CHAPTER 1

Introduction and Literature Review

1.1 Introduction

The Royal Forest Department of Thailand reported that the forest area of the country in 1910 was 224.38 x 10^7 rai (1 ha = 6.25 rai) or 70% of the country area, and it was decreased to 81.0 x 10^7 rai (25.3%) in 1998. The annual rate of forest decline was 2.91 x 10^7 Rai during 1961-1989, and declined to 0.95 x 10^7 rai during 1989-1998 (Charuphat, 1998). It is expected that the present forest area would be about 20-25% of the country area, because the data have not been reported officially since 1998. For the northern region, the forest area was reported as about 43.06 % (Charuphat, 1998). Most forests in this region cover on mountainous areas which are head watershed of the main rivers. Reforestation in the devastated watershed areas is therefore very important, and it has been conducted since 1975 by Watershed Development Stations, Royal Forest Department (WMD, 1992). *Pinus kesiya* is the most common tree species for monoculture plantation in highland according to many advantages. This species is a fast growing species which can grow on poor soil and tolerates to drought, low temperature as well as strong solar radiation.

Three main causes of deforestation have been recognized, (1) forest clearing for permanent agriculture and settlement purpose, (2) shifting cultivation, and (3) the development projects such as the construction of dam, reservoir, road, electric transmission, etc. The cause of forest degradation is mainly illegal cutting whereas forest fragmentation has critical effects on forest biodiversity, flooding, drought, forest fire, and so on. The protection of remained forest and reforestation are considered as the significant ways to solve the problem.

The primary objectives of reforestation program (sub-project) under the Doi Tung Development Project are: (1) to encouraging people to live in harmony with forests, (2) to improve the environment by mixed plantation of various species, and (3) to raise up the socio-economic conditions of local people.

The secondary objectives derived from the primary aims are; (1) to develop Doi Tung to be the prosperous and beautiful area, (2) to establish Doi Tung as a strategic center for Northern Thailand in terms of improving the security and well-being of the local people, and (3) to find out a systematic method of rural development which can be applied for other areas throughout the region which have similar problems particularly poverty, opium production and addiction, and environmental degradation.

There are several goals for the first six years of the project based upon the above objectives are as below:

(1) to have the officials implementing the project and people in the project area fully understand the purpose of development and the intentions of

Her Royal Highness the Princess Mother,

(2) to give people in the project area for confidence in the sincerity and seriousness of the government to develop the area.
(3) to decrease logging and other practices, such as opium growing, disturbance of the forest, etc.
(4) to enhanced people's ability to protect the environment and conserve nature.

After 20 years, the goals have been issued as follow:

(1) to increase productive and sustainable use of natural resources in the area, including water, land and mineral resources for the benefit of local resident.
(2) to find methods to increase agricultural productivity while sustaining natural resources of the area.
(3) to improved the living standard of people in the project area
(4) to develop the area around Doi Tung to be natural tourist attraction.

The project introduces new cash crops to replace opium cultivation. People require new skills to grow new crops with adequate markets to launch their products. In addition, the project also provides agro-forestry practices to villagers since the agricultural area has been replaced by reforestation. Agricultural activities introduced under the Doi Tung Development Project are given:

(1) Encouraging cultivation of secondary cash crops after the main crop harvested. The promoted crops are beans, flowers and ornamental plants, and seed plants. This becomes the important source of income.
(2) Promoting Japanese rice with the high yield and price.
(3) Promoting Japanese vegetables with the high yield and price.

The plantation forest provides various benefits to human both ecological and socio-economic values. The local people can improve their livelihoods. They obtain the direct benefits from timber; wood for construction and non-timber products as food, fuel wood, medicine, fiber, resin, oil, bio-diesel, etc. It also gives those indirect benefits involving restoring ecosystem, environment, carbon sequestration, releasing oxygen, soil loss prevention, land slide, soil nutrients, water flow regulation, improving microclimate, recreation value, etc. Nutrients and carbon releasing from decomposing litter in the forest are accumulated in soil system. Carbon is important as the basis for food, fiber and shelter for human being. Carbon sequestration could accumulate in the aboveground biomass including leaf, bark, stem, branch and reproductive organs as well as belowground biomass in roots (Pumijumnong, 2004).

Carbon fixation is depended on many factors, such as species, growth rate, aging, rotation, rainfall, seasoning, site and location etc. Annual carbon fixing of trees were high in the initial stage of plantation (Ciesla, 1995). Forest plants use carbon dioxide as building blocks for organic molecules and store it in woody tissues. Historic and current land-use changes and resource management practices impact the overall

carbon cycle, such as clearing forests and grasslands and intensive tillage and harvest practices, release CO_2 to the atmosphere (Law, 2008).

Evaluation of the reforestation program in ecological and socio-economic aspects is very important. The data will be useful as indicators of the successful reforestation project. It is my interest to assess the ecosystem recovering of the plantation forests. This includes three parts; (1) tree growths, biomass accumulation and timber production, (2) ecosystem carbon storage, and (3) ecosystem water storage. The socio-economic aspect involves identifying change of livelihood of local people since they can get the direct benefits from forest plantations through wood and non-wood products, and indirect benefits from improving the ecosystem environment.

1.2 Literature Review

1.2.1 Tree Growth and Biomass Accumulation

Biomass is the mass of living organisms in a given area or ecosystem at a given time. It can be measured in term of the dry weight. Most previous studies on biomass in forest plantations are emphasized on energy trees including *Acacia auriculaeformis, Leucaena leucocephala, A. mangium, Eucalyptus camaldulensis, Cassia siamea* and *Azadirachta indica* (Bunyavejchewin and Puriyakorn, 1986; Bunyavejchewin et al., 1985; Bunyavejchewin and Wisetsiri, 1986; Pransin and Nongnuang, 1986; Pitpreecha *et al*. 1988; Nongnuang and Pransin, 1996).

Growth rates and productions of *P. kesiya* in the plantations are different during stand development, and varied with sites. Silvicultural practices such as spacing, weeding, pruning and thinning are also affected on the growth and production. This pine has a rapid height growth after the first year of establishment, 1-2 m annually, with a canopy closure in three to four years (Armitage and Wood, 1980). Oberhauser (1997) has stated that *P. kesiya* plantations might indeed speed up the succession process. Plant succession in pine plantations is important that will increase ecological production of ecosystem.

Some research works on *P. kesiya* plantations have been accumulated, Homjeen (1997) reviewed pine growths at Huey Bong Experimental Station, Chiang Mai Province. Annual height increments during 1-10 and 10-20 year-old stands were 1.22 and 0.66 m, while those of diameter growth were 1.67 and 0.40 cm, respectively. Decreased growth rates during 10-20 year-old stands were influenced by canopy closure. However, its growth rate may be varied with sites. At Doi Suthep, the annual height and diameter increments of 17 year-old pine were 1.02 m and 1.39 cm, respectively. In natural forest, the height growth of pine at Omkoi district, Chiang Mai, was the best in stands of during 20-25 year-old, 1.14 m/yr, whereas the best stem diameter growth was 15-20 year-old as 1.06 cm/yr.
Khamyong (2001) concluded that the stem girth and height of *P. kesiya* at Doi Boa Luang Plantations, Chiang Mai, were increased with stand age. The growth rates varied among stands. It was very rapid during the first ten year after planning, very

slow during 12 and 32 years, and more rapid from the age of 32 to 37. The yield of these plantations at age 7,10, 12, 18, 21, 28, 32 and 37 years old were 7.25,53.25, 115.31, 47.06, 298.94, 156.31, 273.81 and 201.94 m^3/ha. Many factors particularly tree density, thinning and nutrient availability might be affected on these variations. Decomposition of needles of *P. kesiya* resulted in the strongly acid of soils**.**

Nildam (2002) studied on timber volume of *P. kesiya* plantations at Phrao Watershed Management Unit, Chiang Mai, at age 9, 12, 15, 18, 21 and 24 years old. They were 120.82, 149.68, 262.99, 218.53, 379.91 and 316.84 m^3/ha, respectively. Sirikul (1974) carried out a research on environmental factors affecting *P. kesiya* growths in two sites of Thailand, one in the south (Surat Thani) and another in the north (Chiang Mai). The initial height growth in the south was about 70% higher than the north. The site in the south was located at 40 m altitude with high rainfall (1,600-2,000 mm/yr) and fertile soil, while the north site was situated at 800 m altitude with lower rainfall (1,200-1,400 m/yr) and had a poor soil.

Homjeen (1997) reported that wood production of 10-year-old *P. kesiya* at Doi Boa Luang plantation using 2 x 2 m spacing was 161% higher than 4 x 4 m. Intensive plough and weeding in the first three years after planting could increase 157% growth rate of *P. kesiya* (Granhof and Homjeen, 1983). Sakulmeerit and Duangsathaporn (2000) studied the effects of thinning on the growth of *P. kesiya* plantation at Doi Boa Luang plantation in Chiang Mai. They found that the width of annual ring was increased 70.3% of unhinged stand.

1.2.2 Roles of Plantation Forest on Physical Environments

Many researches on soil properties in pine plantations have been conducted in foreign countries, and very few are taken in Thailand.
Soil organic matter consists of plant and animal residue in various stages of environmental degradation. Inputs come from dead plant and animal tissues, often referred to as detritus, which accumulate at soil surface. A large fraction of the nutrients in forest ecosystems is stored in the soil and detritus. Except in old-growth forests, the organic matter in the surface layers of mineral soils generally comprises most of the total organic matter in forest ecosystems. All but the most recalcitrant fractions constantly undergo chemical breakdown by soil organisms that compose and resynthesize the material to form complex carbon-based compounds. Typically, the organic matter concentration of the surface of forest soils range from 0.5-5% by weight. It has profound effects on the chemical, physical and hydrological properties of forest soils and plays a critical role in forest nutrient. Soil organic matter is a major energy source for soil macro and micro invertebrates and is an important component of the global carbon cycle (Landsberg and Gower, 1997).

Parathai (2003) studied on soil properties of *P. kesiya* plantation at Doi Boa Luang, Chiang Mai. It concluded that bulk density of top soil (0-10 cm) and texture during 7-37 year-old plantations were not different among the plantations. It varied between 1.0-1.6 mg m^3. The pH varied during 4.9-6.1 (moderately acid to strongly acid). It was slightly decreased in the old stands.

1.2.3 Roles of Plantation Forest on Carbon Storages

The dynamics of nutrient cycling in plantation ecosystems have been explained by Miller (1989). These include nutrient inputs and cycles in the plantation ecosystems. The internal cycles involve accumulation and release by tree stands, cycle within the trees, accumulation and release in soil organic layers, and retention within the ecosystems.

In Thailand, some researches on nutrient cycling in forest plantations have been conducted. Jutikitdaecha (1996) studied on the nutrient cycling in *Eucalyptus camaldulensis* stands planted with different densities. Parathai (2003) studied on the carbon and nutrient accumulations in *Pinus kesiya* plantations at Doi Boa Luang Plantations, Chiang Mai province. Organic matter was increased with stands age, varying 17.30-66.8 g kg^{-1}. Carbon and nitrogen varied as the same as organic matter. The amounts of organic matter in one-meter soil profile of 7-37 years old stands were 83.86-153.80 Mg ha^{-1}, carbon: 48.64-80.20 Mg ha^{-1}, and nitrogen: 3,243-5,947 kg ha^{-1}. Concentrations and amounts of extractable P, Ca and Mg in soil were higher in older stands, but K was adversely lower. Forest fire and soil erosion were important factors affecting soil properties.

1.2.4 Roles of Reforestation in Socio-economic Aspect

None or very few researches have been conducted about the roles of reforestation program on socio-economic condition of local people in Thailand. The local people would receive wood and non-wood products from the plantation forests. The research in this aspect is therefore important.

1.3 Research Objectives

(1) To evaluate ecological and socio-economic values of two forest plantations including the 22-year-old teak (*Tectona grandis* L.f.) and pine (*Pinus kesiya* Royle ex Gordon) in the Doi Tung Development Project area, Chiang Rai province after 20 years of implementation

(2) To study livelihoods and socio-economic conditions of local people in areas of the reforestation sub-project under the Doi Tung Development Project, Chiang Rai province after 20 years of implementation

1.4 Usefulness of the Research (Theoretical and/or Applied)

(1) The basic data on ecosystem recovering influenced by different tree species in the plantations are useful for the application in other watershed areas as well as improving plantation techniques and management in the highland watershed.

(2) The socio-economic information is important for the successful reforestation program with participation of local people, and their sustainable livelihood as well as the sustainable natural resources and good watershed environment.