp species and 2 crab species. The report in study status of fish species in the lower Songkram river shows that there were 182 fish species and 14 species in endangered (Vittayanon et al.1998). The diversity of fish species are important for the fisheries occupation of villager who live in the lower Songkram river basin. Some village, peoples move to settle in area of the Songkram river basin because of there were abundance of fishes resources. Moreover, floodplain soil is appropriate for agricultural villager found that they can obtain high yields from rice growing. From past to present floodplain areas have been used for agricultural in particular for rice growing and grazing. Mongkolsawat (1987 in Boapan and Yangmee, 1987) reported that in the Northeast the soil that suitable for rice growing is floodplain soil. These soils can also founds in area closed to the river as particularly the Mun river, the Chi River and the Mekong River. The rice production in this area raised up to 600-750 kg/ rai without fertilizer apply.

As a result, it shows that floodplain forest have a high potential in productivity and benefits to communities. However, floodplain forest in the Northeast rapidly degraded these are deteriorated floodplain forest area and over exploitations meanwhile lacking of research and knowledge in its ecosystem. Since 1995 the Department of Environmental Quality and Extension and Tammun Project have been proposed that its should be a research in floodplain ecosystem and environmental impact due to ecological changing (Department of Environmental Quality and Extension and Tammun Project, 1995). At present, most of research study on quantitative data, policy planing and floodplain forest management. For example, Wetlands Mapping in the Northeast, Remote Sensing, GIS in wetlands mapping, Rapid planing and management plan in Patam Rasrisalai Changwat Sri Saket. Consequently, it requires a study on monitoring changing of floodplain forest ecosystem. According to literature review it lacks of study that can be indicator of potential productivity of floodplain forest areas.

Although production systems of wetlands are high production system thus it needs an appropriate management in order to stable their productivity. Due to rapidly degraded of floodplain forest on the other hand communities living very depend on the existing of floodplain forest resources and their production. Wetland soil plays important roles in supporting the production of the systems. Fertility of wetland soil influenced by soil physical, chemical and biological process of soil.

Based on soil ecosystem, which is a major component of the system. The soil organic matter is a key sources and sinks of plant nutrients in soil ecosystem. According to plant nutrients are contained in soil organic matter pools, these nutrients release to soil system by decomposition which is available for plant uptake. Nutrient availability is a major controlling factor in productivity and ecosystem stability.

This research is to study on soil nutrients and carbon pools as an indicators of productivity of floodplain forest areas. Productivity defined as one component of system properties that can also measures per resource unit. The study consider on changing in soil nutrients and carbon pool in order to assess soil degradation and a potential of productivity. Moreover, from this study it can also be a primarily as an indicator of a potential productivity of floodplain forest areas. In the other hand, this can represents the status of floodplain forest in the Northeast in order to maintain sustainability of floodplain forest use.

These concepts were employed in order to assess inland floodplain potential productivity under differences land use system. The technique that using in this study in order to assess carbon pool proposed by Blair et al. (1995) in carbon pool a part of labile carbon was considered. This because of labile pool is the part of carbon pool which is rapidly release nutrients to soil systems due to their ability of lability. Thus, their have roles in rapid nutrient release as well as in area that have been used for long time labile carbon becomes the first part that changed in carbon pool.

The objectives of this study are as follows:

1. To study soil labile carbon of floodplain forest areas under differences land use systems.
2. To assess potential productivity of floodplain forest areas by using soil labile carbon.
3. To assess degree of degradation of floodplain forest areas under different land use systems.

Ban Pak Yam Tambon Sampong Srisongkram district Nakhon Phanom province is located in floodplain area of the Songkram river. Floodplain forest is the dominant vegetation in this area. It is a natural resources based for communities as fisheries, agricultural and gathering forest product. However, since the degradation of fisheries resources thus makes the villagers need to find another way in their production for subsisting themselves. Currently, villagers use floodplain forest for rice growing in dry season. These obviously transformations of land use changes of floodplain forest into cultivated area. These might be affect to natural system of floodplain forest. On the other hand, it need to know how the system continued maintain their stability. Thus, these provide the opportunity to study the affect under land use changing particularly in terms of potential productivity.

CHAPTER II

LITERATURE REVIEWS

A floodplain forest is important natural resources for communities living. Due to changes of floodplain forest use, it needs to understand more clearly on the functions of floodplain forest particularly the productivity of the system. Soil is a major component of the systems as it support the production of the system. In soil system, organic matter plays important roles as nutrients sources for plant uptake this related to productivity and sustainability of the system. Therefore, it needs to search for the relationships between soil organic matter, soil nutrients and productivity. This will provide the information to maintain the sustainability of floodplain forest for coming generations.

2.1 The relationships between human and their environment

Lovelace and Rambo (1991) reported the relationships between humans and their environments by focusing on the systematic interaction of the natural ecosystem and the human socials system. The natural ecosystem consist of biophysical factors, such as soil, water, climate, flora and fauna. The interrelation of change in one component lead to a changing in other components. For example, soil fertility changes lead to a decreasing in an agricultural production. These relations affect the ability of humans to obtain their needed resources and the impacts on an environment where had produced by human activities.

Similarly to a natural ecosystem, the human social system consist of many of interrelated elements. These elements are demography, social organization, economics, ideology and political institutions. The interaction of these components that is largely determined by social characteristic where have considered to be an influence factor on stability, resilience and development of the social system.

The interaction between the natural ecosystem and the human social system formulates in form of energy flow, materials and, information. These flows influence the structure and the function of each system. The social system, for example, requires a steady flow of energy from the ecosystem in a form of food, fuel and manufacturing in human activities. The social system in turn release materials into the ecosystem in a form of wastes and pollutants. These inputs influence a biotic composition of the ecosystem, which in turn affects the availability of energy and materials to the social system. In agroecosystem, for example, land have changed to cultivation as the farmer harvest every years to sell their products in the market. Consequently, nutrients are transferred from the system into form of agricultural products these affects to decline the soil fertility.

The natural ecosystem and human social system need to be balanced and maintained through time, selection, and adaptation under changing in the long run. The natural systems have a capacity to resist change. There are limitation in a system adaptation as some of the relationships and their dependency are not balance because lack of compensation from the outside due to degradation in natural resources. For example, the villager gathers the forest product for their own basic needs where the forest is conserved to prevent over uses. Therefore, this directly affects in obtaining resources for their living. As a result, the villagers needs to adapt themselves to regulate resources use in order to sustain the system.

As discussed above indicated that natural resources are very important resources base for the community living. This comes from contribution of productivity of the natural system. However, use of natural resources can lead to declining in productivity of the system. On the other hand, this will effect to a living style of peoples.

2.2 Components of rural resources systems

The rural resources systems are consist of many sub-systems that have interrelation between each component. Moreover, these have different level as affected to resources uses and production in each area. These components can also describes as (Smutkupt, 1993):

Physical components: The physical components are consists of topography, climate, temperature, rainfall, water, and soil which important to potential of productivity in each area.

Biological components: The biological components are consists of plant and animal type, bio-resources uses, cropping system and husbandry. These components could have changed all the time. These depend on socio-economic criteria of each area.

Socio-economic components: The socio-economic component consist of the communities dependent, attitude, belief, knowledge, decision, inputs, resources management systems and the communities needs. These components uncertainly and have dynamics.

2.3 Characteristic of rural resources

Natural resources is a part of environment that support human needs, societies set up their management and regulation by themselves in order to regulated uses. Smutkupt (1993) reported that there are three characteristics of the rural resources:

Private property: Private property is the resource as owned by each social member. This were regulated under law or social rules.

Common property: Common property is the resource owned by communities or common. The use of its was regulated by the communities.

Excessive property: Excessive property is the resources that have plenty. The use of these does not have affect to the communities.

According to the above, the floodplain forest characterizes in term of private and common property. The main characteristics to described are consist of :
Floodplain forests rule over by the member of the communities that have a right to use. Floodplain forests are limiting resources which can decline throughout the time.
The community rules the regulation in uses and management on floodplain by the community organization.

The broadly research demonstrate the relationship between human and resources are Prakongsri (1995), Chamarik (1993), Vityapak (1995), Srisinurai (2000) Nakam (2000) .

2.4 Landscape-ecology of the Northeast

The Northeast consists of different landscape-ecology thus due to the difference in topography, soil, vegetation and climate. Follow Keeratikasikorn (1984) and Mongkolsawat (1988) the landscape-ecology characteristics of the Northeast are consist of three major characteristics: (Figure 2.1)

Floodplain

The floodplain occurred along the river in the Northeast at the sea level where is lower than 150 meters. The annual inundating caused by water level raised from the river and from the upper reaches. In some area there are oxbow lakes. This caused the river changing the direction of water throughout long time. Between the floodplain and the river, there is usually a levee, which the villages have settled near the floodplain and the river. Mainly, soil is alluvium soil which has a high potential for rice growing in the Northeast.

Low terrace

The low terrace is an area upper than the floodplain where is at a sea level 160-175 meters. The soil is particularly sandy loam, these mostly uses for rice growing and field crops.

Middle terrace and upper terrace

The middle terrace and upper terrace is undulating area where is at sea level upper than 175 meters. The soil particularly sandy loam, it have used for rice growing and field crops.

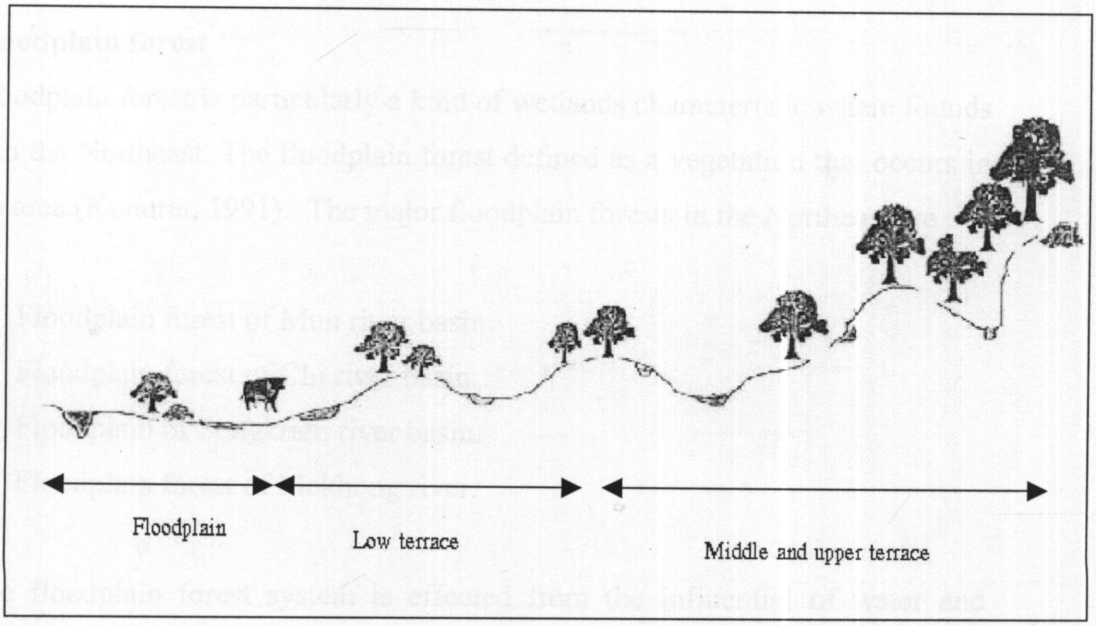

Figure 2.1 Landscape-ecology of the Northeast

Source: Department of Environmental science (1999)

2.5 Forest resources in the Northeast

Follow Dacha (1991) the forest resource in the Northeast is distinction. It has developed under the differences climate, topography, and the sea level. There are three major classes of forest.

Evergreen forest divides to seven categories, it consists of moist tropical evergreen forest, dry evergreen forest, hill ever green forest, hill pine forest, low land pine forest, swamp forest, and floodplain forest.

Deciduous forest divides to two categories, it consists of mixed deciduous forest and dipterocarp forest.

Glass lands in the past it less distribute in the Northeast. Present, there are abundant in many areas in the Northeast as the conversion of forest to the agricultural land.

As a result, the most important forest in the Northeast is deciduous forest includes mixed deciduous forest, dipterocarp forest and floodplain forest. Its is important resources based for the communities over time.

2.6 Floodplain forest

Floodplain forest is particularly a kind of wetlands characteristic where founds typically in the Northeast. The floodplain forest defined as a vegetation that occurs in floodplain area (Kunurat, 1991). The major floodplain forests in the Northeast are :

1. Floodplain forest of Mun river basin.
2. Floodplain forest of Chi river basin.
3. Floodplain of Songkram river basin.
4. Floodplain forest of Mekhong river.

The floodplain forest system is effected from the influential of water and topographical. Based on topography condition, forest structure is different from the terrestrial ecosystem. Follow Yukong (2001) the forest structure were classified as three types follows (Figure 2.2):

1. Temporary inundating area: This forest is inundated during annual inundating season. As it topography condition is lower than water level.
2. Non-inundating area: A levee terrain, forest area is higher than water level. Its area is not inundated during annual inundating season.
3. Permanent inundating area: In some areas there were contemporary water sources this is influenced from the change of the water direction.

There are folk categories as 2 type of sub-characteristic. The first is called "Tam", it means the lower floodplain area that along the river. These areas generally inundated in rainy season. It is consist of a small natural water reservoir such as ponds, oxbow lake, swamp, and water channel. The second is called "Bung" this particularly founded in some areas of Tam which close to riverine (Kunurat,1991).

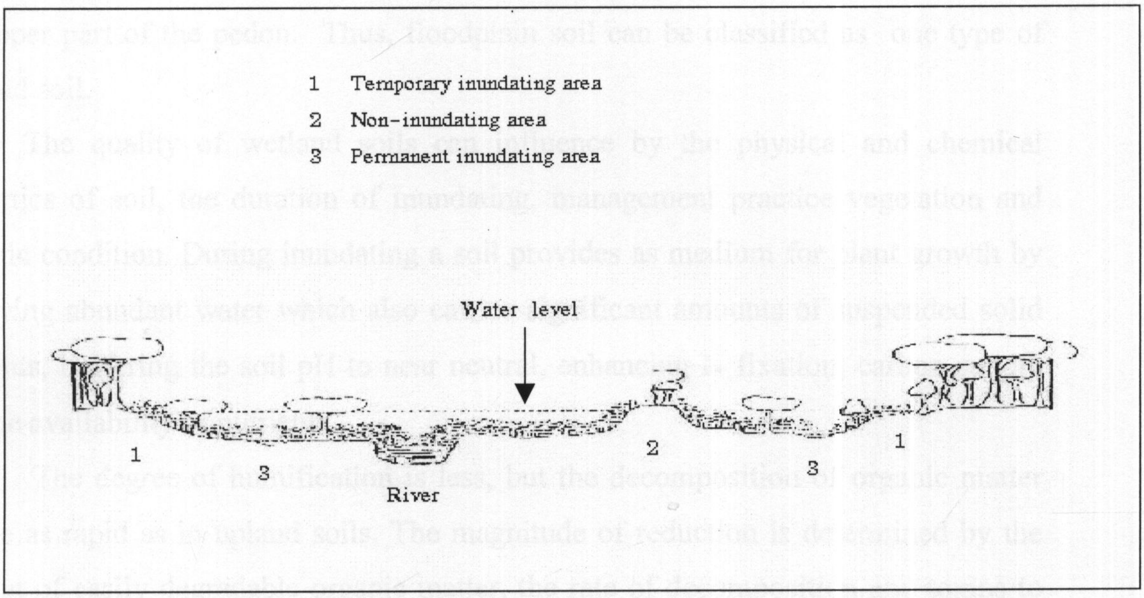

Figure 2.2 Floodplain forest structure
Source: Yukong (2001)

In additionally, Mongkolsawat (1988) reported the area of floodplain in the Northeast cover 5,929,100 rai or 5.62% of all cover area. Floodplain vegetation have a characteristic which adapted to tolerate during flooding. Pawaputanon Namahasarakam (2001) reported the biodiversity of floodplain forest in Mahasarakam province that have also founded 125 species of plant. Usually, during annual inundating this allow sedimentation in order to increase soil fertility. According to Keeratikasikorn (1984) and Vityakon (1996) reported floodplain forest soil have a high fertility greater than other soil in the Northeast.

Moreover, during inundating floodplain forest, it is also provided natural hatcheries, in stead balancing between transition zone and protection flooding in lower area of the river. Moreover, also provide foods and other material for daily living of the villager (Kunurat,1991) and (Srisinurai,1999).

2.7 Wetland soil

Follow Neue et al. (1991) wetland soil can be defined as soils whose development and properties are influenced by temporary or permanent saturation in the upper part of the pedon. Thus, floodplain soil can be classified as one type of wetland soil.

The quality of wetland soils can influence by the physical and chemical properties of soil, the duration of inundating, management practice vegetation and climatic condition. During inundating a soil provides as medium for plant growth by supplying abundant water which also carries significant amounts of suspended solid nutrients, buffering the soil pH to near neutral, enhancing N fixation, carbon supply and the availability of nutrients.

The degree of humification is less, but the decomposition of organic matter can be as rapid as in upland soils. The magnitude of reduction is determined by the amount of easily degradable organic matter, the rate of decomposition and toxins to microorganism, and the amounts and kinds of reducible nitrates, iron and manganese oxides, sulphates and organic compounds. The nutrients status of wetland soils, nitrogen fixation is higher, P is more available, and K supply is better than in comparable upland soils.

Follow Keeratikasikorn (1984) reported that obviously floodplain soil has a high fertility than the general of the Northeast (Table 2.1).

Table 2.1 Floodplain soil properties of the Northeast

Soil properties	
pH (1:1) in water	5.4 - 5.8
Organic matter (%)	2.22
P (ppm)	9.7
K (cmol/kg)	0.3
Ca (cmol/kg)	6.2
Mg (cmol/kg)	2.4
Na (cmol/kg)	0.3

Source: Keeratikasikorn (1984)

2.8 Productivity

Productivity defined as a production under agroecosystem per units of inputs used such as capital, labor, and natural resources. Thus, the assessment of productivity can also measures by production per resource inputs. (Prakongsri,2000). However, in order to assess the potential productivity of agricultural system there are serveral indices of measuring productivity.

Lal (1994) proposed productivity assessment in order to assessed sustainability of agricultural system, there are include with: First, productivity can also measure as production in term of biophysical production per unit of resources used. For example, in system of rice-wheat production in South Asia the productivity of the system tends to unsustainable because there is the decline in soil organic matter content. Thus, due to agricultural practices and harvesting caused of low organic matter in soil. However, in this case the productivity will be considering as single inputs. Second, productivity can also measures as total production in term of a measure of total outputs relative to total managed inputs (e.g. water, labor, land resources, ect.). Third, productivity can also measures as outputs per unit inputs of managed and natural resources used. The indirect costs associated with specific outputs that may be due to the degradation of natural resources. It is an index of the health of the natural resources, and combines biophysical, economics and social dimension of sustainability. Consequently, there are different scales of assessment productivity e.g., soil, plant, land use, farming system, ect. It can also be measured in term of resources qualities and quantities.

However, there are serveral approaches to measure the productivity. The main factors among this it should consider in term of components of the productivity as there are many components that relate to the level of productivity. To measure the productivity in any approach, it is necessary to measure the flow of inputs and outputs across the boundary of the system over time. As, taking care to include all the inputs and outputs and to aggregate each set to produce a single measure of inputs and a single measure of outputs.

Karen et al. (1997) proposed a sustaining on productivity is one of a soil function of the ecosystem. Thus, due to the capacity of soil function indicated that it could have reflected to the productivity. The function of soil as proposed by Karen et al.(1997) are:

1. sustaining biological activity, diversity and productivity;
2. regulating, partitioning water and solute flow;
3. filtering, buffering, degrading, and immobilizing;
4. storing, cycling nutrients and other elements within the earth's biosphere; and
5. providing support of socio-economics structures

In agricultural system, the soil is an important component to maintain the productivity to indices the ability of agricultural systems to remain productive and efficiently (Cassman et al, 1995). In this study, the assessment of potential productivity in aspect of soil properties were considered.

2.8.1 Productivity system

Follow Prakongsri (2000) productivity system contained three components which have interaction between each component in order to contributes productivity. There are consists of:

Inputs

In agroecosystem inputs were considered in term of natural resources and socio-economics environment. These have been used in production system. For example, in land use systems the soil have been used in agricultural while soil are consist of sub components that supported soil system in their production such as nutrients, organic matter, and soil structure. Moreover, the farmer needs is a part of production as changing land use for their needs.

Process

The process of agroecosystem are considered in aspect of the interaction between sub components and outputs in the system where is a result of taking inputs into the system. For example, in any land uses processing, the natural system were converted to an agricultural land for the production and harvesting meanwhile the nutrients are released and uptake via plants into the process of land use.

Outputs

The outputs are resulted of the system process due to the interaction between each component which coinside with system inputs.

To undertake the potential productivity measurement, it is necessary to understand the productivity system and its components. It is difficult to assess inputs, process and, outputs in agrocosystem where has a complicate system. Alternatively, the assessing from sub component in system can represents the system productivity. However, productivity is a result of a relationship between inputs and management on the used of resources base within a given socio-economic context. To consider the system there are three aspect of system (Herdt and Steiner, 1995) includes with:

Spatial levels

One may consider systems across an infinite range of space : global, regional, farm field, individual plant and microscopic. Simply defining the level of a system under consideration is only a beginning because at any level many possible types of system exist. Thus a clear definition of the particular system is defined in order to distinguish it from other types at the same level. For example, in agricultural system the production is affected not only by the weather, with its variation in rainfall, solar radiation and temperature, but also by the biotic environment, diseases and by the soil with its physical, chemical, and biological characteristics

Time

System can only be thought of in the context of a defined time period. Consideration of the time dimension is further complicated by the dynamic nature of reality. The agricultural production system is constantly changing. Almost everywhere the systems in use by farmer today are different from the past.

Dimensions

In aspect of systems dimension, it is too complicates in which people think about the human condition. However, the agriculture system plant growth is a biological process where results in physical change, but agriculture is an economics activity serving a social purpose. The three dimensions, biological, economics, and social may be analyzed in very different, although interrelated way.

Conway (1985) reported an important phase of the procedure of agroecosystem analysis is pattern analysis. Four patterns are chosen as likely to reveal the key functional relationships that determine system properties. Four of these include space, time, flow and decision making. Space, time and flow are known to be important in understanding the properties of ecological systems.

Space

Spatial patterns are most readily revealed by simple maps and transects. Overlays are particular useful in uncovering potentially important functional relationships. Transect are particularly useful in revealing the spatial relationships of different forms of land use and in pinpointing the location and the origin of the important problems.

Time

One of the most useful conceptual tools is the seasonal calendar. This reveals the interaction between climatic patterns and the cropping cycle to identify the critical points in the year.

Flow

Flow includes the pattern of flow and transformations of energy, materials information, ect. Flow involves in the generation of farm income, a transference of cultural influences and ideas.

Decisions

Two patterns are important. The first is the choices made in a given agroecosystem under differing conditions. These can suggests what are the important factors that determine. The second pattern is of the spheres of influence of decision makers. Analysis is primarily required in order to identify the critical decision makers in the system.

2.9 Land use

2.9.1 Definition of land use

Land use is determined in term of any human activities that related to the land thus human determined land use type in order to achieved their needs as ecological and socioeconomic. In the other hand, land use affects in positive and negative to the ecological and human living (Lal,1995).

Prakongsri (2000) reported land use as a resources base in agroecosystem which need to managed in production. Management determined the changed natural ecological of land resources in order to make land suitability in agricultural. Consequently, the agricultural production has been continuity removed as crops from agroecosystem. Nutrients outputs via crop harvests far exceed the other nutrient loss pathways combined. Thus this is a main cause of decrease the potential productivity of soil in order to maintain agricultural production and leads to degradation of soil and productivity.

2.9.2 Effects of land use on soil properties

2.9.2.1 Soil physical properties

Physical properties of soil are limiting factors for plants growth. Subsequently, agricultural land use effects physical soil properties. As such, changing structure typically solidity in soil structure is an obstacle in water and air movement and difficult of root growing. These lead to decreasing on productivity. From the study on Alfisol soil that have been used for agriculture over period of time it founded that there is more than 13% increase in bulk density (Titan,1998). As a result, the appropriate physical soil properties support increase in plant growth and productivity (Theinsukhon, 1994).

2.9.2.2 Soil chemical properties

Soil chemical properties concerned in nutrient quantitative and availability. There are many factors controlled chemical soil properties such as, soil pH, quality and quantity of organic matter. Ruaysoongnern (2000) reported soil pH have roles in nutrient availability, nutrient dissolved and microbial activities. The comparison between agricultural soil and forest soil founded that pH in natural soil higher than agricultural soil. Titan (1998) reported that in Alfisol soil has been used for agriculture soil as pH is lower than in natural forest. This could have predicted that soils were degraded. Ruaysoongnern (2001) reported land degradation in the Northeast under conversion forest land to agricultural land where lead to soil pH declined.

According to Ruaysoongnern (1996) reported that due to the rapid decline of organic matter will be result in low buffering capacity, low CEC, and a low nutrient pool. This relates to depletion of soil nutrients, such as, P, K, Ca and Mg. Consequently, these will be lead to low biological activities. As well as microbial activity could directly influence nutrient availability, cycling and nutrient uptake mechanism.

2.10 Soil degradation and land use

As stated by Oldeman (1994) soil degradation defined as a process which lowers the current and/or future capacity of the soil to produce goods or services. According to the world map of soil degradation was published under scheme "Global Assessment of Soil Degradation" UNEP project . The main types of soil degradation are as follow:

1. Water erosion

The displacement of soil material by water can have broadly negative consequence. The removal of part of top soil reduce the productive capacity of the soil.

2. Wind erosion

The displacement of soil material by wind is nearly always caused by a decrease of the vegetative cover of the soil, includes overgrazing or to removal of vegetation for agricultural purpose.

3. Chemical degradation

Chemical degradation process are very different. The degradation occur through loss of nutrients and organic matter. The salinization, acidification and pollution are also included.

4. Physical degradation

Physical degradation can be identified into three types as follow:

1. Compaction, crusting and sealing. Compaction of soil caused by the use of heavy machine, sealing and crusting of top soil occur soil cover disappear.

2. Waterlogging. Human intervention in natural drainage system may caused of waterlogging.

3. Subsidence of organic soil. This phenomenon is caused by drainage and oxidation of organic soils.

The degree of soil degradation is presently degraded in a qualitative manner to agricultural suitability of the soil, to its reduced productivity, to its possibilities for restoration to full productivity and in relation to its original biotic function. The degree of soil degradation can be described as follow:

1. Light

The terrain has a somewhat reduced agricultural suitability, but is suitable in local farming systems. Restoration to full productivity possible by improved management, original biotic functions are largely intact.

2. Moderate

The terrain has a greatly reduced productivity, but is still suitable for use in local farming systems. A major improvement are required restore the terrain to full productivity. Original biotic functions are partially destroyed.

3. Strong

The terrain has virtually lost its productive capacity and is not suitable for use in local farming systems. Major investment is required to rehabilitate the terrain. Original biotic functions are largely destroyed.

4. Extreme

The terrain is unreclaimable and beyond restoration. Original biotic functions are fully destroyed.

The increasing in pressure on the land, the increase desire for better living condition, have resulted in some kinds of intervention that have caused the soil degraded. There were five factors caused soil degradation:

1. Deforestation or removal of the natural vegetation.

Clearing of the land for agricultural purposes, large scale commercial forestry, road construction, urbanization.

2. Overgrazing

Actual overgrazing of the vegetation may not only lead to disappear of vegetation, but can cause soil erosion.

3. Agricultural activities

This includes a wide variety of agricultural practices, such as insufficient or excessive use of fertilizer, use of poor quality irrigation water, use of heavy machinery, etc.

4. Overexploitation

Use of the vegetation for domestic consumption such as fuel needs, fencing, etc. There is not a complete removal of the vegetation but the remaining vegetation does not provide sufficient protection against soil erosion.

5. Bioindustrial an industrial activities

This factor is directly related to the soil degradation, particularly soil pollution.

Deforestation, overgrazing and agricultural activities are all the main factors of soil degradation. Deforestation leading to a rapid decline of organic matter in the top soil, is an important cause of chemical degradation of soil. Agricultural activities such improper water management in irrigation area is cause of chemical degradation of soil.

2.11 Soil organic matter

2.11.1 Pools of organic matter

Follow Gregorich and Janzen (1996) the pools of organic matter are largely conceptual and are considered to be regulated by a number of physical, chemical and biological factors, which in turn can be modified by management practices. The largest sources of carbon in soils are from litter. Litters enter the soil as dead and decaying above-ground biomass, senescent root tissue, sloughed root cells, and root exudates. The carbon in these litters is present in a wide range of substrates, from readily decomposable cytoplasmic materials to more resistant cell wall components.

Upon entering the soil, these litters undergo physical and chemical transformations and the organic carbon is eventually released from soil as CO_2 or stabilized by humification or association with mineral components. On the other hand during decomposition nutrient also released to soil.

In the model of carbon pool, litter added to soil consist of two components, metabolic and structural. The metabolic component is more decomposable than the structural material. It provides a readily available energy sources for decomposer and is therefore most influential during the initial stages of decomposition.

Swift et al. (1991) proposed there are five major pool of organic matter fractions. The component pools can be defined as follows:

1. Litter

The litter is the generic term for dead plant matter, providing inputs, above ground and below ground from plant to soil. The litter is the source of energy for driving the soil system, and is an important linkage in the pathway through which nutrients are cycled within ecosystems. Moreover, surface litters have marked environmental effects on the physical and biological properties of soil.

2. The soil biomass

Soil biomass is the living microbial and animal component of soil. It play a central roles as the mediator of most process of organic matter transformation in soil. Soil biomass is also a pool of carbon and nutrients in the soil. Although one with a rapid turnover. The soil biomass is the means by which the nutrients in the other organic matter fractions are made available to the plant. The scale of nutrient release by biological activity depended on factors which determine the decomposability of the materials and weather nutrients are immobilized in the biomass or released to the soil through cell death, as well as by the physiochemical environment of soil.

3. Labile soil organic matter

Labile soil organic matter is organic matter which is readily decomposable by the direct action of microbial enzyme systems. It is heterogeneous mixture of comminuted, and partially decomposed fragment of litter, animal carcasses and dead microbial cells. The labile soil organic matter is significant for soil fertility as a sources of readily available nutrients.

4. The slow soil organic matter

Slow soil organic matter pool is defined as intermediate pool of polymer of plant origin that have been transformed by decomposition but should not be classified as humic substances.

5. Passive soil organic matter

Passive soil organic matter is the amorphous polymeric organic material synthesized as a byproduct of the litter decomposition processes. This is the humus which is resistant to further decomposition. Passive soil organic matter constitutes a stable reservoir of nutrient such as N, S and P. It is as a major sources of cation through the surface change properties of the humic colloids.

2.11.2 Roles of soil organic matter and soil nutrients on productivity

Sanchez et al. in Lefroy et al. (1995) indicated that soil organic matter is a key material resources and key nutrients sources and sinks in agroecosystem. As, it is a reservoir and sources of energy in soil ecosystem. Thus, the fertility of most agricultural soils depends to a large extent on their organic matter content. The important are usually considered in terms of soil physical, chemical, and biological properties affecting the ability of a soil in production. Soil organic matter was contributed to the physical fertility of a soil by affecting soil structure through the formation of stable aggregates. In turn, soil aggregates affect the rate of infiltration of water, water holding capacity, the gaseous exchange. In addition, soil organic matter affects the chemical fertility of the soil through the total supply and availability of plant nutrients. Soil organic matter is a direct sources of plant nutrient, which are released to through microbial activity, as well as being a significant component of the ion exchange capacity of soil.

Tate (1987) reported soil organic matter pool provides as sources and sinks of plant nutrient in order to supplying nutrient to the system. Nutrient availability is a major controlling factor in biomass productivity and ecosystem stability. Although the substantial quantities of plant nutrients are contained in soil organic matter pools where these nutrients will release to soil by decomposition which is available for plant uptake.

The decomposition of organic matter releases many nutrients, such as nitrogen, phosphorus, potassium and sulfur. As well as many micro nutrient. (Phetchawee and Chaitep,1995). A nutrient release under decomposition, Anuar et al (1995) founded there were 70 % to 80 % of K in the litter was released within the first five weeks while the release of N, P, Ca and Mg follow the trend in the rate of litter decomposition.

The efficiency of plant biomass synthesis and the rate of return of this to the soil ecosystem also controls ecosystem productivity. The ratio of nutrients that release from soil organic matter and total nutrient contained in soil fraction vary with ecosystem type. The higher of the organic matter content implied that there were the greater of the potential nutrient yield.

Nutrient status in soil, the roles of nutrient is to the growth of plants. Particularly, productivity is to sensitive to different level of soil nutrient. However, it tend to increase productivity with the high level of soil nutrient. For example in case of soil phosphorus, crop yield may be relatively insensitive to level of phosphorus over a wide range of available phosphorus. But, when the level is depleted below a critical value yield will fall, and it may take more than mere application of the amount of normally required by a crop to return yields and to return their former level.

Although, there is no universally accepted a set of resource base quality measures, some, mostly, reflecting various soil properties, are broadly accepted. Soil organic matter, soil structure and soil pH may be change as a consequence of the inputs applied and the outputs removed. However, it depend on the ecosystem in using criteria for measurement.

Tiessen et al. (1994) reported in many natural ecosystems P availability limits overall ecosystem productivity through its effect on plant production and nitrogen fixation. Correlation between available P and soil carbon are therefore frequently observed as an expression of the overall P limitation on ecosystem productivity and soil organic matter accretion.

Aune and Lal (1995) reported the relationship between soil properties and relatives productivity these included soil organic carbon, available P and exchangeable K. The data show that there are relatives between soil organic carbon, available P,exchangeable K and cereal yields(Figure 2.3-2.5). These implied that soil properties has effected on productivity. Similarly, Thinsukon (1994) also reported there are relatives between yields and soil properties such as pH and organic carbon.

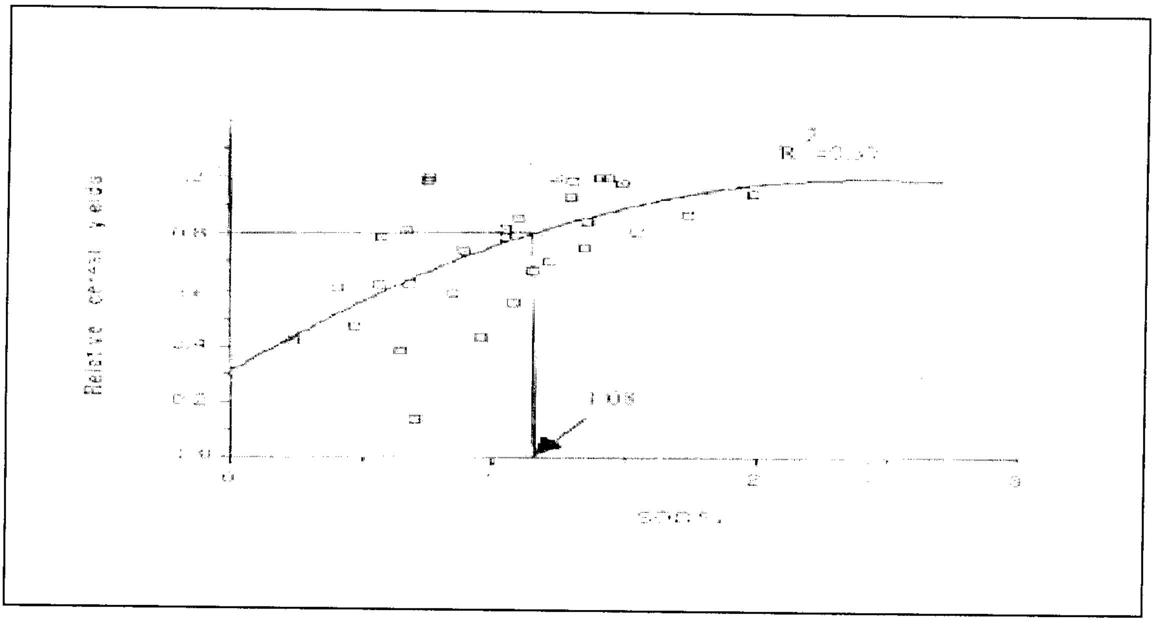

Figure 2.3 Relationship between % SOC and cereal yields

Source: Aune and Lal (1995)

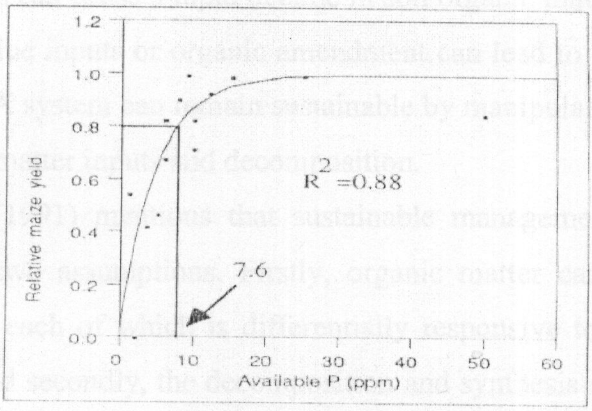

Figure 2.4 Relationship between available P and relatives yield of maize

Source: Aune and Lal (1995)

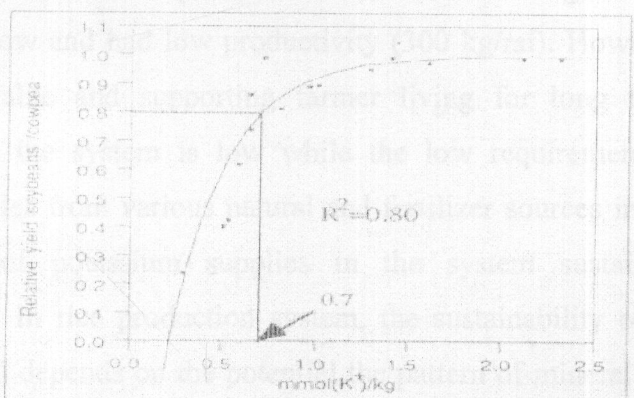

Figure 2.5 Relationship between exchangeable K and relatives yield of soybean

Source: Aune and Lal (1995)

Soil organic matter is a labile resource that can also depletes and renew by altering cropping practices. Changes in the soil environment leading to a decrease in plant productivity this can cause a rapid decline in soil organic matter levels, while an increase in crop residue inputs or organic amendment can lead to a synthesis of new soil organic matter. A system can remain sustainable by manipulating the factors that regulate soil organic matter inputs and decomposition.

Swift et al. (1991) mentions that sustainable management of soil organic matter is based on two assumptions. Firstly, organic matter can separate into a number of fractions, each of which is differentially responsive to management and land use practices, and secondly, the decomposition and synthesis of each fraction is regulated by definable sets of physicochemical and biological factors, which in turn may be modified by management. Vityakon (2001) reports as a result of land use for agriculture over time can be obviously lead to declined in soil organic matter. Soil organic matter in natural forest is higher than in paddy rice soil and field crop soil. From the study of land degradation in the Northeast when compare between forest soil and agricultural soil, it found that soil organic matter in agricultural soil decreased particularly in top soil (Ruaysoongnern, 2000).

Vityakon (1989) reported in rainfed rice agroecosystem potassium requirement is low and had low productivity (300 kg/rai). However, the system can maintain the stable and supporting farmer living for long time as potassium requirements in the system is low while the low requirements can adequate by potassium supplies from various natural and fertilizer sources in the agroecosystem. The adequate of potassium supplies in the system sustain the rainfed rice agroecosystem. In rice production system, the sustainability of rice production in sandy paddy soil depends on the potential the pattern of mineral transfer. In order to improve nutrient availability, the nutrient use efficiency and to prevent potential of nutrient loss from the system its need to be management organic matter in the system (Ruaysoongnern, 1995).

Panchaban (1995) reports the agricultural productivity in the Northeast is low due to the physical characteristic of the area which is the major factor. For example, the soil is low fertility, mostly it is sandy soil. Particularly, in upland soil the productivity is lower than the lowland. To increase productivity is to increase soil fertility in cropping and soil management.

Herdt and Steiner (1995) reported in order to measure the potential productivity in term of all inputs and all outputs, it is also necessary to analyse what is happening to the quality of the resources base since, by the quality of resources base is expected to affect future physical and biological production. The potential productivity indicators can also measures by using the resources base characteristics that contribute to expected to future productivity and may change over time.

2.12 Soil carbon fractions

As Blair et al. (1995) reported changing in carbon pool is one of indicator in assessing a sustainability of agricultural system. As such, changes in agricultural practices results in marked changes both the pool size and turnover rate of SOM, carbon and therefore nutrients. Consequently, the key to sustain a productivity of agricultural system is the maintenance of soil organic matter levels and nutrient cycling.

The status of the soil organic matter resources base is assessed by measurement of the amount of carbon pool in the soil. This base on the ability in break down of soil organic matter. Measurement of the rate of break down have been used to assess the quality of soil organic matter. Most attempts to develop models of soil organic matter turnover and relate soil organic matter dynamics to soil fertility have involved in seperation of carbon into a number of pool on the basis of their rate of turnover (Lefroy et al., 1995).

However small changes in total SOM or C are difficult to detect because of the generally high background levels and natural soil variability. For this reason many attempts have been made to use sub-pools of SOM or C as more sensitive indicators of change in pool size. Changes in the lability of soil carbon have been proposed by Lefroy et al. (1993) as a measure of sustainability. Additionally, based on changes in the total C in the soil and its lability as determined by permanganate oxidation technique have been used in development of carbon mangement index (CMI). Particularly, SOM exist in a wide diversity of form with considerable variability in decomposition rates.

Using permanganate oxidation technique, total carbon pool can also separate into two parts. There are consists of labile carbon form and non-labile carbon form. The labile organic carbon provide the sources of plant nutrient in soil due to its chemical composition and rapid turnover rate, and is responsible for temporary soil structural stability until it is further decomposed (Coneth and Blair, 1998). In different land use system changes in carbon pool can also founds both total pool, labile pool, and non-labile pool .The loss of labile fraction is greater than the loss of total soil organic carbon upon cultivation.

Follow Conteh et al. (1997) by using 333 mM$KMnO_4$ oxidation technique to determine a change in soil carbon under different land use systems. It was found that cultivation has led to a decrease in the organic carbon status of the soil. The effect of cultivation was found to be more pronounced in the C_L and the carbon manegment index (CMI) than in the C_T and C_{NL}. The changes in the ratio of C_L to C_{NL} as a result of cultivation have been variable. The CMI has generally declined during cultivation, and since the CMI has incorporated the changes taking place in C_T, C_L, and C_{NL}, the use of this index can provides very useful results in monitoring of organic matter status of soil (Table 2. 2).

Konboon (1998) reported increasing in labile organic carbon in soil related to the productivity of the lowland rice cropping system. The ability of organic matter to release nutrients depend on the ability of litter decomposition, carbon release and the amount of nutrients during decomposition. This is an indicator of the system fertility on both short term and long term. The difference of land management had effected on the changing of carbon pool. The ability of nutrient release is measured in term of the ability of carbon release includes total pool size and labile pool. The increasing of the carbon pool leads to increase soil nutrients.

In the Northeast, the research found that the rice grain yield is increased after a managing litter inputs. The forest soil has C_T, C_L, and C_{NL} where is higher than 20 years soil for rice growing. After litter management for four seasons cropping C_T, C_L, and C_{NL} increased. Additionally, these can be different by type of organic matter. (Table 2.3-2.4)

Table 2.2 Carbon fractions in soils of Gwydir Valley

Cropping history	C_T	C_L (mg/g)	C_{NL}	Lability (C_L/ C_{NL})	CPI	LI	CMI
	Red clay						
Reference	9.9	1.5	8.4	0.17	1.00	1.00	100
5 years	9.6	1.1	8.5	0.13	0.97	0.76	74
14 years	7.7	1.2	6.5	0.18	0.78	1.06	83
	Brown clay						
Reference	21.7	4.2	17.6	0.23	1.00	1.00	100
5 years	11.1	1.4	9.7	0.14	0.51	0.61	31
14 years	8.3	1.2	7.2	0.16	0.38	0.70	27
	Grey clay						
Reference	22.4	3.6	18.7	0.19	1.00	1.00	100
5 years	9.8	1.3	8.5	0.16	0.44	0.84	37
18 years	9.4	1.3	8.1	0.16	0.42	0.84	35

Source: Conteh et al. (1997)

Table 2.3 Relationship between rice grain yield and leaf litter addition

Treatment	1992	1993	1994	1995
	Kg/ha			
No leaf litter	1,012	1,051	1,197	1,188
Cajanus cajan	1,683	1,604	2,010	1,637
Samanea saman	1,194	1,210	1,631	1,456

Source: Konboon (1998)

Table 2.4 Effect of leaf litter addition on soil organic carbon status

Treatment	C_T	C_L	C_{NL}	L	CPI	LI	CMI
Reference site	23.02	4.55	18.47	0.25	1.00	1.00	100
Before year 1992	3.48	0.44	3.04	0.14	0.15	0.59	9
Starting experiment in year 1995 with out litter apply	3.92	0.66	3.26	0.20	0.17	0.82	14
Cajanus cajan	4.36	0.73	3.62	0.20	0.19	0.82	16
Samanea saman	4.63	0.83	3.80	0.22	0.20	0.89	18

Source: Konboon (1998)

In the native state, soils are in equilibrium and have characteristic organic matter content. This equilibrium is disturbed when the soil is brought into cultivation. It reduced accumulation of fresh organic materials and the accelerated breakdown of the already existing organic matter through cultivation.

Consequently, the relatives loss (% decline) of each carbon fraction as described by Conteh and Blair (1998) which calculated from the different between values in a reference (uncropped) and cultivated soil as follow:

$$\text{Relatives loss (\%)} = \frac{\text{Amount of reference soil - amount in crop soil} \times 100}{\text{Amount in reference soil}}$$

The relatives loss is used to assess a level of carbon fraction loss in soil in different land use systems. This study applied the concept of relatives loss measurement to assess a land degradation.

2.13 Approaches for the estimation of soil organic carbon

Nelson and Somers (1982) reported total soils organic carbon are consist of organic carbon and inorganic carbon. Mostly, organic carbon has a form of soils organic matter fraction and inorganic carbon has a form of carbonate materials. Organic carbon is measured by difference portion between total organic carbon and inorganic carbon. Additionally, it can directly measures from the amount of total soils carbon as in case of non-calcareous soil the total soil carbon will be adequate to soil organic carbon.

The methods in order to measure organic carbon can be directly and indirectly measurement. Organic carbon is generally measure instead of organic matter, partly because measuring organic matter is more difficult, and partly because organic carbon is more useful for some purposes. However, organic carbon can also measures for a variety of reason, the two main reasons. Firstly, if the client really needs only an approximately idea of organic carbon, then the analyst can save time and money using a cheap and easy, approximate method. Secondly, if an analyst has a professional approach, then part of the professional approach is to give advice to the client on the quality and the potential use of the data (Myers, 1996).

Basically, there are two methods in order to measure organic carbon: combustion with measurement of the CO_2 produced, and digestion with measurement of the amount of reduction of dichromate. The total organic carbon measurement by the method of Walkley –black (1934) have been widely employed for monitoring of soil organic matter (Conteh et al., 1997). The principle of this method is that organic matter in soil was oxidized by treatment with a hot mixture of $K_2Cr_2O_7$ and H_2SO_4, and the $Cr_2O_7^{\ 2-}$ reduced during the reaction is assumed to be equivalent to the organic carbon originally present. In this method, the heat required is that generated by mixing 10 mL of 1 N $K_2Cr_2O_7$ with 20 mL of H_2SO_4. However, this amount of short duration heating does not give full conversion, and worse, the extent of conversion varies between 40 to 90 % in range of soil (Nelson and Somers, 1982). This method is suitable for analyses where the client who needs only an approximate estimate of organic carbon (Myers, 1996).

In the region of the Northeast, most of soils are low carbonate soil so, the amount of organic carbon will adequate to the amount of total carbon , particularly in top soil (Tulaphitak,1999).

2.14 Approaches for the estimation of soils labile carbon

The labile and non-labile organic carbon fractions have been widely employed for monitoring indicators of organic matter changes in soil (Conteh et al., 1997). The lability of any organic carbon fraction will depend on either chemical composition or protection within the soil aggregates. The distribution of organic carbon among labile and stable pool are affected by many factors such as the length of cultivation. The greatest effects of cultivation on soil organic carbon have been reported to occur in the microaggregate fraction and has been suggested to be the major organic carbon pool depleted as a result of cultivation.

The issue of what constitutes labile carbon in soil is unresolved. Approaches recommended for the estimation of soil labile carbon have been ranged such as microbial biomass carbon, light fraction organic carbon. Consequently, the use of microbial biomass carbon in characterizing the labile carbon has grained considerable interest, the question of reliable methodology remains unresolved. The use of the light-fraction as a measure of labile carbon appears to have had the greatest consideration.

Lefroy et al.(1995) reported rather than assessing the chemical forms of soil organic matter by fractionation techniques which analyze different functional groups, measurements of the rate of breakdown have been used to assess the quality of soil organic matter. Most attempts to develop models of soil organic matter turn over and relate soil organic matter dynamics to soil fertility have involved the separation of carbon into a number of pools on the basis of their rate of turn over Blair (1989) and Swift et al. (1991).

The decomposition of soil organic matter generally involves uptake of oxygen and liberation of carbon dioxide. The evolution of carbon dioxide has also been used extensively in incubation studies on organic matter decomposition .

The UV-photo oxidation technique by using mild oxidising agents to assess the relative proportions of different forms of soil organic matter in terms of the ease with which they could have broken down (Lefroy et al.,1995). As, Loginow et al., (1987) have been developed a method of fractionating soil organic matter and fractions or substrates of soil organic matter based on susceptibility to oxidation by permanganate. Solution of potassium permanganate have been extensively used for the oxidation of organic compounds the rates and extent of oxidation of different substrates is governed by their chemical composition and the concentration of permanganate. Oxidation with less than the amount of permanganate required for complete oxidation should reveal the quantity of readily oxidisable component in the soil organic matter. The degree of oxidation with excess amounts of three different concentrations of $KMnO_4$ was used, in conjunction with the total carbon content of the soil, to obtain four fraction of soil carbon.

The method is based on the supposition that the oxidative action of potassium permanganate on soil organic carbon under neutral conditions is comparable to that of the enzymes of soil microorganisms and other enzymes present in the soil. The lower the concentration of $KMnO_4$ required for oxidation of a certain class of compounds, the more labile the organic component. The degree of oxidation was analyzed by measuring the release of CO_2 or the consumption of oxidizing agent.

The permanganate–oxidisable carbon technique was proposed by Blair et al.(1995). By using mild oxidizing agents such as 333mM $KMnO_4$ solutions can uses for estimating the labile fraction of soil carbon. Labile carbon is determined by such a procedure has been shown to break down more rapidly than total organic carbon. Additionally, the use of a single strength $KMnO_4$ provided sufficient characterization of the labile carbon to define the state of soil systems. The amount of oxidizing agent consumed by the $KMnO_4$ are used to calculate two fraction of organic carbon; one which is oxidized by $KMnO_4$ and a second fraction which is not oxidized by the $KMnO_4$. The change in the concentration of $KMnO_4$ is used to estimate the amount of carbon oxidized, assuming that 1 mM MnO_4 is consumed (MnVII $\rightarrow$ MnII) in the oxidation of 0.75 mM, or 9 mg of carbon. The results are expressed as mg C g^{-1} in soil. The two fractions are labile carbon (C_L) = the carbon oxidized by 333 mM $KMnO_4$ and non-labile carbon (C_{NL}) = the carbon not oxidized by 333 mM $KMnO_4$.

As the continuity of carbon supply depends on both the total pool size and the lability, both must be taken into account in deriving a carbon management index. These can follows as:

(a) Change in total carbon pool size

The loss of carbon from a soil with a large carbon pool is of less consequence than the loss of the same amount of carbon from a soil already depleted of carbon or which started with a smaller total carbon pool. Similarly, the more a soil has been depleted of carbon the more difficult it is to rehabilitate. To account for this a carbon pool size index is calculate as:

$$\text{Carbon Pool Index (CPI)} = \frac{\text{Sample total carbon (mgg}^{-1}\text{)}}{\text{Reference total carbon (mgg}^{-1}\text{)}} = \frac{C_T \text{ sample}}{C_T \text{ reference}}$$

(b) The loss of labile carbon is of greater consequence than the loss of non-labile carbon. To account for this a carbon Lability Index is calculated as:

$$\text{Lability of carbon (L)} = \frac{\text{Carbon in fraction oxidized by KMn O}_4}{\text{Carbon remaining un-oxidized by KMn O}_4} = \frac{C_L}{C_{NL}}$$

$$\text{Lability Index (LI)} = \frac{\text{Lability of carbon in sample soil}}{\text{Lability of carbon in reference soil}}$$

(c) The Carbon Management Index (CMI) can calculates as:

$$\text{CMI} = \text{Carbon Pool Index x Lability Index x 100} = \text{CPI x LI x100}$$

Calculation of the CMI require sample of the soil of interest and sample collected from a reference area. The choice of reference area depends on the circumstances. In studying the impact of agricultural practices, an undisturbed or relatively undisturbed site on the same soil and near to the study unit was selected. Such a site represents an area where change in soil carbon dynamics is likely to be slow relative to the disturbed area, and this can serves as a reference sample (Blair et al., 1995).

As mentioned above indicated that by using changes of soil carbon can be indicator of soil degradation. However, there is no study in area of using changing of carbon pool as an indicator of productivity.

From reviews of literature about floodplain mostly focused on use of floodplain forest, management and biodiversity as showed by Kunurat (1991), Kunurat et al (1998), Srisinurai (2000) and Pavaputanon na mahasarakam (2001). Obviously, floodplain forest is important natural resources for community use. This comes from high productivity and biodiversity of the systems. On the other hand use of natural resources can lead to both positive and negative affection to the systems.

Thus, it needs to assess the status of natural resource system to support the production of system.

However, there are lack of study in area of soil ecosystem where soil is a major component to support the productivity. On the other hand, the productivity is supporting the use of floodplain forest by community.

As many reports showed that land use changes can lead to a changing on soil properties. Consequently, a changing of soil organic carbon and depletion of soil nutrient relates to a changing of the productivity. On the other hand, this lead to a changing to a soil capacity in maintaining the productivity as soil organic carbon is a key source of plant nutrients in the systems.

Labile organic matter plays important roles to release nutrients to the soil system where are rapid available for plant uptake. On the other hand, this relates to the productivity of system. As mentioned above labile organic matter relationship with soil nutrients is support the productivity in the system.

According to Blair et al. (1995) indicated that the change of land use leads to the change on soil organic carbon particularly on labile carbon. However, there are lack of a study in area of potential productivity by using soil labile carbon. On the other hand, its lack of a study on the relationship among soil labile carbon, productivity and soil nutrients. In this study, the indicator of assessment of potential productivity was determined by using changes of soil organic carbon, on carbon fractions which are consists of total carbon, labile carbon and non-labile carbon. Soil organic carbon fraction, soil nutrients and a relationship on the productivity are an indicators in order to assess a potential productivity of floodplain forest.

CHAPTER III

MATERIALS AND METHODS

3.1 Agroecosystem analysis

The study has been carried out since 1999-2001. Follow Conway (1985) and Prakongsri (2000) an agroecosystem analysis was employed in order to understanding the system components and interaction between community and floodplain forest. In this study, the level of analysis is village level. The step of analysis consist of reviews of secondary sources, the selection of the study site, filed data collection, the system properties analysis. The steps of analysis are as follow:

3.1.1 Reviews of pre-existing data

The secondary data were collected to describe the village history, natural resources such as water resources, climate and soil. There are two kinds of pre-existing data first, is topography map. The second, are reports such as environmental impact studies report form Khon Kaen University, research thesis and government statistics report.

3.1.2 Selection of the study site

The study site was floodplain forest in Ban Pak Yam Tamboon Samphong, Srisongkram district, Nakhon Phanom province in the Northeast. This area is part of the Songkram river watershed. Site selection was selected after reviews of secondary data. The criteria for selection the site as follow:

1. The floodplain forests in this areas is an abundance area and are very important for communities use for long time.
2. The areas can be the represent of floodplain forest use in the Northeast.
3. There were some areas of floodplain forest have been conversion to cultivated area.

4. There was a natural floodplain forest nearby selected site. This will be reference site in order to compare between different land use systems.

3.1.3 Transect walk

The transect walk taken in company with key informant by select two point (A and B) in the area, draws a line between point A and point B. Then walk following that line and draw a picture.

3.1.4 Semi-structure interview

Semi-structure interview (Khon Kaen University, 1987) was conducted by using key questions with key informants (see appendix I). The key informant such as village head man, older man, and a person who relevant to floodplain forest use such as a person who is a fisher man and a person who were owner of individual rice growing plots. These were interviewed in order to obtain background information about the village such as history, the information about status of floodplain forest and their use, land use history and land use system. The 'six helpers' type of questions (what, when, where, why, who, how) were used during interviews.

3.1.5 Seasonal calendar

The floodplain forest use and fishing methods were discussed by using seasonal calendar. This provides to understand season activities which concerned floodplain.

3.1.6 Mapping

The mapping was drown up by involves key informants to illustrate the land use of floodplain forest areas of Ban Pak Yam. This attempt to understand how they see and use floodplain forest.

3.1.7 Direct observation

As observer, the researcher attended with activities of villagers from time to time. Any activities which concerned floodplain forest use such as growing rice, fishing and village meeting. There were two purposes of the observation firstly, to understand how people see and use floodplain forest, to see the daily activities of villager. The second is to see who is who, to found the key informants whom concerned floodplain forest and who can be gave an information about the village.

3.1.8 Field survey

After the existing situation of village was studies, the field survey was conducted during the researcher visit the village. This based on two propose, sampling soil and to confirm the data/information obtained from existing document and from key informants.

3.1.9 Photograph

During visit the village and field survey, the researcher took the photograph of villager activities.

The framework of data collection are as follow (Figure3.1):

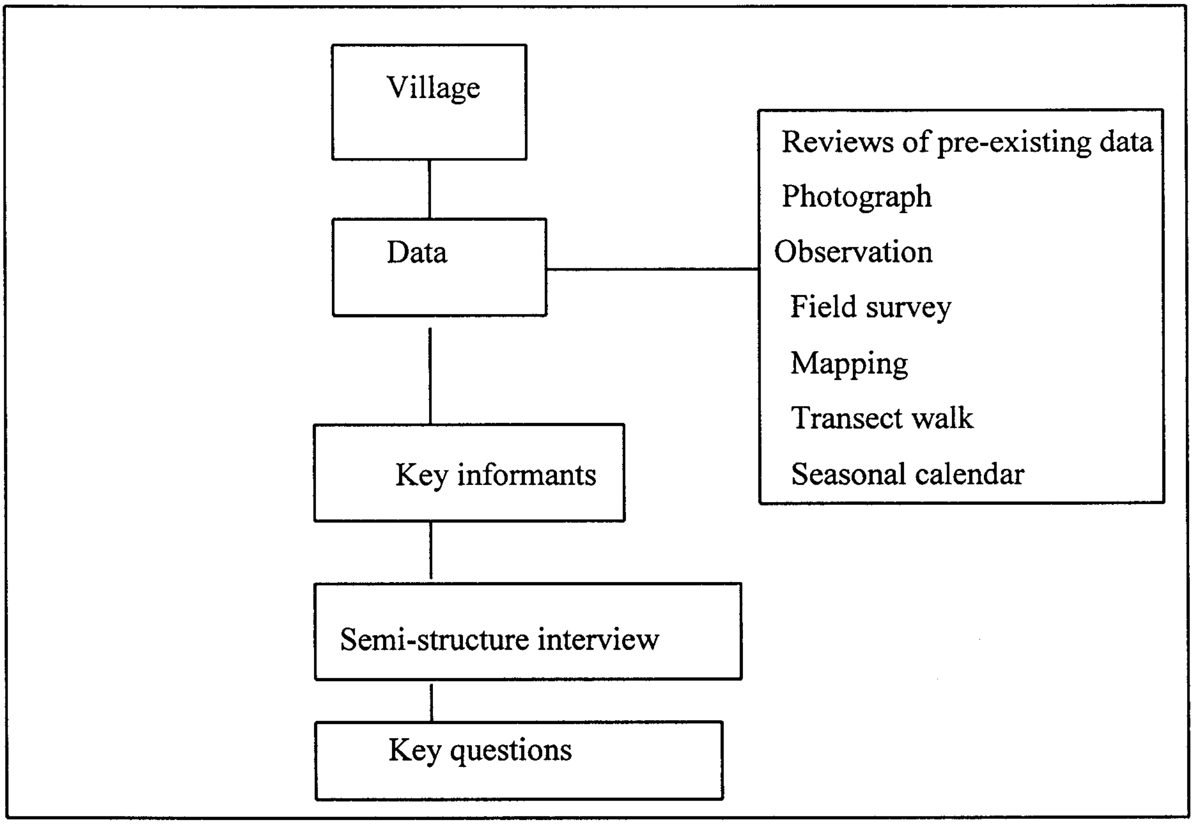

Figure 3.1 The framework of data collection

3.1. 10 The system properties analysis

According to agroecosystem analysis, the pattern analysis and system properties analysis were considered by following Conway (1985) and Prakongsri (2000). The analysis was an investigation of the agroecosystem properties. There are three properties of agroecosystem which are important in this study were considered. There are productivity, stability and sustainability. These indicate status of the system.

3.2 Collection of soil data

3.2.1 Soil sampling

Following the mapping with key informant, sampling sites were selected. There were the remaining forest, the scattered forest, the disturbed forest and the agricultural forest.

The area code of agricultural forest were R1 to R10. Where the area code of remaining forest is F1, the area code of scattered forest is F2 and the area code of disturbed forest is AF (Table 3.1). The remaining forest (F1) was selected for reference site, one plots of scattered forest and disturbed forest were selected because this demonstrate trend where conversion remaining forest to agricultural forest. The twenty of rice growing plots were selected because this will be the represent of agricultural forest. This number could be minimum replication of sampling in order to compare with reference site. The agricultural area has been converted to cultivated for last ten years ago.

The 30 meters transect line has been carried out by using systematic sampling technique (Murt, 1995) each plot, in every 5 meters has been selected for sampling (Figure 3.2). The total are 23 plots. In every 5 meter of transect line in each plots, the soil samples were collected at depth of ground layer (0-10 cm.), by using a hand spade. Samples from each transect was thoroughly mixed. Air-dried soil was first gently crushed by hand and sieved through 2 and 0.5 mm. sieve and keep in plastic bags. All samples were collected during dry season after water level fall. The chemical analysis done at laboratory of Department of Land Resources and Environment, Faculty of Agriculture, Khon Kaen University.

Table 3.1 Plot numbers, area codes and land use history

Plot numbers	Area code	Land use history
1	F1	Remaining forest
2	F2	Scattered forest
3	AF	Disturbed forest
4	R1	Rice growing 10 years
5	R2	Rice growing 10 years
6	R3	Rice growing 10 years
7	R4	Rice growing 10 years
8	R5	Rice growing 10 years
9	R6	Rice growing 10 years
10	R7	Rice growing 10 years
11	R8	Rice growing 10 years
12	R9	Rice growing 10 years
13	R10	Rice growing 10 years
14	R11	Rice growing 10 years
15	R12	Rice growing 10 years
16	R13	Rice growing 10 years
17	R14	Rice growing 10 years
18	R15	Rice growing 10 years
19	R16	Rice growing 10 years
20	R17	Rice growing 10 years
21	R18	Rice growing 10 years
22	R19	Rice growing 10 years
23	R20	Rice growing 10 years

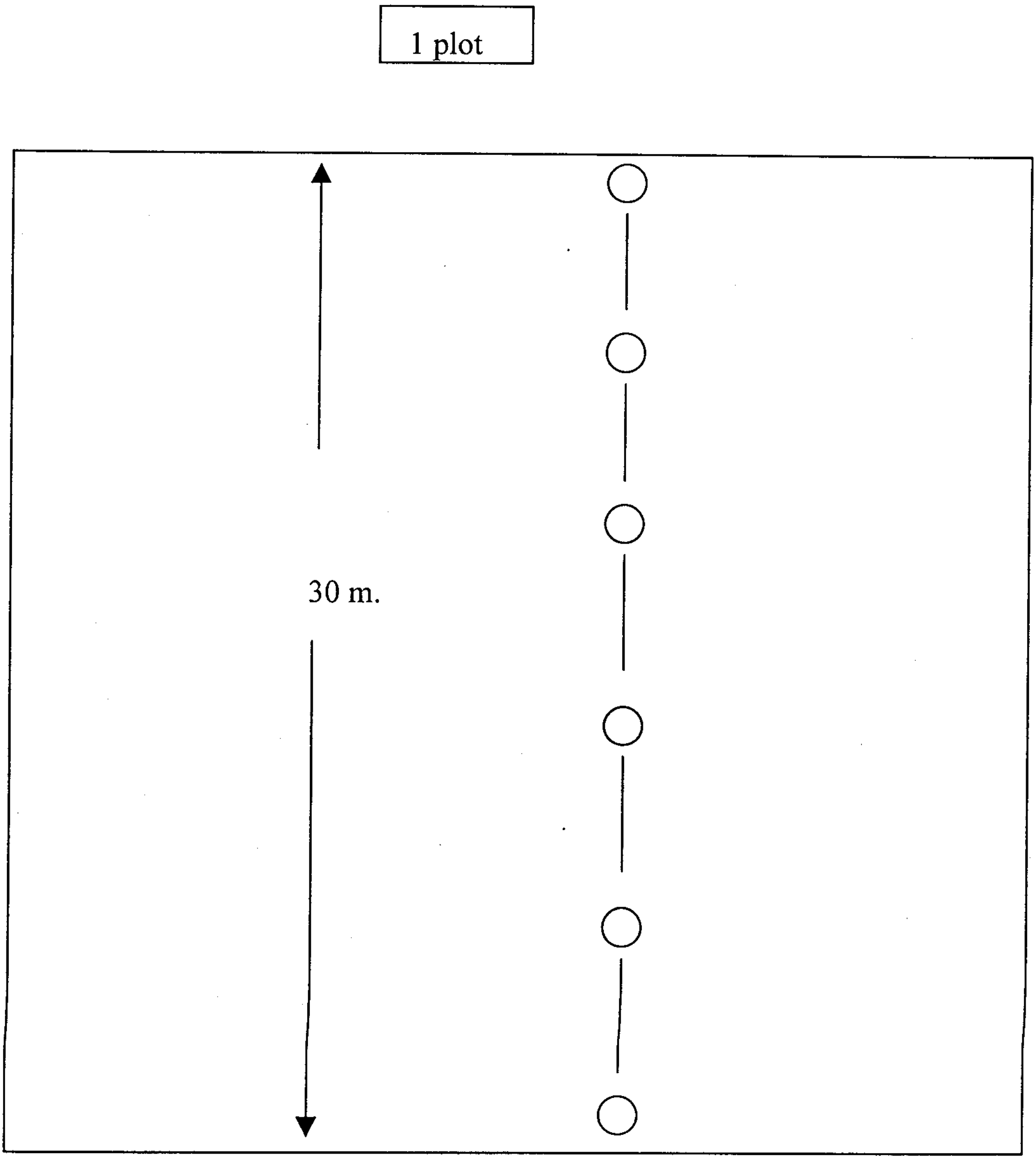

Figure 3.2 Sampling plots

3.2.2 Soil analysis

Soil properties analysis derives as follow table 3.2 :

Table 3.2 Soil properties analysis

Soil properties	Methods	References
Soil pH (1:1) in water	Standard glass method	Peech (1947)
Available P (ppm)	Bray II	Jackon (1960)
Exchangeable K	NH_4 Oac Flame spectrophotometer	Peech (1947)
Exchangeable Ca	NH_4 Oac Flame spectrophotometer	Peech (1947)
Exchangeable Mg	NH_4 Oac Flame spectrophotometer	Peech (1947)
Exchangeable Na	NH_4 Oac Flame spectrophotometer	Peech (1947)

3.2 .3 The organic carbon and total carbon analysis

Each of soil obtained from 23 samples were analyzed for organic carbon and total carbon by Walkley-Black method (Allison, 1965). From the principle, in case of non-calcareous soil, the total carbon will be adequate to total soil organic carbon.

3.2.4 The labile carbon analysis

The labile carbon in each soil was determined as described by Blair et al. (1995) as follow :

Reagents

333 mM $KMnO_4$

Conc. HCl (36%)

20% NaOH

0.0025M KI

As_2O_3

Preparation of 333 mM stock solution

Weigh out 263.40 g of AR grade $KMnO_4$ and make to 4.5 L with distilled H_2O in a 5 L beaker, add a teflon coated stirrer, cover with plastic film, cover the entire beaker with foil to exclude all ligth, place on a hot plate stirrer at low heat and leave over night. Remove the $KMnO_4$ from the stirrer and cool slowly to avoid recrystallisation. Transfer to a 5L volumetric flask and using the washings of the beaker, make to volume and store in dark place.

Preparation of 20 % (w/v) NaOH

Add 20 g of NaOH to 80 mL of dd H_2O in a beaker, mix and wait until cool, transfer quantitatively to 100 mL volumetric flask and make to volume.

Preparation of 0.0025 M KI

Weigh 0.41 g of KI and make to 1L with dd H_2O

Titrations

1. Each batch of extracting solution will titrate against As_2O_3 to obtain its exact concentration. This concentration is then used in the regression to prepare the calibration curve and in the subsequent calculation of C_L.

2. Weigh out 0.5 g of As_2O_3 to five decimal places into a 500 mL conical flask.

3. Add 20 mL of 20% NaOH with a bulb pipette and allow to dissolove for at least 8 minutes, whilst swirling occasionally.

4. Add 200 ml of dd H_2O whilst rinsing down the sides of the conical flask.
5. Add 20 ml of conc. HCl with bulb pipette.

6. Add four drops of 0.0025 M KI with a pasteur pipette.

7. Using a fine point 10 ml burette filled with 333 mM $KMnO_4$, titrate against the As_2O_3. Swirl the flask constantly until the end point is reached, which is when a faint pink color persists for 30 seconds. Record the volume of $KMnO_4$ add.

Calculate the concentration of $KMnO_4$ using the following equation:

$$\text{mM } KMnO_4 = \frac{(\text{g } As_2O_3) \times 1000}{(\text{mL } KMnO_4) \times 0.247275}$$

Measurement of Labile carbon

1. For each batch of samples include the following:
(a) At least 2 blanks (ie. 333mM $KMnO_4$ with soil)
(b) The unknown soil samples.

2. For each soil calculate, the amount of soil contains 15 mg C (g soil=1.5/%C). Weigh this amount into 30 mL centrifuge tubes record the weight to g x 10^{-4} . If the soil sample has a % C of less than 0.4% weight out a maximum of 4 g of soil .

3. Add 25 mL of the 333 mM $KMnO_4$ extracting solution to the unknowns and blanks. Instead of adding by volume, tare the tube and soil on a balance and use a bottle top dispenser to add the $KMnO_4$ the exact weight of solution added is then used in all calculations in place of the volume.

4. Firmly cap tubes and place in an end-over-end shaker for 60 minutes.
5. Centrifuge at approximately 800 g for 5 minutes.
6. Using the 333mM stock solution make 7 standards for prepared standard curve (Table 3.3).

Table 3.3 Standard preparation from 333mM stock solution

Std No.	Concentration (mM)	333mM $KMnO_4$ (uL)	H_2O (uL)
1	333.00	100	24900
2	326.4	99	24900
3	319.7	98	24900
4	313.1	97	24900
5	306.5	96	24900
6	299.8	95	24900
7	293.2	94	24900

7. Remove samples from centrifuge and dilute all the unknowns and blanks by 1/250 with dd H_2O and mix thoroughly.

8. Using a sensitive spectrophotometer set at 565nm, fill two cuvettes with the highest concentration standard. Set zero absorbance with these cuvettes in the reference and sample positions. Using the top standard as the reference.

Calculations

Labile carbon

The labile carbon can calculate as follow:

$$C_L\ (mg/g) = \frac{(mMBlank - mMUnknown) \times 25 \times 9}{1000 \times \text{weight of soil (g)}}$$

The differences between the total carbon and the labile carbon give the non-labile carbon.

$$C_{NL} = C_T - C_L$$

Using the C_L and C_{NL} content obtained, the following monitoring indicators were calculated as follow:

$$\text{Carbon Pool Index (CPI)} = \frac{\text{Sample total carbon (mgg}^{-1})}{\text{Reference total carbon (mgg}^{-1})} = \frac{C_T \text{ sample}}{C_T \text{ reference}}$$

$$\text{Lability of carbon (L)} = \frac{\text{Carbon in fraction oxidized by } KMnO_4}{\text{Carbon remaining unoxidized by } KMnO_4} = \frac{C_L}{C_{NL}}$$

$$\text{Lability Index (LI)} = \frac{\text{Lability of carbon in sample soil}}{\text{Lability of carbon in reference soil}}$$

$$\text{Carbon Management Index (CMI)} = \text{Carbon Pool Index x Lability Index x 100}$$

$$= \text{CPI x LI x100}$$

Percent decline were determined as described by Conteh and Blair (1998) as follow:

$$\text{Percent decline (\%)} = \frac{\text{Amount in reference soil - amount in crop soil x 100}}{\text{Amount in reference soil}}$$

3.3 Data analysis

The data analysis consists of two main parts:

The first part of analysis was an investigation the relationships between community and floodplain forest use. The properties of agroecosystem, productivity, stability and sustainability were analyzed.

The second part was soil analysis. The Soil data analysis described as below:

1. Changes of soil pH and soil nutrients; available P, exchangeable K, Ca, Mg, and Na under different land use system were analyzed by using MS Excel.

2. Changes of carbon pool status under different land use systems will measure by using total carbon, labile carbon, non-labile carbon, carbon pool index, lability, lability index and carbon management index. The different and relatives change of carbon pool will correlate to percent decline.

3. The relationship between soil labile carbon available P and exchangeable K under different land use systems were analyzed by using MS Excel.

CHAPTER IV

RESULTS

4.1 Agroecosystem of Ban Pak Yam

Ban Pak Yam is located in a floodplain area of the Songkram river where is the junction between the Songkram river and the Yam river. Follow the government administrative Ban Pak Yam is in Tambon Sampong Srisongkram district Nakhon Phanom Province (Figure 4.1). The communication and transportation are relatively good in this village. There are two main local roads to Srisongkram district and Nakhon Phanom province. About 85 kilometer from Ban Pak Yam to Sakhon Nakhon province and about 30 kilometer from Ban Pak Yam to Srisongkram district.

The settlement history of Ban Pak Yam began since 95 year ago. The target of the first encroachment was for fishing because this area is very abundance of fish resources. The first encroachment was Thai-Lao who came from Laos this group was the ancestor of Chaipakdee family.

In the past, Ban Pak Yam was very well known as market place for trader via river transportation. Because the village located near the river, there were many traders came to visit this village to buy and sell goods. Rice, fish fermented, forest product and salt is very important goods during that time.

Present, the total households of Ban Pak Yam are 142 and populations are 896 people. The villager practice Buddhism. There is one temples, one school and one public health center. This village was a predominantly fisheries village for long time ago. Presently, the main occupations in this village are fisheries and rice growing particularly rice growing in dry season. There were many of ethic groups of peoples in this village as follow:

Thai-Lao: The first Thai-Lao group moved from Lao, the next group from Nakhon Phanom Ubon Rachathani, Yasothorn, Mukdahan ect. The first group was ancestor of Chaipakdee family and groups from Nakhon Phanom were ancestor of Uthumthisan, Tapakul and Bonyasri family.

Thai-Chinese: Thai -Chinese group moved from Nakhon Phanom to Ban Pak Yam since 1922. This groups were ancestor of Phipatsuk family.

Thai-Yor: Most of Thai -Yor moved from Tha Uthan district Nakhon Phanom. This groups were ancestor of Kantacha family, Sririwong family ect.

Thai-Kmear: There was one Thai – Kmear family, the family name is Chompun.

Thai-Yoi: Thai –Yoi group moved from Akat Umnui district Sakhon Nakhon. This groups were ancestor of Prombut family, Kumkae family, Wongwandee family ect.

Phu-Thai: Phu-Thai group moved from Warichaphum Sakhon Nakhon and from Renu Nakhon district Nakhon Phanom. This group were ancestor of Srinukul family, Mongkolnam family.

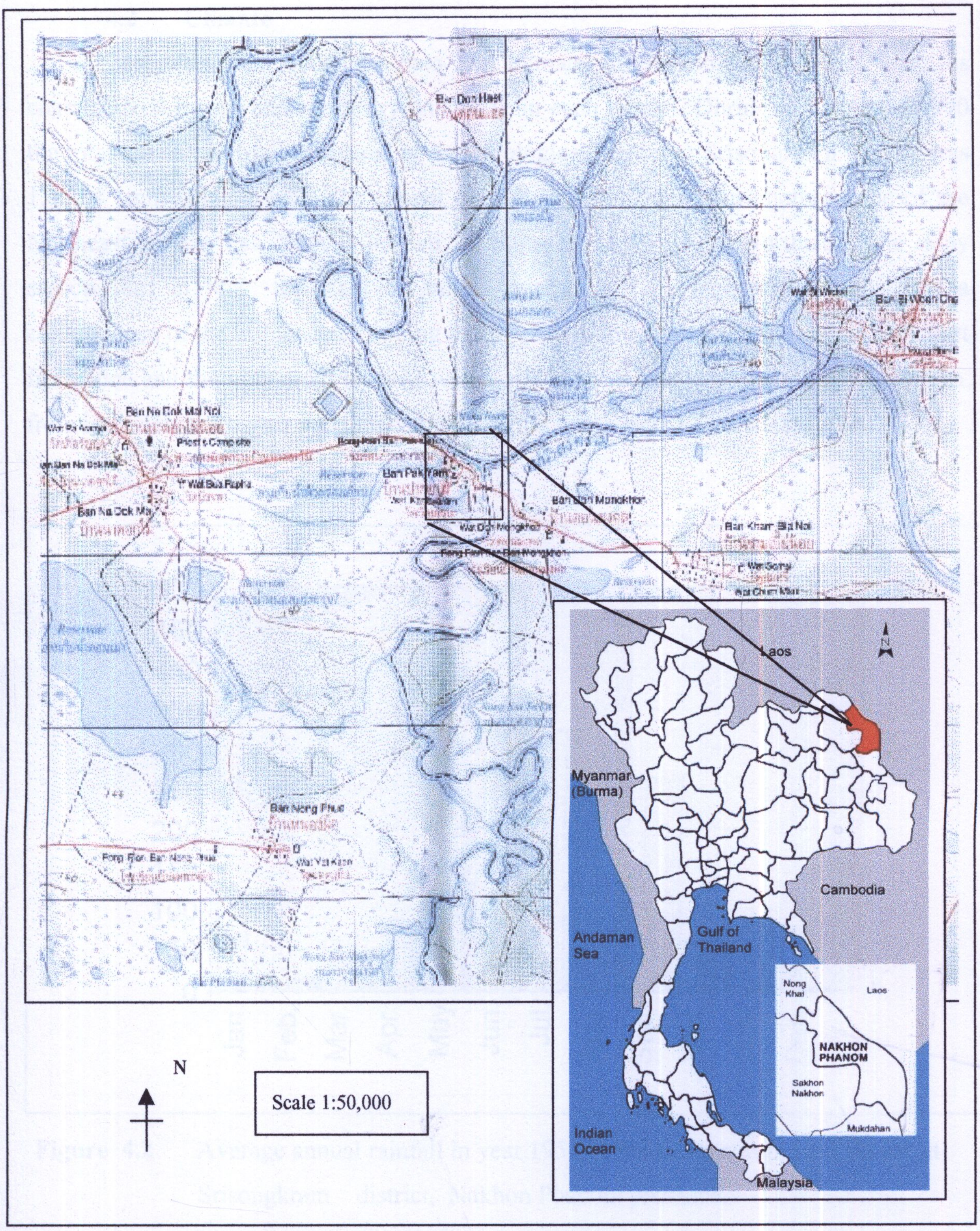

Figure 4.1 Map of Ban Pak Yam, Tambon Samphong, Srisongkram district, Nakhon Phanom province

4.2 Climate

Based on the secondary data the climate in the Songkram river basin is characterized by sawanna with dry and rainy in each annual. During period 1954-1990 the total annual rainfall measured at meteorological station at Srisongkram district was 1,859.4 mm (Figure 4.2). The annual rainfall rate is higher than another zone of the Northeast as Ban Pak Yam is located in monsoon zone of the Northeast. The rainy season start in May, the level of annual rainfall will be highest in August. As a consequence of the influence of raining in this region, inundating the floodplain will start from June and the maximum level of water will be in August or September. Therefore, from interview three year ago rain came early the water level raised in late April.

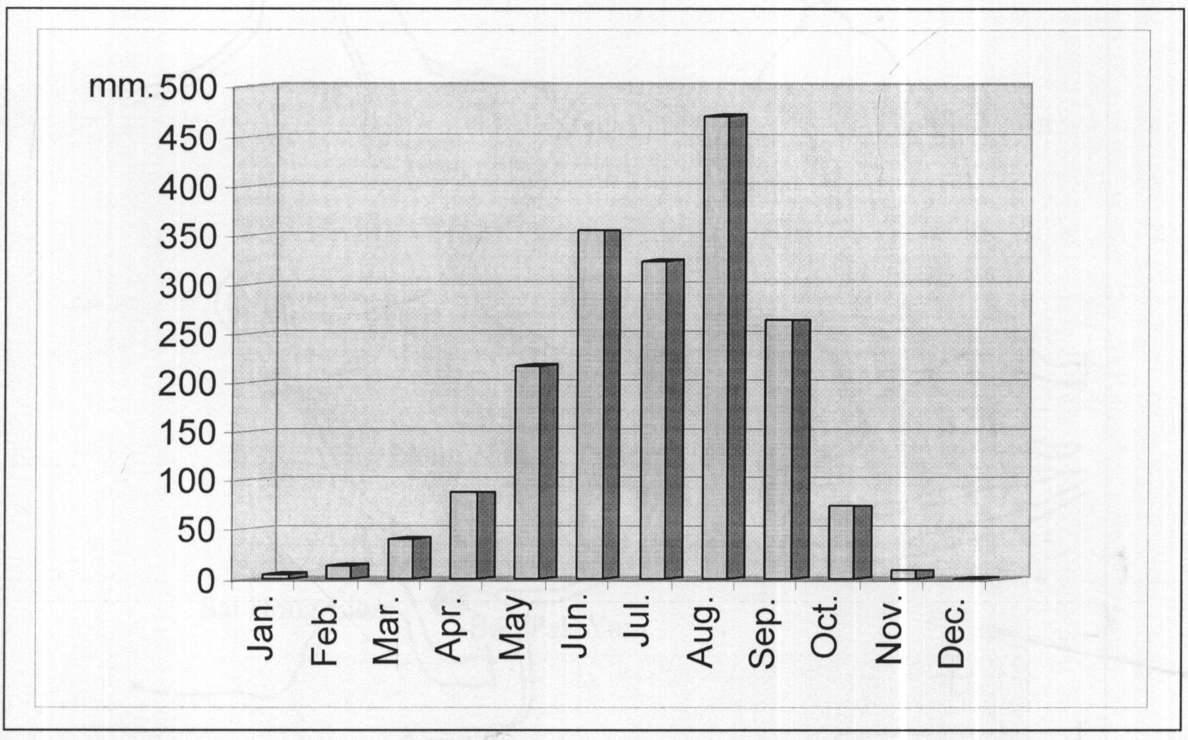

Figure 4.2 Average annual rainfall in year 1954 -1990 at meteorological station at Srisongkram district, Nakhon Phanom province.

Source : Khon Kaen University (1999)

4.3 Water resources

Water resources include rainfall temporary and contemporary water sources. Thus, it floodplain then there are a lot of water sources. The main water sources are the Songkram river, the Yam river, Nong Ake, Nong Phue, Haui Pak Ara, Sai Hong Eien, Nong Nua and Nong Tai (Figure 4.3). During inundating season the water from the Songkram river will raised above the surrounding of floodplain. This is important for fisheries occupation of Ban Pak Yam. In dry season a contemporary water sources are important for rice growing.

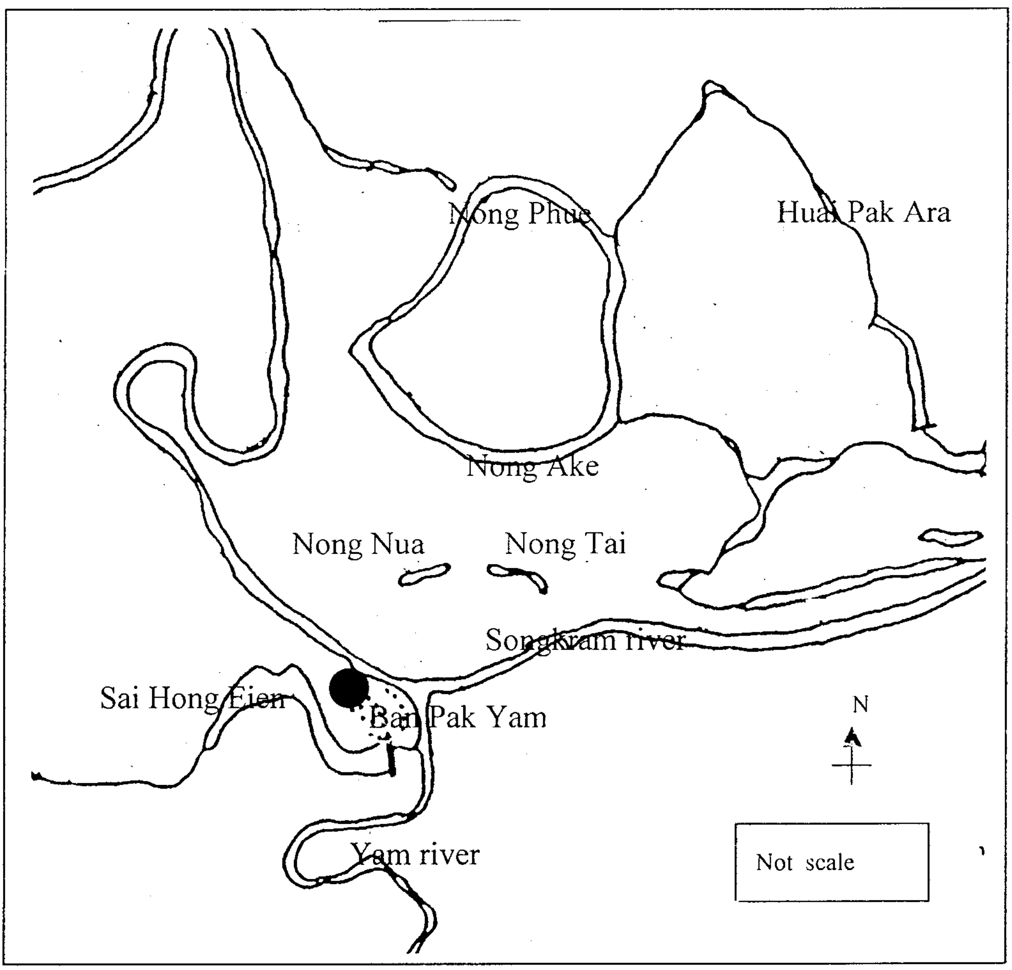

Figure 4.3 Water resources of Ban Pak Yam

4.4 Soil type

Alluvial soil is a common soil throughout floodplain area. Soil has been developed over sedimentation of alluvium floodplain. The soil series on this type of land included alluvial complex (AC), and Nakhon Phanom, flooded phase (Nn-f). The main characteristic of soil is high clay content soil. Generally, soil color is gray, red or brown and poor drainage. Additionally, floodplain soil is fertile soil however this is wetland soil. It needs an appropriate land use in order to sustain fertility.

4.5 Transect of Ban Pak Yam

This area is a floodplain of the Songkram river where includes from the middle to the lower area of the Songkram river basin. The elevation of the area ranged from 140 to 150 meter from sea level (Figure 4.4). The banks of the Songkram river is quite high and sharp. These come from natural erosion of water direction. In dry season average depth is about 2 meters and will raised up to 10 meters during inundating season. Floodplain area includes floodplain forest, rice fields, reservoir, swamp and oxbow lake in local name called Nong Ake. The village located at the area of levee where is non inundating area .

Generally, in raining season it will be inundating among the floodplain area. This is influential from the Mekong river, the Songkram river, mini river and, run off water. The annual inundating is important for village fisheries in this region.

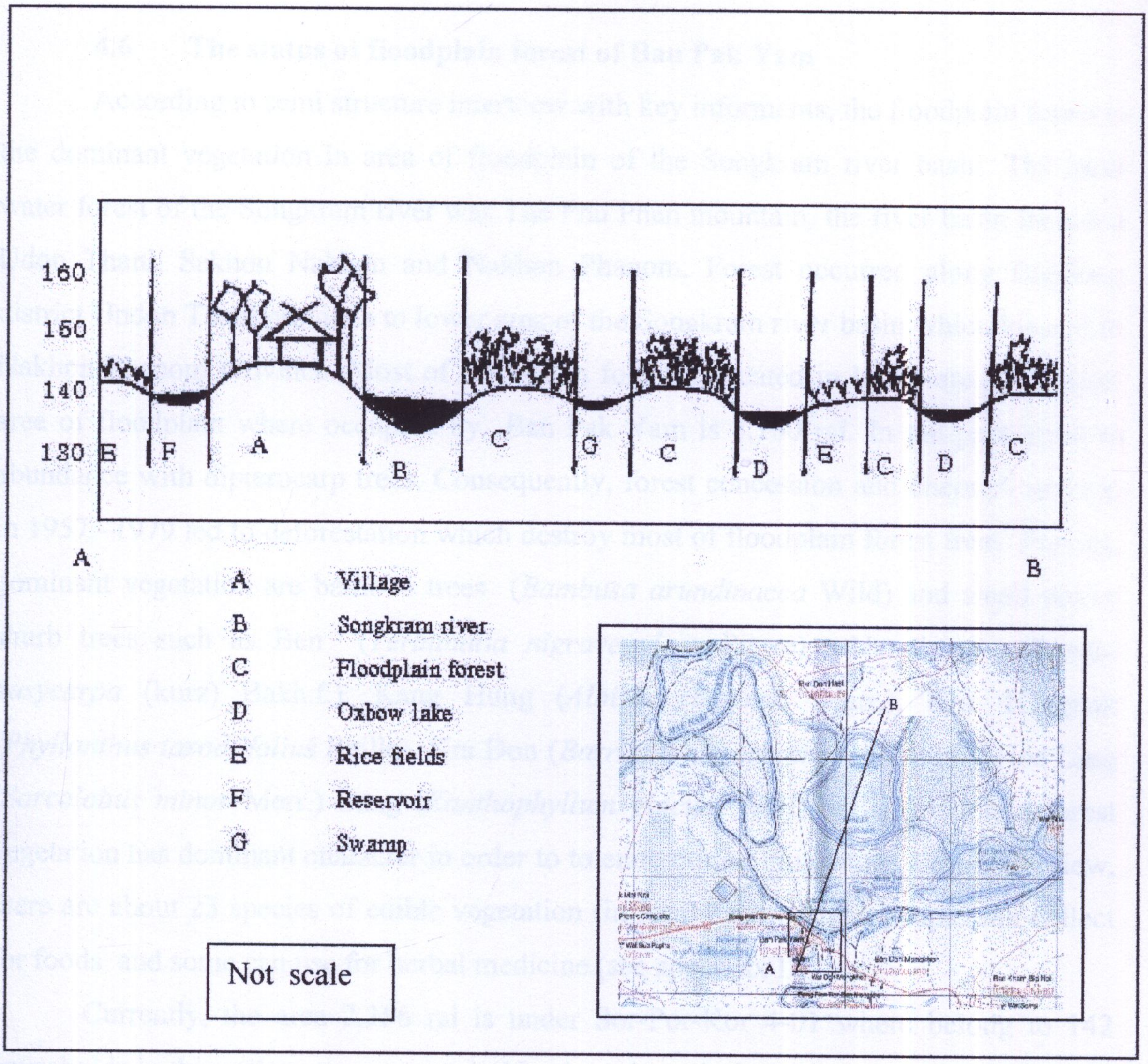

Figure 4.4 Transect of Ban Pak Yam (elevation in meter)

4.6 The status of floodplain forest of Ban Pak Yam

According to semi structure interview with key informants, the floodplain forest is the dominant vegetation in area of floodplain of the Songkram river basin. The head water forest of the Songkram river was The Phu Phan mountain, the river basin included Udon Thani, Sakhon Nakhon and Nakhon Phanom. Forest occurred along Bandung district Undon Thani province to lower area of the Songkram river basin which located in Nakhon Phanom province. Most of floodplain forest is located in lower area. The total area of floodplain where occupied by Ban Pak Yam is 3,160 rai. In the past, used to abundance with dipterocarp trees. Consequently, forest concession and charcoal making in 1957 –1979 led to deforestation which destroy most of floodplain forest trees. Present, dominant vegetation are bamboo trees (*Bambusa arundinacea* Wild) and small native shurb trees such as Ben (*Terminalia nigrovenulosa* Pierre) , Namtheng (*Randia dasycarpa* (kurz) Bakh.f.), Kang Hung (*Albizia chinensis* Merr.), Krai Hangnak (*Phyllanthus taxodiifolius* Beille), Kra Don (*Barringtonia acutangula* Gaertn), Hoa Ling (*Sarcolobus minor* Merr.) Sang (*Xanthophyllum glacum* Wall) ect. Floodplain forest vegetation has dominant character in order to tolerate during inundating. From interview, there are about 23 species of edible vegetation (in local name) which people can collect for foods and some can use for herbal medicine (see appendix II).

Currently, the area 2,356 rai is under Sor-Por-Kor 4-01 where belong to 142 households in this village the average is 18 rai per households.. The area about 260 rai is community forest. Forest use is significantly in order to supporting basic needs for villager living. Present, some of forest has been converted to rice growing.

4.7 Land use history of floodplain forest

Floodplain forest areas were selected to be study areas where have been experiencing many changed in land use over period of time. Based on information from key informant interviewing, and existing reports the land use change from 1910 to present divided into 5 phases:

Phase 1: Subsistence period

In this period start from the beginning of the village establishment in 1907. The Villagers use floodplain forest for subsistence purposes. During this period floodplain forest was very abundance of wild life. The forest also provides natural foods for villager such as natural vegetables, medical herb, wild animal, building materials and fishing equipment. In inundating season floodplain forest will provide as natural habitat for fishes. Fish is a natural resource which attract people to settle in this area for fishing. Until the end of this period use of floodplain forest by villager base on subsistence purposes.

Phase 2: Floodplain forest concession

Phase 2 during 1957 to 1974 was a concession period when timber products from floodplain forest in this area became valuable under forest concession. The large trees were cut and transport along the Songkram river to Nakhon Phanom province. Toward the end of this period, most of large trees were cut. Nevertheless, villagers still use floodplain forest for their living.

Phase 3: Charcoal concession

During 1965 to 1979 was a period of charcoal concession. Some of villagers were hired to be a labor for cutting tree and making charcoal. This concession owned by the business man in Nakhon Phanom province. At the end of this period, due to cleared cut three for charcoal making large tree and small tree disappeared.

Phase 4: Drought year starting rice growing

In this phase covered from 1984 to 1985. This region suffers from drought it makes no inundating in this area. Some of villager start growing rice in floodplain forest. At beginning the area was border zone next to Ban Don Tay area. Rice was growing in rainy season because there is no inundating during this phase.

Phase 5: Starting rice growing in dry season

This phase covered period from 1991 to present, most of villagers change lifestyle from fisheries to both of fisheries and rice growing in dry season. Consequently, some of floodplain forest had been converted to rice growing fields. There are two main factors, first due to the changes of socio-economic situation and second, the decline of fisheries resources. These effect to lifestyle of community, particularly increase demand of rice for households consumption. Therefore, previously most of villagers were not growing rice. The influencing factors were inappropriate area due to inundating in raining season and fish resources incentive villagers to setting in this area for fishing. At starting some of villager had experience from nearly village then their starting rice growing. Currently, thee are approximately total area 300 rai of paddies fields where near Nong Ake (oxbow lake). Because it depend on water supply in dry season. However, the main purposes for rice growing is for household consumption.

4.8 Traditional and current floodplain forest use

According to the semi-structure interview with key informants founded that area 2,356 *rai of floodplain forest has been owned by 142 households under Sor-Por-Kor 4-01 , area 260 rai is the community properties. The use of forest by villagers relates to* the annual inundating of floodplain forest. In each year inundating starts in June to September. There were not only villager from Ban Pak Yam but, there were many peoples from another village came to use floodplain forest in this area. The main forest use are as follow table 4.1.

1. Fisheries

During annual inundating season floodplain forest surrounding will becomes as natural lake, all of water sources were linked to the Songkam river. It is natural fish habitat and important sources for fisheries. The villager has been operated fishing all year, from past to present, the different kind of fishing methods were developed. Villager used many of fishing methods and fishing tools to catch fishes its depend on timing, kind of fish and fish habitat (Table 4.2). Each tool designed for the different fish species habitat and seasonal. The traditional such as net, cast net, hook and line and bamboo fish trap are very common methods. Therefore, some of villager employed new methods for catch fish such as push net and wing set bag these methods were more destructive than traditional method. Fishing will be intensively during inundating season until the water level fall in late raining season. From past to present fisheries is the main occupation of Ban Pak Yam. Fish fermented (pra-ra) from Ban Pak Yam is very well known in the Northeast (Figure 4.5 –4.6).

However, the one problem which effects to living style of community, resulted from fisheries resources decline. From interview villager said that in the past, there were abundance of fish resources. The first encroachment group settle in this village with fishing purpose. Decline of fish resources might be resulted from many ways such as overexploitation and changes of forest structure due to deforestation.

2. Livestock

From past to present, floodplain forest was important area of the community for livestock. Because, generally in village there were some of villagers who has cow or buffaloes this also found in Ban Pak Yam. This was resulted of plentiful of natural foods for livestock grazing in floodplain forest. Currently, in dry season, floodplain forest is a area for livestock particularly cows and buffaloes. Villager from Ban Pak Yam and others who next to the floodplain forest will come to use floodplain forest for livestock during dry season and in raining season their will move to upland area (Figure 4.7).

3. Rice growing in dry season

Ban Pak Yam began growing rice in dry season since ten years ago. Rice growing in this area was promoted by the Nakon Phanom Irrigation office. Rice growing starts in early January then finish in late April. Rice yield in this area is higher than general of the Northeast. The rice growing area is next to Nong Ake, Nong Nau, and Nong Tai. Where Nong Ake is a main area for rice growing this because of sufficient water supply.

Growing rice in dry season depend on supporting of water pump machine from the irrigation office because there are many of villager who needs to growing rice, mainly tree group with tree machine the total member are approximately 50 persons, one person from one household . Thus, if the machine come 2 in 3 then some of villager will be left in that year. Last year there were only two machines (Figure 4.8).

4. Non-timber product gathering

Villagers gather a non-timber product from floodplain forest for household consuming and for selling. The most important which villager collected were bamboo shoot and natural vegetables such as Kra Don (*Barringtonia acutangula* Gaertn.). Particularly, some of villager who collecting bamboo shoot for sell could earn income up to 7,000 – 10,000 Bath per year. In dry season bamboo shoot price is expensive. Additionally, floodplain forest provided fuel sources, building material and material for fishing equipment.

The result of study indicate that floodplain forest is very important resources base for community living. The villager obtained benefits from floodplain forest through foods, income, quality of life and ecosystem function.

Table 4.1 Seasonal calendar of floodplain forest use

Use	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Fisheries	←	—	—	—	—	—	—	—	—	—	—	→
Livestock	←	—	—	—	—	—	—	→				
Rice growing	←	—	—	→								
Bambooshoot gathering	←	—	—	—	→							
Natural vegetables	←	—	—	—	—	→						
Fuel woods	←	—	—	—	—	—	—	—	—	—	—	→
Building materials	←	—	—	—	—	—	—	—	—	—	—	→
Fishing materials equipment	←	—	—	—	—	—	—	—	—	—	—	→

Table 4.2 Seasonal calendar of some fishing methods

Tools	Jan.	Feb.	Mar .	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Line and hook							◄	—	—	—	—	►
Gill net	◄	—	—	—	—	—	—	—	—	—	—	►
Cast net	◄	—	—	—	—	—	—	—	—	—	—	►
Large lift net										◄	—	►
Wing set bag								◄	—	►		
Bamboo fish traps (in local name)												
Toom			◄	—	—	—	—	—	—	—	—	►
Juun			◄	—	►							
Zai					◄	—	—	—	—	—	►	
Kaa	◄	—	—	—	►							
Loob						◄	—	—	—	►		

Figure 4.5 Use of floodplain forest for fisheries

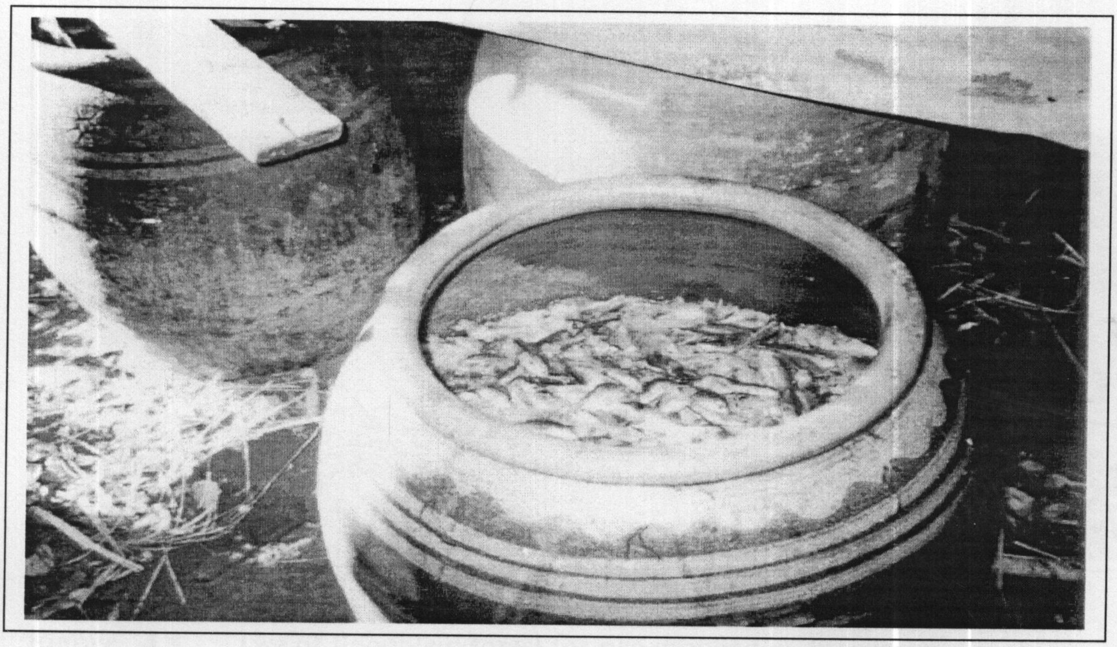

Figure 4.6 Fish fermented (pra-ra)

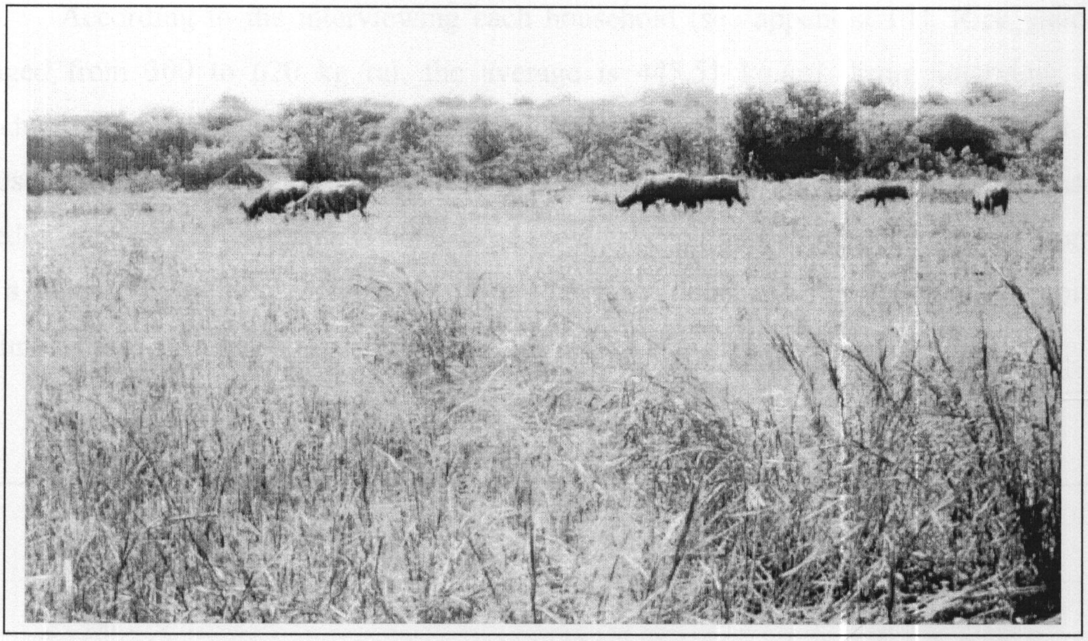

Figure 4.7 Use of floodplain forest for livestock

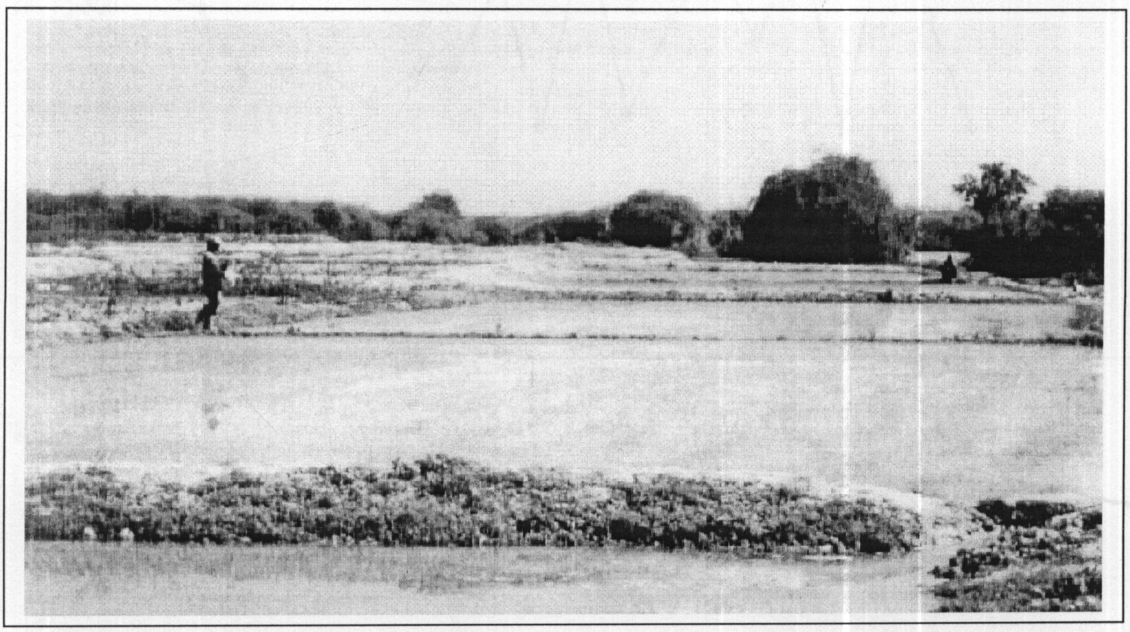

Figure 4.8 Use of floodplain forest for rice growing in dry season

4.9 Rice yield at household level

According to the interviewing each household (see appendix III). Rice yield is ranged from 300 to 620 kg./rai, the average is 445.51 kg./rai. From interview, the productivity is stable when compare with last four years. Rice yields are sufficient for household consumption. Some household sell their rice to earn some cash for basic needs. The rice growing area is not a large scale for each household where range from 2 to 8 rai per households. The level of productivity depends on time, labors, capital, technology, topological and water sources (Figure 4.9).

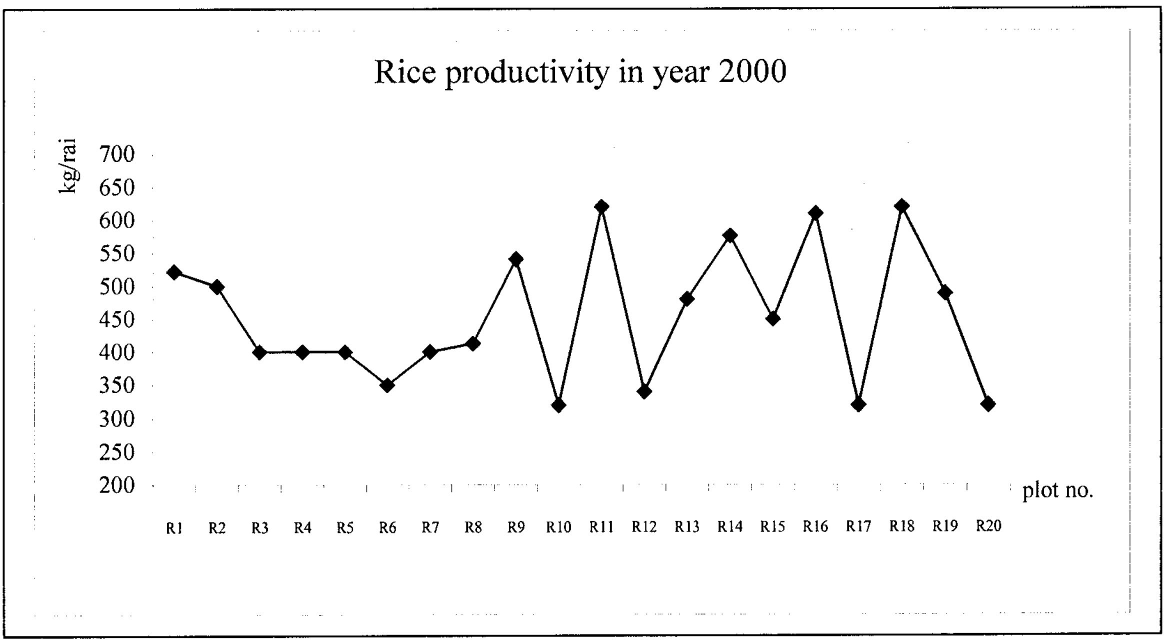

Figure 4.9 Rice yields in year 2000 in each plots

4.10 Land use systems

According to land use history of Ban Pak Yam, the land use systems divided to 4 zone from land use history by using mapping technique with key informant (Figure 4.10). Mapping with key informants provide to understand land use of floodplain forest which related to land use history.

1. Remaining floodplain forest

The remaining floodplain forest is area that never been cleared for agriculture, present the area is approximately 2,500 rai. As described from land use history, this area remained from charcoal concession in the second phase since twenty-three years ago. Forest covers with vegetation such as natives shrub trees (as mentioned above) and bamboo (*Bambusa arundinacea* Wild) . The bamboo is dominant vegetation in remaining forest it important for villager use (Figure 4.11).

2. Scattered forest

Some area of floodplain forest is scattered forest. The area approximately 10 to 15 rai. Because, since ten years ago, the villager can not growing rice this due to lack of capital and inappropriate area particular water supply thus it still remain as scattered forest. The vegetation are natives shrub tree and bamboo but less dense than remaining floodplain forest (Figure 4.12).

3. Disturbed forest

Some area of floodplain forest used to converted for rice growing last five years ago, then the villager had abandoned the area as there was insufficient water supply. From interview key informant disturbed forest area is approximately 30 – 50 rai. Presently, some of native floodplain forest vegetation is recovering such as Kra Don (*Barringtonia acutangula*) (Figure 4.13).

4. Agricultural forest

This area has been used for rice growing during dry season for ten year ago. The total area is about 300 rai. The villagers have been converted floodplain forest into rice fields. Mainly, rice was planted next to the oxbow lake called "Nong Ake" by local name. There were two of irrigation pump machines. The Nakhon Phanom Irrigation Office provides two of irrigation pump machines to this village. Planting season was started in early January and finish in late April it depend on irrigation pump machine arrived. Rice varieties planted by villager was RD 10 (Kor-Khor 10). Chemical fertilizer were applied at rate 25 kg/rai of the 16-16-8 $N:P_2O_5:K_2O$ fertilizer and include lime applies at rate 20 kg/rai (Figure 4.14).

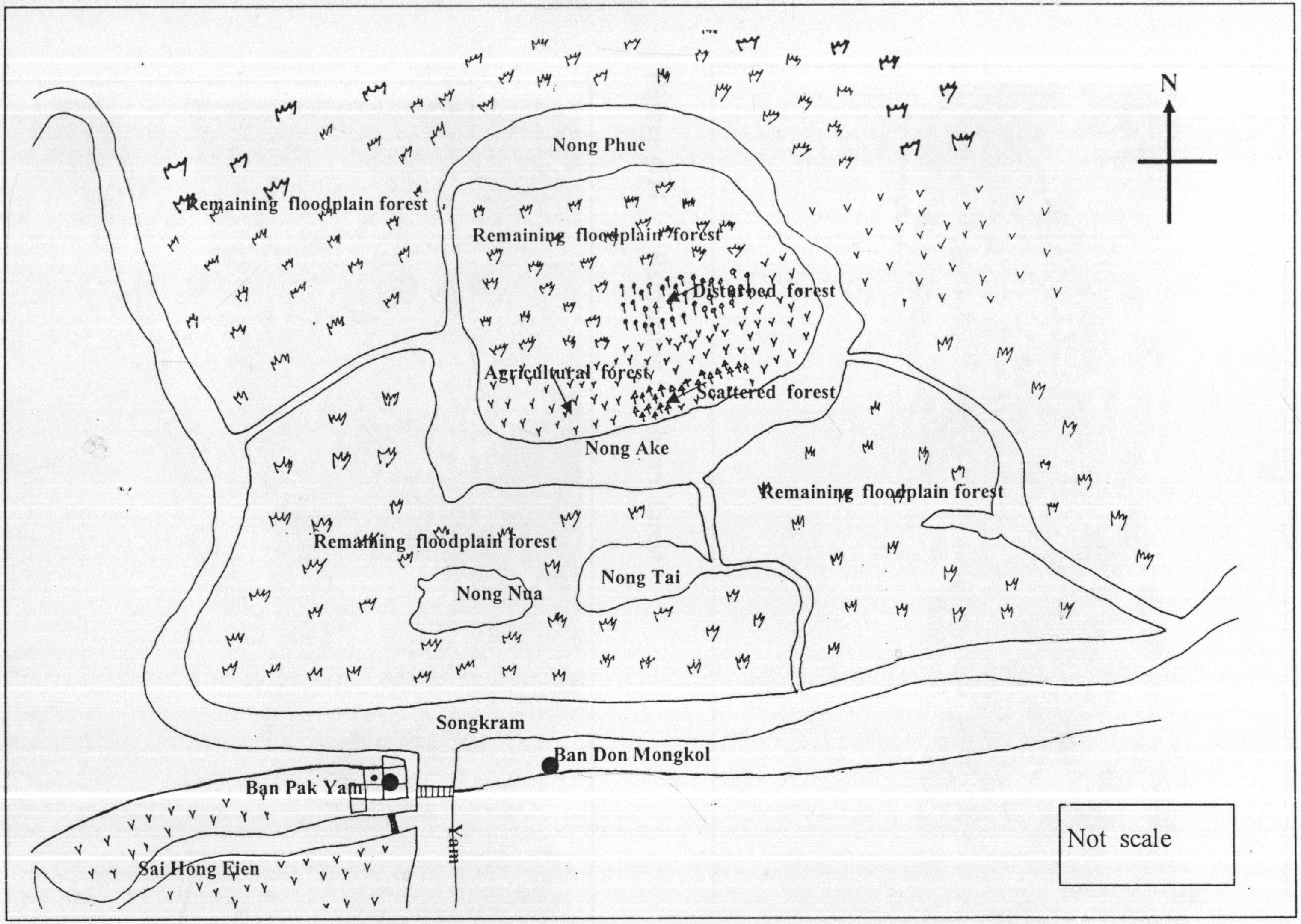

Figure 4.10 Land use systems of Ban Pak Yam (from mapping with key informants)

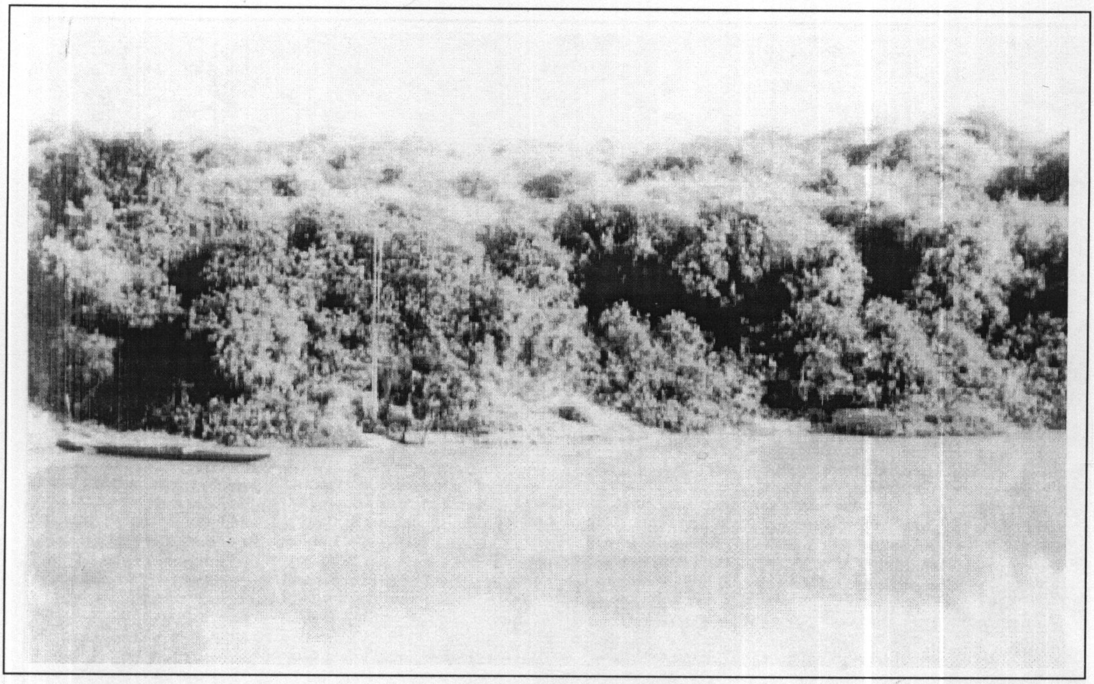

Figure 4.11 Remaining floodplain forest

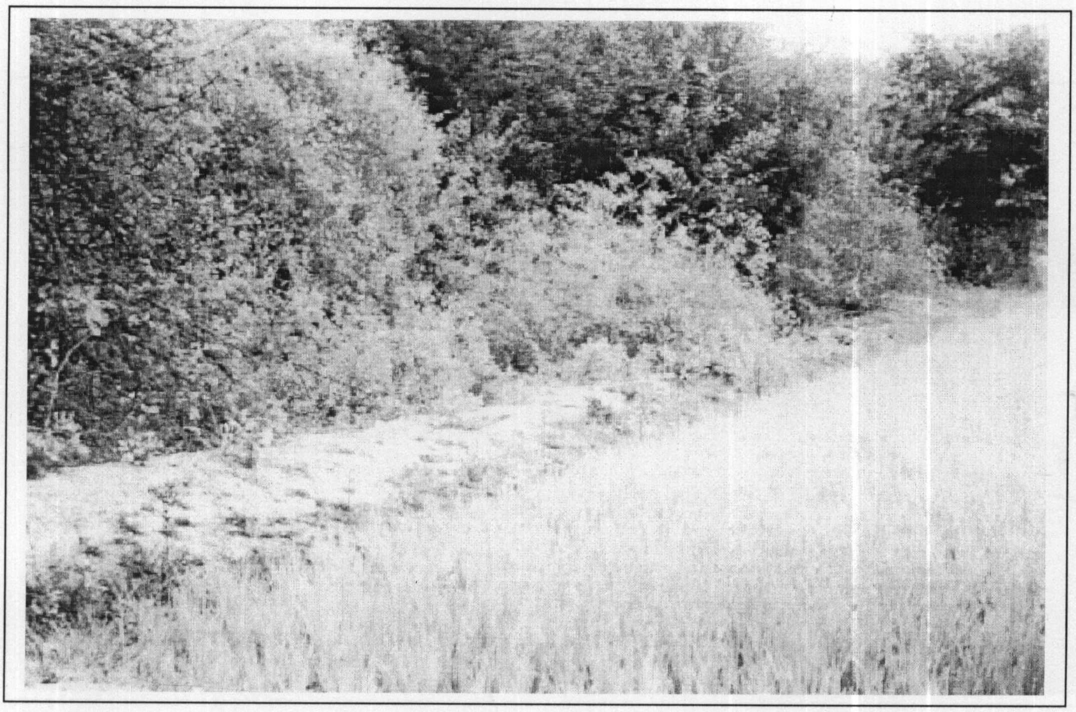

Figure 4.12 Scattered forest

Figure 4.13 Disturbed forest

Figure 4.14 Agricultural forest

4.11 Agroecosystem properties analysis

4.11.1 Productivity of rice production in agricultural forest.

Rice production of Ban Pak Yam since conversion floodplain forest to agricultural forest indicates that rice yield per rai from rice growing in dry season is higher than average rice yield of the Northeast. The rice yield was 445.51 kg/rai while the average rice yield of the Northeast is 418 kg/rai. However, rice production in dry season was limited by soil quality, topographic condition, seasonal inundating and socio-economics situation.

As a result of soil analysis showed that in natives state flood plain forest soil has high relatively fertility than agricultural forest. Whilst in agricultural forest soil nutrients, soil carbon tend to decline this indicates that soil has been degraded. For long term, decline of soil fertility can be reflects to productivity of the system.

Rice growing in dry season, mainly, resulted of resources decline. This is incentive factors to changes living style of Ban Pak Yam to start growing rice.

4.11.2 Stability of rice production in agricultural forest

The stability of rice production in dry season where conversion floodplain forest to agricultural forest, farmer observed that rice production in dry season could be obtain rice yield higher than upland rice. Rice production when compare with three years ago the productivity quite stability. Villager very satisfy with rice yield because it adequate for households consumption in each year. However, stability of the system will depend on seasonal inundating, physical factor such as soil quality and water supplies.

4.11.3 Sustainability of rice production in agricultural forest

Rice production in dry season of Ban Pak Yam increase food security of community due to sufficient rice for home consumption. The sustainability of rice production, based on soil analysis indicated that soil has been degraded where conversion floodplain forest to agricultural forest. The degradation degree appeared through the decline of soil nutrients and soil carbon. As a result of degradation of soil indicates that where conversion floodplain to agricultural forest the system does not sustain. However, it might be due to adequate nutrients supplies so that the system can maintain it stability.

Occurring of soil degradation in agricultural forest indicates that the system does not sustain. However the sustainability depend on many factors such as the capacity of the system in order to recovering and management. Rice production in dry season showed that the system has the potential of stability but, due to degradation of soil it needs to improve the capacity of the system in order to maintain sustainability.

4.12 Soils properties under different land use systems

4.12.1 Soil pH

Soil pH showed that in agricultural forest is higher than the remaining forest, the scattered forest, and the disturbed forest. Range from 4.01 to 4.68. In remaining forest pH appear 4.34 while in agricultural appear 4.01-4.68. Soil pH in all land use indicated that the floodplain soil is acidity soil. This suggests that soil pH in remaining forest is lower than agricultural forest. This difference from general that it should be higher than agricultural forest (Figure 4.15).

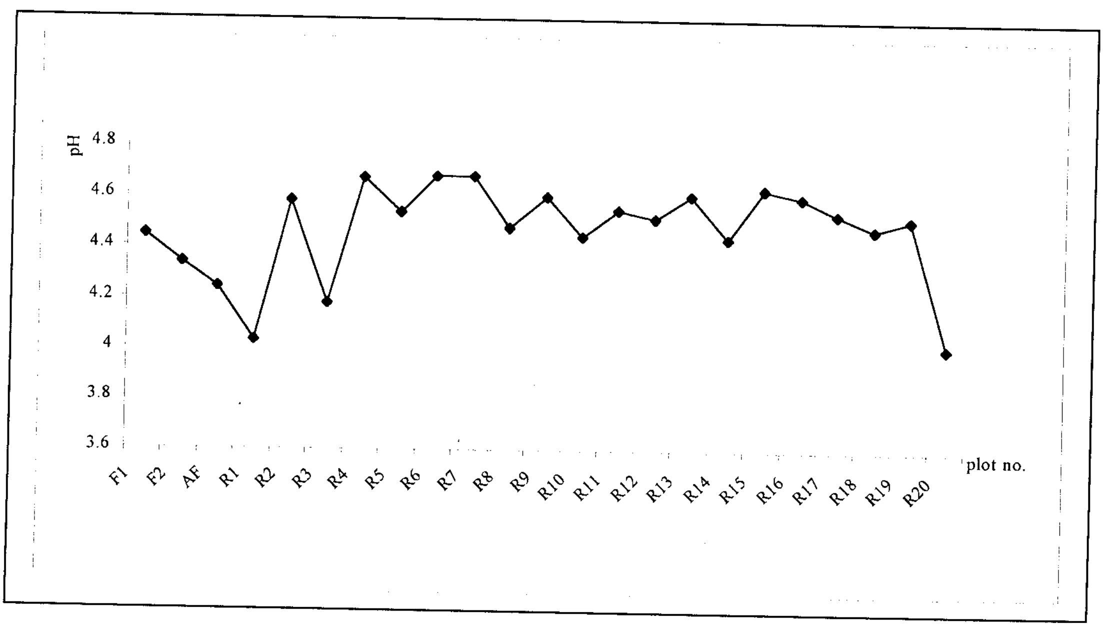

Figure 4.15 Soil pH under different land use systems

4.12.2 Available P

Available P values were difference under different land use systems. The result showed that available P value in the remaining forest was higher than the scattered forest, the disturbed forest, and agricultural forest. Range from 2.02 to 11.26 ppm. The available P appear 11.26 ppm in the remaining forest and remain at 0.9-5.06 ppm in the agricultural forest. Available P value tend to decline in agricultural forest. However, available P in floodplain forest is higher than the general soils in the Northeast (Figure 4.16 and appendix IV).

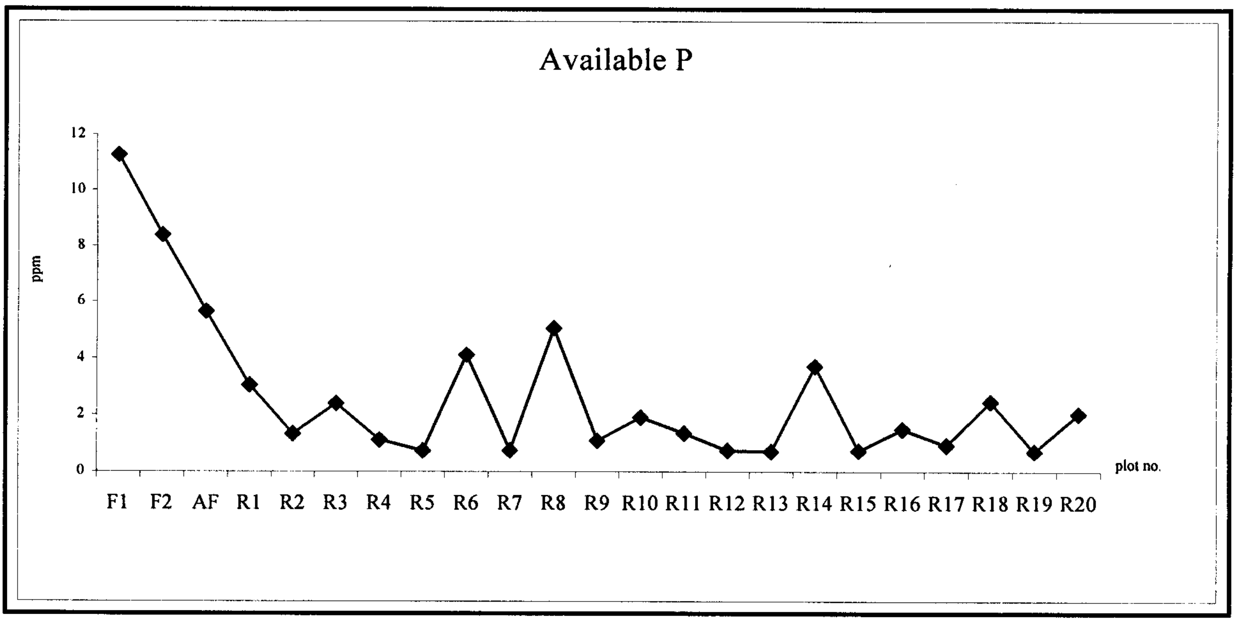

Figure 4.16 Available P under different land use systems

4.12.3 Exchangeable K

According to the difference of land use systems the values of exchangeable K were differences. Exchangeable K values in the remaining forest were higher than in the scattered forest, the disturbed forest and the agricultural forest. Range from 24.31 to 123.24 ppm. Exchangeable K appear 123.24 ppm in the remaining forest while appear

22.62-120.27 ppm in the agricultural forest. Additionally, exchangeable K in the scattered forest and the disturbed forest tends to similar to an agricultural forest (Figure 4.17 and appendix IV).

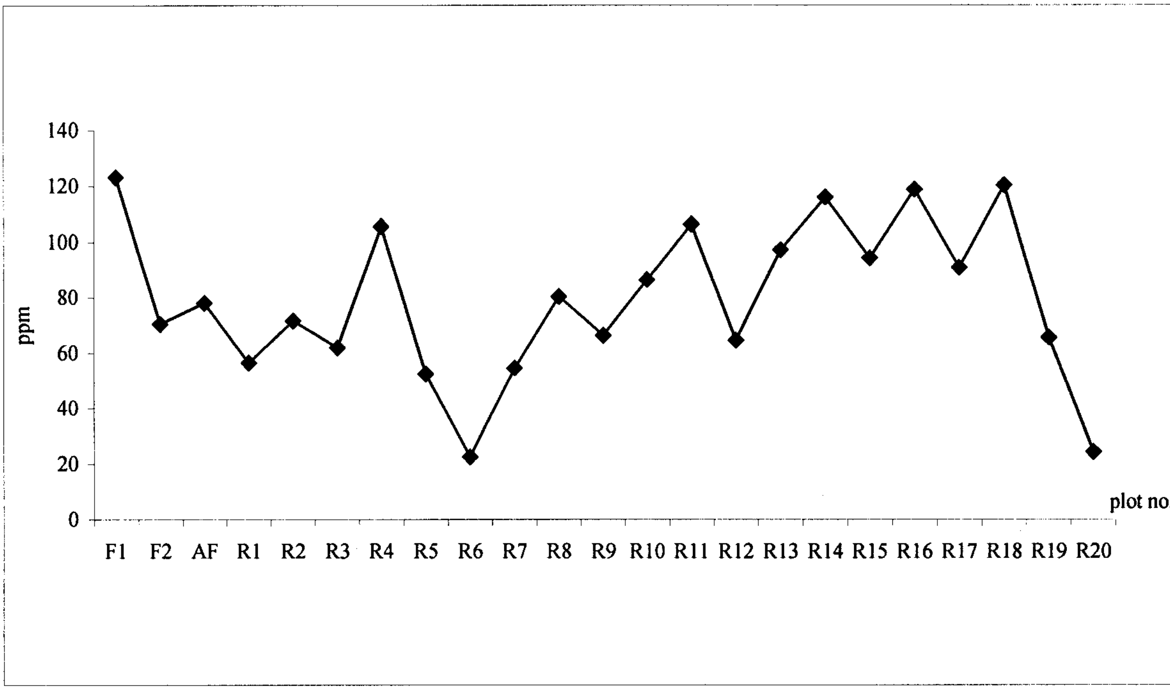

Figure 4.17 Exchangeable K under different land use systems

4.12.4 Exchangeable Ca, Mg and Na

Under a difference of land use systems there were difference of exchangeable Ca, Mg and Na. Values of exchangeable Ca, Mg, and, Na in remaining forest was higher than in the scattered forest and the disturbed forest. The range from 534.82, 27.95, 33.93 to 1071.98, 493.62, 303.55 ppm. The values from agricultural forest is higher than another site (Figure 4.18 and appendix IV).

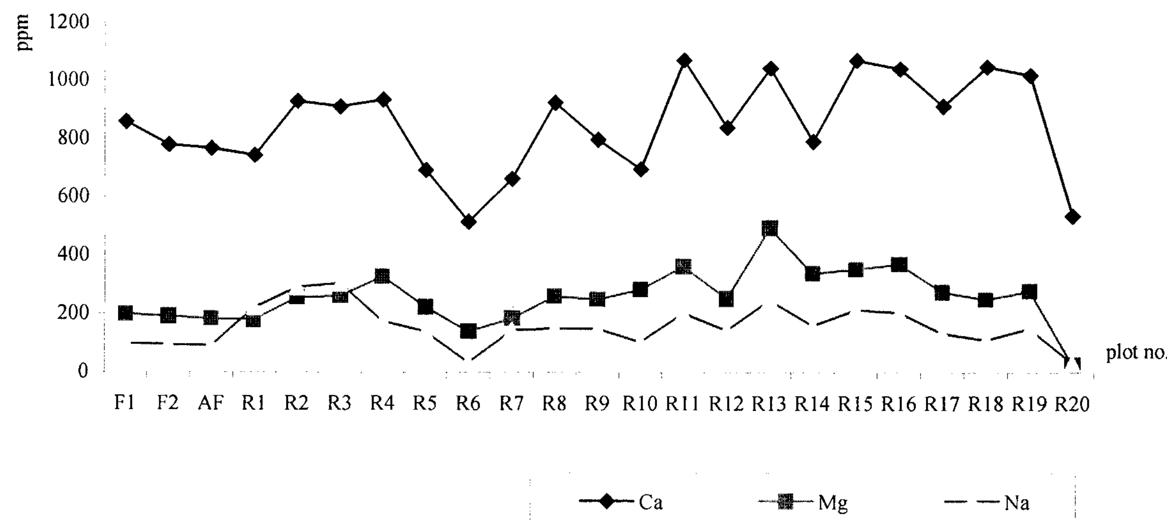

Figure 4.18 Exchangeable Ca, Mg and Na under different land use systems

4.13 Carbon fractions and percent decline under different land use systems

4.13.1 Total Carbon (C_T)

The result of carbon fractions under different land use systems showed that the greatest decline in C_T was observed in agricultural forest when compare with references site. Consequently, C_T in agricultural forest was lower than disturbed forest and scattered forest. The values range from 7 to 33.7 mg/g. The C_T value in remaining forest appear 33.7 mg/g while appear 7-17.3 mg/g in agricultural forest. Loss of C_T appear 49 - 79 % when compare with references site. As with percent decline in agricultural forest was higher than other sites showed that due to cultivated can affects to losses in C_T (Figure 4.19, table 4.3 and appendix V-VI).

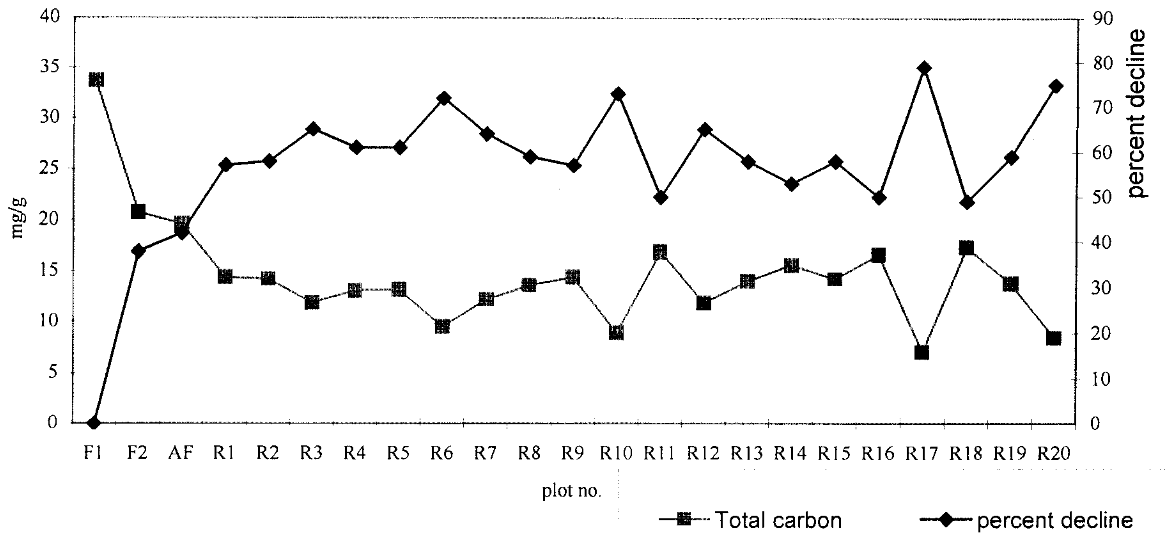

Figure 4.19 Total carbon and percent decline under different land use systems

4.13.2 Non-Labile Carbon (C_{NL})

As a result showed that under different land use systems C_{NL} in agricultural forest tend to greater decline than in disturbed forest and scattered forest when compares with references site. The ranges were 6.65 to 25.77 mg/g. The C_{NL} value in remaining forest appear 25.77 mg/g while appear 6.65-15.13 mg/g in agricultural forest. Loss of C_{NL} appear 41-74 % when compare with references site. Percent decline of C_{NL} in agricultural forest was loss greater than disturbed forest and scattered forest. However, loss in C_{NL} was lower than C_T and C_L (Figure 4.20, table 4.3 and appendix V-VI).

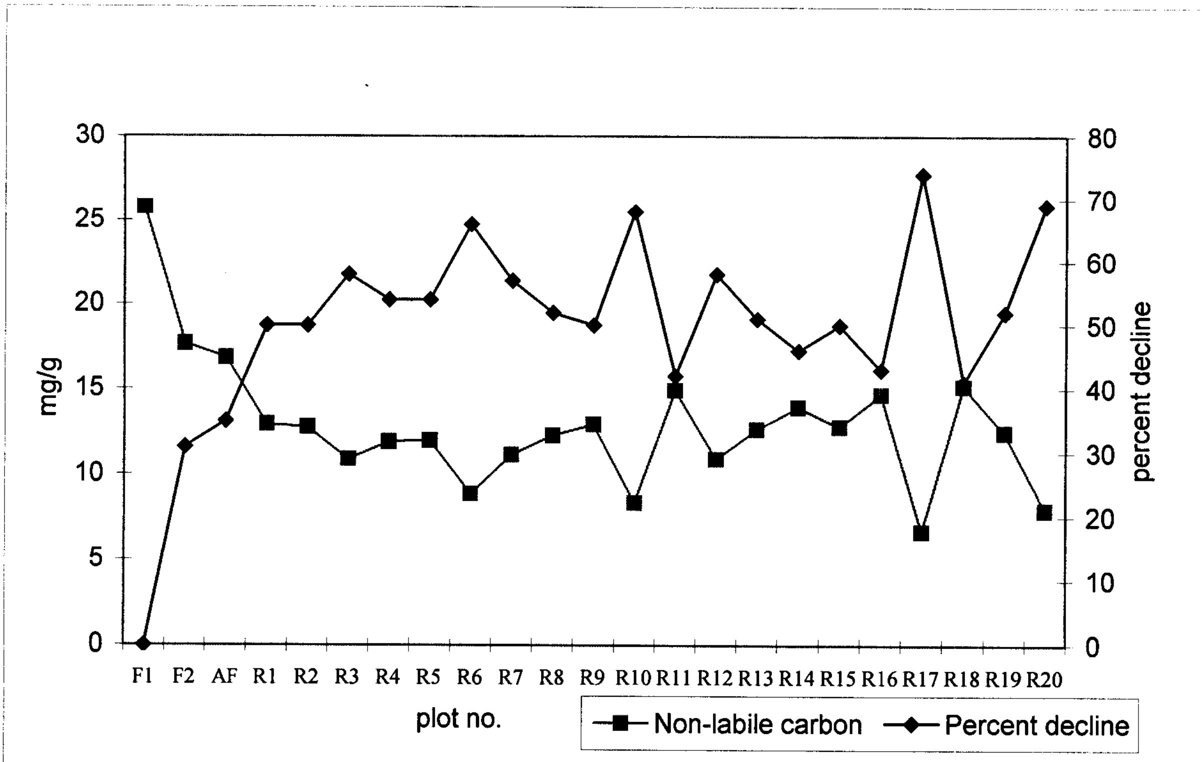

Figure 4.20 Non-labile carbon and percent decline under different land use systems

4.13.3 Labile Carbon (C_L)

As a result showed that under different land use systems C_L in agricultural forest tend to greater decline than in disturbed forest and scattered forest when compare with references site. The ranges were 0.35 to 7.39 mg/g. The C_L value in remaining forest appear 7.39 mg/g while appear 0.35-2.17 mg/g in agricultural forest. Loss of C_L appear 72-96 % when compare with references site. Similarly, in agricultural forest percent decline in C_L was greater loss than disturbed forest and scattered forest. (Figure 4.21, table 4.3 and appendix V-VI). Moreover, percent decline in C_L appears to be greater than percent decline in C_T and C_{NL}. In the other hand, changes in C_L were greater than changes in C_T and C_{NL}. This indicates that due to cropping can lead to decreasing in C_L .

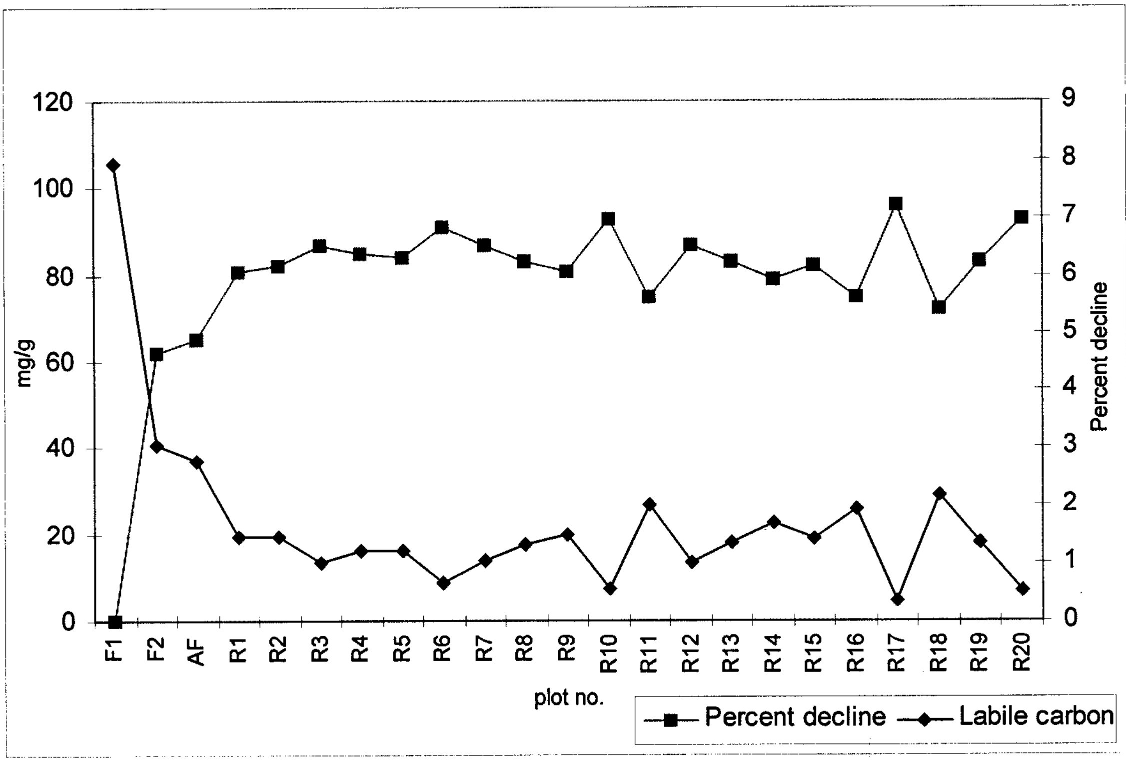

Figure 4.21 Labile carbon and percent decline under different land use systems

4.13.4 Lability (L) and lability index (LI)

As a result from soil analysis in this study showed that under different land use systems L and, LI in agricultural soil tend to decline across all soil. The lability and lability index in remaining forest is greater than in agricultural forest. The lability appear 0.307 in remaining forest while appear 0.053-0.143. The lability index in agricultural forest appear 0.173-0.436 when compare with the reference. The value from agricultural forest was lower than scattered forest and disturbed forest. However, increased in C_T, C_{NL}, and C_L can reflect to increasing in L and, LI (Figure 4.22 and appendix V)

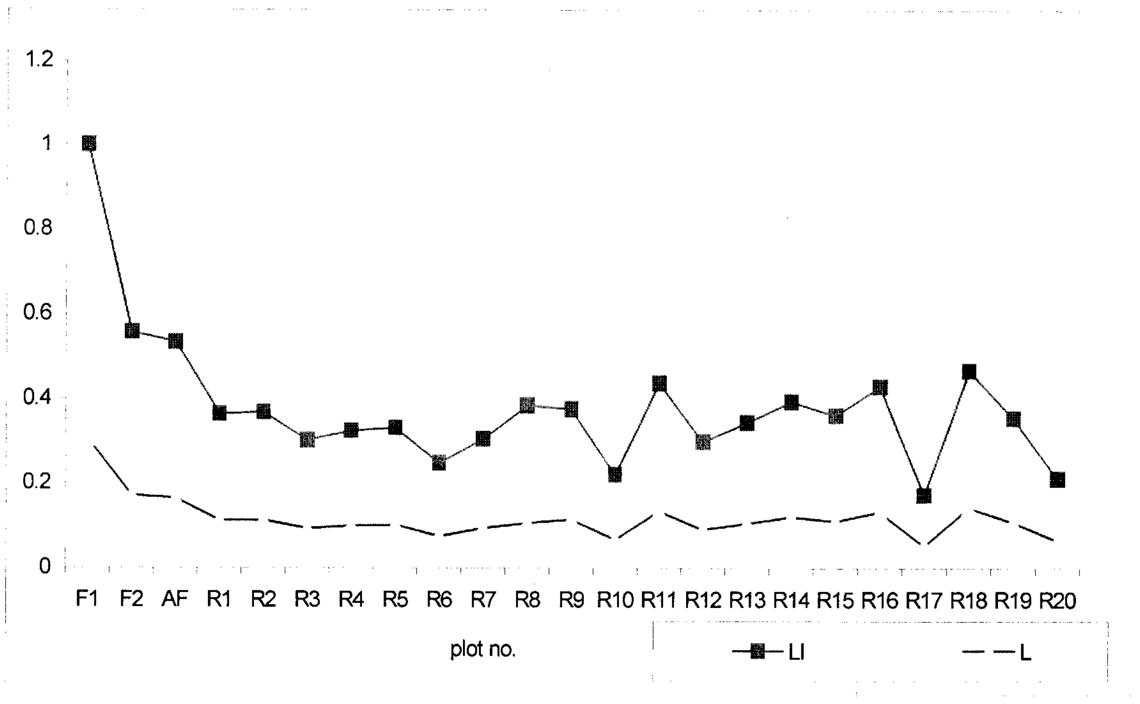

Figure 4.22 Lability index and lability under different land use systems

4.13.5 Carbon pool index

As a result from soil analysis in this study showed that under different land use systems CPI in agricultural soil tend to decline across all soil. The carbon pool index appear 0.21-0.49. When compare with references soil the CPI value from agricultural forest was lower than scattered forest and disturbed forest (Figure 4.23 and appendix V).

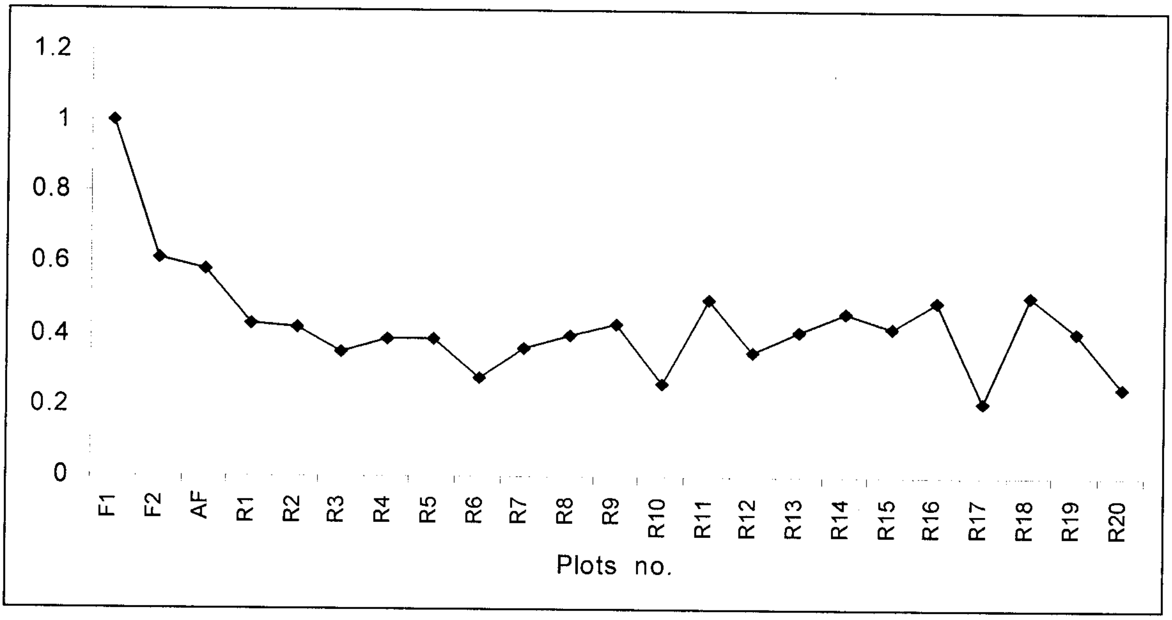

Figure 4.23 Carbon pool index under different land use systems

4.13.6 Carbon Management Index (CMI)

As a result shows that under different land use systems, there was the greatest changes in CMI from agricultural forest. The CMI appear 5-24% in agricultural forest when compare with reference. Changes in CMI as a result of changes in C_T, C_L and C_{NL} of a cropped soil. In the other hand, changes in soil carbon fractions leads to change in CMI. The increasing in C_T, C_L and C_{NL} relate to increase in CMI. Moreover, under cultivated can reflects to changing in CMI (Figure 4.24 and appendix V).

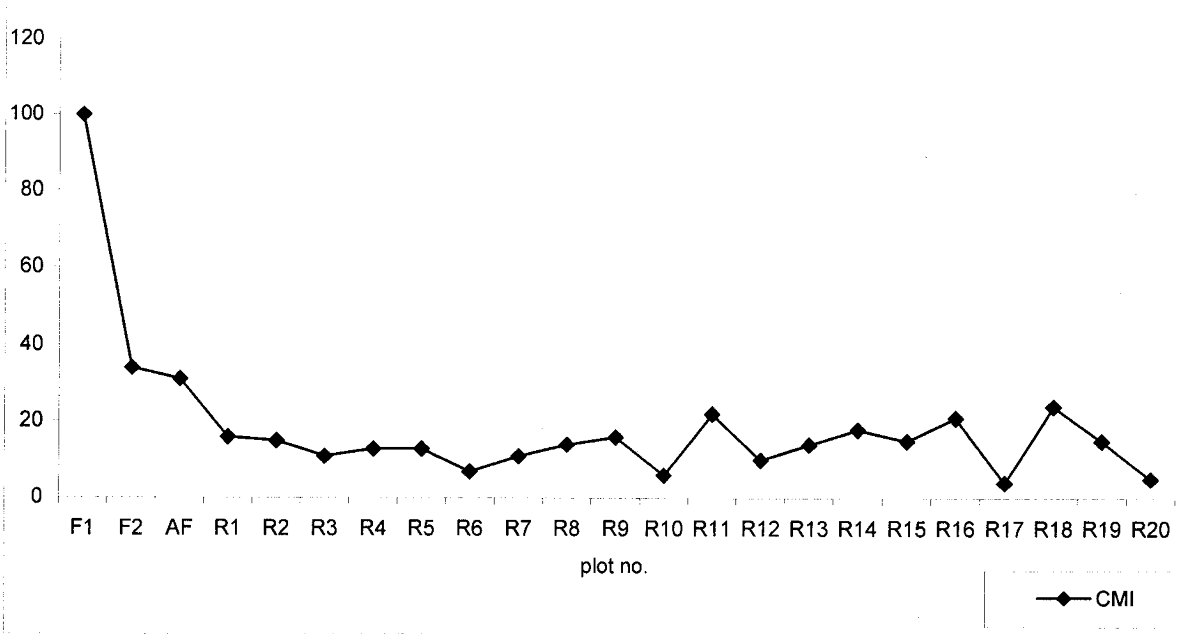

Figure 4.24 Carbon management index under different land use systems

Table 4.3 Percent decline of carbon fractions under different land use system

Carbon fractions	Remaining forest %	Scattered forest %	Disturbed forest %	Agricultural forest %
C_T	0	38	42	49-79
C_L	0	62	65	72-96
C_{NL}	0	31	35	41-74

4.14 Relationship between C_L, available P and, exchangeable K

The result showed that there were significant relationship between C_L, available P and exchangeable K. A relationship between C_L, available P and exchangeable K indicates in higher C_L available P and exchangeable K tends to increase more than in lowest C_L soil (Figure 4.24-4.25).

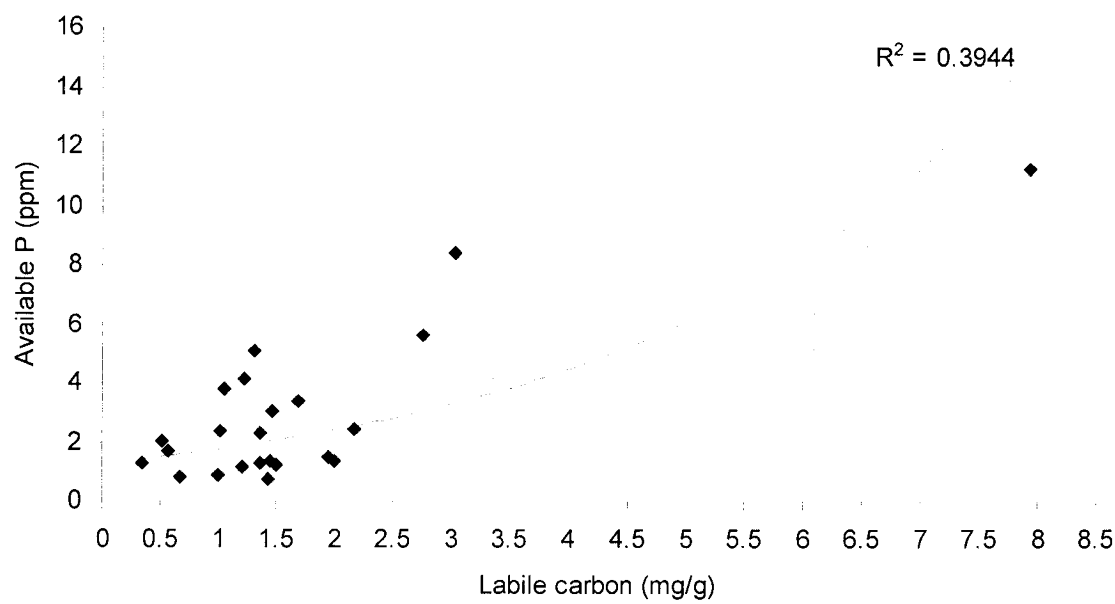

Figure 4.24 Relationship between available P and labile carbon

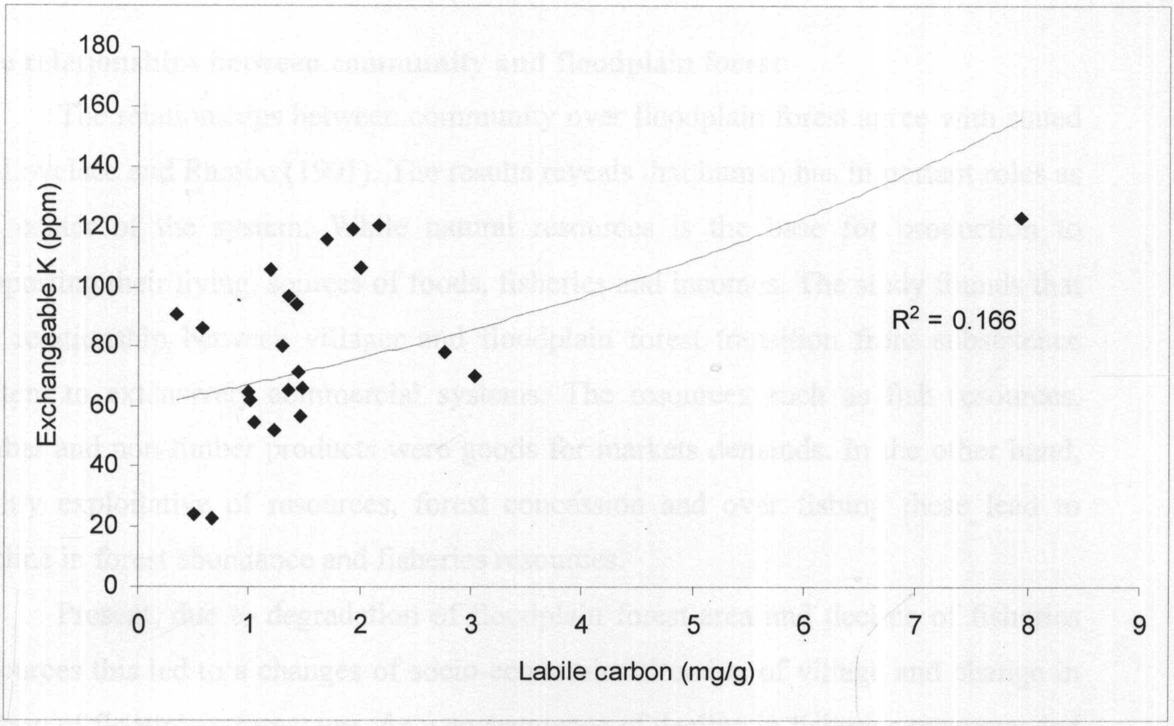

Figure 4.25 Relationship between exchangeable K and labile carbon

CHAPTER V

DISCUSSIONS

The relationships between community and floodplain forest

The relationships between community over floodplain forest agree with stated by Lovelace and Rambo (1991). The results reveals that human has important roles as the center of the system. While natural resources is the base for production to supporting their living, sources of foods, fisheries and incomes. The study founds that the relationship between villager and floodplain forest transition from subsistence system to extensively commercial systems. The resources such as fish resources, timber and non-timber products were goods for markets demands. In the other hand, highly exploitative of resources, forest concession and over fishing these lead to decline in forest abundance and fisheries resources.

Present, due to degradation of floodplain forest area and decline of fisheries resources this led to a changes of socio-economics situation of village and change in pattern of floodplain forest use. As a consequence of decline in fisheries resources led to changing in their living style. Alternatively, villager started rice growing for households consumption. Consequently, floodplain forest area were used for growing rice since fisheries resources is inadequate for supporting community living.

Factors influencing on land use changes

Land use change of floodplain forest was effected from many factors as follow:

1. Changes of socio-economics situation

Socio-economic is one of factor which is can change over time. In the past, households obtained rice through brothers system with rice farmer in the upland an /or sold fish products and brought rice for consumption.

Changing in socio-economics situation of community from subsistence to extensively commercial relate to degradation of floodplain forest and fisheries resources. Consequently, villager starts rice production in floodplain forest areas. The mainly benefit from rice growing is for self-sufficiency. However, expanding of area is slowly this depends on water sources, capital, labor, technology and time. These are general in agricultural production, the limiting factors are consist of water resources, labor forces, financing and new knowledge.

2. Decline of fisheries resources

In the past, abundance of fish resources attacks people to settle in this village. Decline of fisheries might be associate with over fishing and degradation of natural habitat led to decline of fish resources. Destructive fishing method is one of main factor effected to fish abundance. Fisheries resources has been declined continuously whilst this effects to living style of community. Subsequently, decline in fisheries resources this is alternatively motivation of villager to growing rice for consumption in their households.

3. Topography

Use of floodplain forest depends on topography. Due to the topography-characteristic is floodplain terrain where elevation is lower than 150 mm. from the sea level, typically it will be inundating during rainy season this limiting land use patterns of floodplain forest area. Because, villager can not use the land during that time. So their can use the land only during dry season. Moreover, due to typical of physical feature landscape of floodplain is not appropriate for paddies fields this also limiting factors of expansion area for rice growing.

4. Government policies

In the past, the government policy allowed to logged tree from floodplain forest through forest concession and charcoal concession this led to directly impact to degradation of floodplain forest. Similarly , Pintong (1994) reported the main problem of deforestation in Thailand resulted from forest concession. Due to development under government policies can be lead to changing in living style of community. Such as, most of floodplain forest of this village is a private property for long term this will be lead to expanding of agricultural area or land might be sale to the business man. For long term it needs appropriate and sustainable policy in order to practice.

Agroecosystem analysis

Rice production system where conversion floodplain forest to agricultural forest is higher than upland rice production in the Northeast. While at households level, high outputs of the rice yield implied that this will increasing food security for villager because there are sufficiency rice for consumption in their households.

Productivity of rice production in agricultural forest is higher than general of the Northeast. The rice yields obtained from rice production in agricultural forest is quite stable from year to year. This might be associate with floodplain soil has high potential to supplies nutrients to the system.

Due to decline in soil nutrients and soil carbon pool indicates that soil has been degraded. The degradation of soil in agricultural forest demonstrate that the system does not sustain. However, may be due to adequate of nutrient supplies this can maintain stability of rice production in agricultural forest. This agree with Vityakon (1989) reported stability of rainfed rice agroecosystem depend on an adequate potassium supplies.

Follow Conway (1985), the decision making suggest what are the important factors which determined the system properties. The decision making of villager who growing rice in dry season relates on decline of fish resources, while their needs to obtain rice for household consumption. So, villager start growing rice in dry season.

In the aspect of time, the sustainability might be continue degraded. It needs an appropriate land management in order to sustain the production of the system.

Effects of land use on soil nutrients

In this study, declining in available P and exchangeable K in agricultural forest might be associate with declining in organic matter. Because, the roles of organic matter provide as the reservoir for plant nutrients. Particularly, decline in available P and exchangeable K might be reflect to decrease in C_L. Cultivation affected the status of soil nutrients through changes in both inputs and outputs of nutrients (Konboon ,1998). Subsequently, decline in soil nutrients indicates that soil fertility reduced. Changes in exchangeable Ca, Mg and Na indicated that it might be effected of lime applies. Because, as a result of lime application cation such as Ca, Mg and Na were released in soil. Unlikely from general that in natural forest should have exchangeable cation higher than in agricultural forest. In natural forest, organic carbon provide main sources of cation in soil (Duxbery et al., 1988). However, exchangeable Ca, Mg and Na in floodplain forest soil were higher than general soil in the Northeast. In the other hand, lime apply could be effects to availability of soil nutrients through pH changing.

Soil carbon fractions under different land use systems

In remaining forest soil carbon fractions, total carbon, non-labile carbon and labile carbon were greater than in agricultural forest. This might be resulted of there were various sources of organic inputs to the system such as litter fall and sedimentation. Whilst in agricultural forest cultivation reduce sources of organic matter.

In remaining forest soil labile carbon appear 7.39 mg/g and remain 0.35-2.17 mg/g in agricultural forest. The total soil carbon appear 33.7 mg/g in remaining forest and in agricultural forest appear 6.65-15.13 mg/g. The non-labile carbon appear 25.77 mg/g in remaining floodplain forest and remain 0.35-2.17 mg/g in agricultural forest.

Loss of labile carbon where conversion floodplain forest to agricultural forest is greater than loss in the total carbon and non-labile carbon. The percent decline appear 72-96% when compare with natives state. This indicates that when the soils from native state have been converted to cultivation the organic carbon that were readily oxidisable were lost more rapidly than recalcitrant component. The loss of labile pool is greater than total carbon because the labile carbon is more sensitive pool than total carbon and non-labile carbon. (Conteh and Blair, 1998).

Decline of LI where conversion floodplain forest to agriculture forest implied that the ratio of C_L to C_{NL} has decreased during cultivation of the soil. This was resulted from soil management systems which lead to either (a) a rapid decomposition of the readily available carbon while maintaining the resistant carbon fractions or (b) a rapid transformation of the readily decomposable carbon into stable form; or (c) though increasing both the C_L and C_{NL}, the conversion from C_L to C_{NL} occurs at a much faster rate than the rate of increase in C_L (Conteh et al, 1997).

In this study, decline of CPI expressed that loss soil carbon occur where conversion floodplain forest to agricultural forest. As state by Blair (1995) the carbon pool index (CPI) can uses to indicate to what exists in the native state. The CPI expresses the total carbon of a cultivated soil as a proportion of the total carbon in a reference soil, rapid decline in the CPI is a direct result of the reduction in the total soil carbon.

In this study, the CMI remains 5-24 % when compare with natives state. Loss of CMI occur rapidly in agricultural forest this might be resulted of decline in organic matter sources due to cultivation and clearing native vegetation. This agree with Conteh et al. (1997) reported the CMI in Red clay and Brown clay soil under 14 years cropping have been declined under cultivation. The CMI express the rate of change in soil carbon dynamics of systems relative to a more stable reference soil (Blair, 1995).

Roles of soil labile carbon on productivity

Soil labile carbon contributes to productivity through the potential in order to provide nutrients to the system rapidly. During it oxidation soil nutrients were released and some may become available to plants uptake readily (Tate 1987). The relationship between labile carbon and soil nutrients shows that high C_L content in soil tend to provide higher soil nutrients contents than in lower C_L soil. As Conteh and Blair (1998) reported labile organic carbon provide the sources of plant nutrients in soil due to its chemical composition and rapid turn over rate. Consequently, changes of C_L effects to changes in soil nutrients. Based on Swift (1991) reported that labile soil organic matter is significant for soil fertility as a sources of readily available nutrients. Similarly, as stated by Ruaysoongnern (1996) that decline of soil organic matter lead to depletion of soil nutrients. The sustainability of rice production in Sandy paddy soil depends on the potential of the pattern of mineral transfer from organic matter (Ruaysoongern, 1995). However, when compare with general soil in the Northeast there were high organic carbon contents in floodplain forest soil. It might be there are many sources of organic matter particularly from litter fall and sedimentation.

Potential productivity assessment

The assessment of productivity can also measure by production per resources inputs (Prakongsri, 2000) . On the other hand, it can measure by potential of resources inputs in order to support the production of the system. Based on soil system, the result shows that labile organic carbon could be indicator to assess potential productivity. The C_L is a sensitive fraction in carbon pool which can be rapidly changing under different land use. In this study, based on, the status of labile organic carbon the significant finding showed that floodplain forest areas have high relatively potential of productivity. While conversion floodplain forest to agricultural forest the C_L tends to decline it could be demonstrate that potential productivity might be reduced. As, decline in C_L indicates that degradation of soil fertility taking place.

As stated by Konboon (1998) labile organic carbon in soil related to the productivity of the system, high nutrients inputs and faster rate of decomposition associated with more nutrients available for rice crop. This was resulted of the ability of labile fraction in order to release nutrients to soil system rapidly. Therefore, C_T, C_L, and C_{NL} in agricultural forest reduced but the system can continues maintain it stable. Because, based on inputs and outputs flows of the floodplain forest ecosystem it might be that the system has high potential of nutrients supply from the labile pool.

Assessment potential productivity, indicates that floodplain forest areas have high relatively productivity. This provides resources base for basic needs for the communities. Villager living depends on the existing of floodplain forest. Productivity supports community living where to increase food security of the communities. On the other hand, in-appropriate use of floodplain forest directly affect to the degradation of floodplain forest area, particularly decline in potential of productivity.

Degradation of floodplain forest areas

The degradation of floodplain forest, as a resulted of decline in soil carbon fractions, total carbon, non-labile carbon and labile carbon indicates that soil has been degraded where conversion floodplain forest to agricultural forest.

This might be coinside with decline in soil organic matter due to cultivation practice such as clearing native vegetation and crop removal. Whereas in natives state, soils were equilibrium and have characteristic organic matter contents. This equilibrium was disturbed when the soil conversion into cultivation due to decreased accumulation of organic materials and the accelerated breakdown the existing organic matter through cultivation (Conteh, 1998). Clearing and subsequent cropping affects the organic matter status of soils through changes in both the input of organic matter and rate of turnover (Konboon, 1988).

Based on soil system, according to Oldeman (1994) the soil degradation types can be classified as chemical degradation of soil. Due to losses of soil nutrient and soil organic carbon taking place both total, non-labile and labile pool. The degradation might be caused by removal of natural vegetation for agricultural purpose, crop removal in harvested products and residues and by leaching.

In this study, the degree of degradation is moderately because, soil still suitable for rice growing. Although, the productivity tend to decline due to decline in potential of nutrients supplies from labile pool. Although, the system can continue maintain it stability but for long term it need an appropriate management in order to secure the productivity of floodplain forest area.

CHAPTER VI
CONCLUSIONS AND SUGGESTIONS

This study investigated potential productivity of floodplain forest areas, a case study Ban Pak Yam Srisongkram district, Nakhon Phanom province. The objectives of this study were to study soil labile carbon, to assess potential productivity and to assess degree of degradation of floodplain forest areas under differences land use systems. The study based on agroecosystem analysis and soil analysis. The analytical method to assess soil labile carbon is $KMnO_4$ oxidation technique.

The results of this study shows that floodplain forest is important resources base for communities living. Mainly, during inundating floodplain forest provide sources for fish habitat this plays important roles on fisheries occupations of Ban Pak Yam. In dry season floodplain forest provides sources for rice production, this based on villager needs to obtained rice for households consumption. The productivity of rice production where conversion floodplain forest to agricultural forest, the average rice yield from this study is 445.51 Kg/rai . Moreover, villager gather natural foods from floodplain forest for household consumption and some for sell. Presently, the main use of floodplain forest are for fisheries, non timber products gathering, livestock and rice growing in dry season.

The study founds that the decline in fisheries resources relate to changing in land use of Ban Pak Yam. Decline of fish resources is incentive factors to conversion floodplain forest to agricultural forest. Agroecosystem properties analysis indicates that although soil has been degraded but rice production system in agricultural forest is quite stable. The productivity and stability of rice production system might be associate with high relatively potential of soil to supplies nutrients to the system. The degradation of soil in agricultural forest demonstrated the system does not sustain.

Soil nutrients analysis indicates that land use change has led to changing soil nutrients. Conversion floodplain forest to agricultural forest led to decline in available P and exchangeable K content in soil. This might be associate with decline in soil labile carbon in agricultural forest. While Ca, Mg and Na tends to increase in agricultural forest this resulted of lime application.

The status of soil labile carbon in soil carbon fraction, showed that soil labile carbon in remaining floodplain forest appear greater than in agricultural forest. The labile carbon appear 7.93 mg/g in remaining forest and remain 0.35-2.17 mg/g in agricultural forest. Conversion floodplain forest to agricultural forest coinside with decline of soil labile carbon. Loss of labile pool appear 72-96 % in agricultural forest when compare with natives state. This might be due to decrease in sources of soil carbon particularly from crop removal and clearing native vegetation. Loss of labile carbon was more pronounced than total carbon and non-labile carbon due to, labile fraction is more sensitive fraction than other fractions.

Potential productivity assessment, total soil carbon, non-labile carbon, labile carbon determined by using $KMnO_4$ oxidation technique can provide more useful information in order to assess potential productivity. The significant finding based on status of soil labile carbon, indicates that floodplain forest areas have high relatively potential productivity. The study found that soil nutrients appear significant associate with soil labile pool. The soil labile carbon plays roles on productivity via the ability of labile pool in order to release nutrients to soil system rapidly and readily available for plant uptake. While conversion floodplain forest to agricultural forest the potential productivity tends to reduce due to decline of nutrients sources from labile pool. As a result of conversion floodplain forest to cultivated area the soil carbon remain 5-24 % when compare with native state. However, rice production in agricultural forest is quite stable this might be due to adequate nutrients supplies from labile pool.

Loss of soil carbon fraction could be indicator of soil degradation. The labile carbon plays more sensitive fractions in carbon pool. The result found that where conversion floodplain forest to agricultural forest lead to decline in soil carbon fractions. In agricultural forest loss of total carbon occur 49-79% while loss of non-labile carbon occur 41-74% and loss of labile carbon appear 72-96% when compare with remaining forest. Based on soil system, the degree of soil degradation occur moderately. Because, soil still has potential of nutrients supplies for rice production in dry season.

The potential productivity assessment as measure by soil labile carbon demonstrate that floodplain forest areas have high relatively potential productivity. The soil labile carbon appear 7.93 mg/g in remaining floodplain forest. Where conversion floodplain forest to agricultural forest soil labile carbon remain 5-24%. As a result indicates that soil labile carbon can be use as indicator of potential productivity and soil degradation.

Suggestions

Based on the finding of study, the following suggestions have been formulated:

1. Determination of soil labile carbon by the $KMnO_4$ oxidation technique is appropriate method for measuring status of soil labile carbon. The $KMnO_4$ oxidation technique provide more useful sensitive indicator of soil labile carbon status. The advantages of this technique are save time, simple and low cost.
2. For further research, in order to sustain productivity and for rehabilitating degraded soil, the long-term experiment should conduct to monitor on changes of carbon pool of the floodplain forest ecosystem. Because, from this study indicated that changes of soil carbon fractions could be indicator of degree of degradation. This provide more useful information in order to rehabilitate and sustain the remaining floodplain forest in the Northeast of Thailand.
3. Conversion floodplain forest areas to agricultural forest, soil degradation taking place due to loss of soil carbon fractions, especially soil labile carbon, so in order to secure the productivity of floodplain forest the organic matter rehabilitating should be implementing.
4. In this study, selection of the study site did not cover all of floodplain forest in the Northeast it is a case study in the Songkram river basin. The study should conducts on

the existing floodplain forest in the Northeast it will be useful information for policy making for wetland management.

5. Due to the fact that decline of fisheries is main factors which is influencing on land use change, so it needs to rehabilitating natural fish habitat especially floodplain forest in order to secure fish resources for communities and for conserve the existing floodplain forest.

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APPENDICES

Appendix I

Key Questions

Village history

1. Were you born in this village?
2. How long have you live in this village ?
3. Where were your ancestor came from?
4. Why your ancestor move to this village?

Floodplain forest use

1. What do you think about the condition of the floodplain forest at present compared to the past?
2. What species are there?
3. What is edible species and/or herbal medicine ?
4. What do you think about the status of floodplain forest?
5. In your opinion, what is the main cause of forest degradation?
6. In your opinion, what is the main cause of fish resources decline?
7. Have you ever collect any products from floodplain forest? When ? and What is your purpose for collect products from floodplain forest?
8. Is the floodplain forest important for your daily life?
9. Do you think the quantity of fish resources compared to the past has increased or decreased?
10. What is technique for fishing which you have used it?
11. When do you start fishing? And How ?
12. What kinds of land use ?
13. How long floodplain have conversion to agricultural forest?
14. When growing rice in floodplain forest start?
15. Why do you start growing rice in dry season?
16. How do you learn to growing rice?

17. Is there any supporting from any agencies for rice growing?
18. How much you have gained rice yields and compared to 3 year ago?
19. How do you manage rice growing in dry season?
20. Does the rice yield adequate for you household consumption?

Appendix II Flora of floodplain forest of the Songkram river
Source: (Sombatphuthorn,1999)

Species	Edible	Herbal medicine
Parameria barbata Schum.		
Barringtonia acutangula Gaertn.	✓	+
Crudia chrysantha Schum.		
Crateva magna DC	✓	+
Combretum trifoliatum Vent.		
Phyllanthus taxodiifolius Beill.	✓	
Phyllanthus sp.		
Hydrocarpus anthelminthicus Pierre.		+
Bambusa arundinacea Willd.	✓	+
Imperata cylindrica Beauv.		+
Vetiveria zizaniodes Nash		
Garcinia schomburgkiana Pierr.	✓	
Hymenocardia wallichii Tul.	✓	+
Lagerstroemia spirena Gagnep.		
Hiptage tricantra Pierr.		
Memecylon pauciflorum Bl		
Memecylon celastrinum Kurz.	✓	+
Pachygone odorifera Miers.		
Acacia pennata Wild.		
Rauwenhoffia siamensis Scheff.		
Heliotropium indicum R.Br.		
Capparis radula Gagnep.		
Maytenus mekongensis Ding Hou		
Grangea maderaspatana Poir.		
Connarus semidecandrus Jack.		
Aniseia martinicensis (Jacq.) Choisy		
Ipomoea digitata Linn.		
Merremia gemella (Brum.f.) Hall.f.		

Appendix II (cont.)

Species	Edible	Herbal medicine
Trichosanthes integrifolia Kurz		
Tetracera loureiri Pierre		
Dipterocarpus alatus Roxb		
Albizia lebbeckoides Benth.		
Mimosa pudica Linn.		
Ficus heterophylla Linn.		
Maclura cochinchinensis Corner		
Streblus asper Lour		
Streblus taxoides Kurz		
Syzygium cinereum (Kurz) P. Chantaranothai & J. Parn.	✓	
Syzygium cumini (L.) *Skeels*		
Bridelia sp.		
Croton sp.	✓	
Phyllanthus collinsae Craib		+
Phyllanthus reticulatus Poir.		
Mitragyna diversifolia (Wall. Ex G. Don) Havil.		
Morinda pandulifolia Kurz		
Morinda talmyi Pierr		
Randia sp.		
Smilax luzonensis Presl.		
Antidesma ghaesembilla Gaertn		
Strychnos axillaris Colebr.		
Syzygium gratum (wight) S.N.		
Jasminum sp.		
Dalbergia sp.		
Dendrolobium lanceolatum Schindl.		+
Derris elliptica Benth.		
Passiflora foetida Linn.		
Streptocaulon juventas Merr.		

Appendix II (Cont.)

Species	Edible	Herbal medicine
Fagraea fragrans Roxb.		
Ventilago calyculata Tul.		
Carallia branchiata Merr.		
Catunaregam tomentosa (Bl.Ex DC.) Tirveng.		
Cardiospermum helicaçabum Linn.		
Colona auriculata Craib		
Schoutenia sp.		
Centella asiatica Urban		
Xanthophyllum lanceatum (Miq.) J.J. Smith	✓	
Polygonum tomentosum Wild		
Diospyros sp.		
Cynometra craibii Gagnep.	✓	
Cyperus pilosus Vahl.		
Rosa clinophylla Thory		
Elaeocarpus hygrophilus Kurz		
Blumea napifolia DC		
Marsilea crenata presl	✓	

✓ = Edible

\+ = Herbal medicine

Appendix III Interviewee, rice growing area and rice yields data

Interviewee	Rice growing area (rai)	Rice yields Kg/rai
Suriya Kotamee	3	480
Laun Tepakul	4	450
Samai Kantacha	3	320
Saw Sriracha	5	576
Supoj Ratipan	3	400
Sanit Phukaew	4	300
Wanchai Kantacha	4	540
Kantee Kongsuk	4	412.5
Banlaung Kongsuk	3	521.7
Yodchai Sareerot	4	425
Phangsree Kanchaiwong	4	411
Boonkhien Sareerot	4	400
Watcharin Phongraj	8	620
Sawaeng Wongkan	2	600
Boonlee Phrombut	5	384
Lue Oonsa	4	450
Uthai Wongkan	4	400
Pitsamai Wongkan	7	411.4
Boonluan Sriracha	4	488.57
Wandee Uthumthisan	3	320

Appendix IV Soil analysis data

Plots no.	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)
F1	11.26	123.24	859.04	197.6	99.06
F2	8.399	70.46	778.68	190.99	95.61
AF	5.65	78	766.37	182.535	92.46
R1	3.04	56.55	742.95	248.5	220.74
R2	1.37	71.63	927.54	255.71	290.42
R3	2.38	62.01	909.48	258.205	303.55
R4	1.14	105.56	933.66	327.055	174.98
R5	4.15	52.52	690.82	222.17	138.84
R6	0.78	22.62	514.67	140.27	35.62
R7	3.78	54.6	662.22	250.5	143.78
R8	5.06	80.34	924.43	258.96	151.58
R9	1.2	66.43	798.33	310.42	148.2
R10	1.67	86.45	693.81	273.86	104.26
R11	1.35	106.47	1070.94	487.31	201.63
R12	0.9	64.74	839.8	252.45	144.17
R13	2.3	97.24	1043.12	493.62	246.35
R14	3.42	115.96	791.57	337.365	158.99
R15	0.75	94.51	1071.98	352.41	213.59
R16	1.49	118.85	1041.3	368.805	204.36
R17	1.32	90.87	912.6	234.125	134.42
R18	2.45	120.27	1049.23	248.625	112.71
R19	1.3	65.65	1020.63	277.55	150.93
R20	2.02	24.31	534.82	27.95	33.93

Appendix V Soil carbon fractions data

Plots no.	C_T mg/g	C_{NL} mg/g	C_L mg/g	CPI	L	LI	CMI
F1	33.7	25.77	7.93	1	0.307	1	100
F2	20.7	17.67	3.03	0.614	0.171	0.557	34
AF	19.6	16.84	2.76	0.58	0.164	0.534	31
R1	14.4	12.94	1.46	0.43	0.112	0.365	16
R2	14.2	12.76	1.44	0.42	0.113	0.368	15
R3	11.9	10.89	1.01	0.35	0.093	0.303	11
R4	13.1	11.9	1.2	0.39	0.1	0.325	13
R5	13.2	11.98	1.22	0.39	0.102	0.332	13
R6	9.5	8.83	0.67	0.28	0.076	0.248	7
R7	12.2	11.15	1.05	0.36	0.094	0.306	11
R8	13.6	12.29	1.31	0.4	0.107	0.384	14
R9	14.4	12.91	1.49	0.43	0.115	0.376	16
R10	8.9	8.33	0.57	0.26	0.068	0.221	6
R11	16.9	14.9	2	0.5	0.134	0.436	22
R12	11.9	10.9	1	0.35	0.092	0.299	10
R13	14	12.64	1.36	0.41	0.106	0.345	14
R14	15.6	13.91	1.69	0.46	0.121	0.394	18
R15	14.2	12.78	1.42	0.42	0.111	0.362	15
R16	16.6	14.66	1.94	0.49	0.132	0.429	21
R17	7	6.65	0.35	0.21	0.053	0.173	4
R18	17.3	15.13	2.17	0.51	0.143	0.466	24
R19	13.8	12.44	1.36	0.41	0.109	0.355	15
R20	8.4	7.89	0.51	0.25	0.065	0.212	5

Appendix VI Percent decline of C_T ,C_L and, C_{NL}

Plots no.	% decline C_T	% decline C_L	% decline C_{NL}
F1	0	0	0
F2	38	62	31
AF	42	65	35
R1	57	81	50
R2	58	82	50
R3	65	87	58
R4	61	85	54
R5	61	84	54
R6	72	91	66
R7	64	87	57
R8	59	83	52
R9	57	81	50
R10	73	93	68
R11	50	75	42
R12	65	87	58
R13	58	83	51
R14	53	79	46
R15	58	82	50
R16	50	75	43
R17	79	96	74
R18	49	72	41
R19	59	83	52
R20	75	93	69

VITAE

Name: Ms. Nanta Sitthirach

Date of birth: May 6, 1972

Education Qualification:

2002 Master of Science Agricultural Resources and Environment
Khon Kaen University

1995 Bachelor of Science, major in Biology. Prince of Songkla University

Work Experiences:

2002: Project assistant, Fish Seed Quality Project (FSQ). Asian Institute of Technology.

2000: Data collector, for the project "Survey and database development of community business organization in the villages in middle Northeast of Thailand".

1999: Project officer, Wetlands International-Thailand Programme "Community Participation in Mangrove Forest Management and Rehabilitation in Southern Thailand".

1998: Program officer , The Biodiversity Research and Training Program (BRT) in the position of in the BRT secretariat.

1997: Project officer, Wetlands International-Thailand Programme. "Community Participation in Mangrove Forest Management and Rehabilitation in Southern Thailand".

1996: Volunteer , Head Water Forest Project in Trang province.

1996: Research assistant, Marine National Park Supporting Center. Studies in "Macro fauna in seagrass beds".

1995: Yadfon Association (Environmental NGO). Work with local communities and people organization in coastal resources management Trang province.