Historical Changes of Forest Area in Thailand: A Case Study of Mae Klong Watershed Research Station, Lintin, Kanchanaburi

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Abstract

During the past few decades, the forest area in Thailand markedly decreased from 53 % to 26 % of the total land area during the period 1960-1995. The forest cover has been converted to other types of land use, such as, farmland, urban areas, orchards, etc. In this study attempts were made to analyze the process of deforestation in the Mae Klong Watershed Research Station (Lintin), Thongphaphum District, Kanchanaburi Province, Thailand. This case study is useful to observe the drastic changes in land use and land cover in rural areas in Thailand.

Five different time series of aerial photographs were interpreted and land use maps were made in 1954, 1969, 1974, 1986 and 1994 to evaluate the impact of anthropogenic forces on land use changes in rural Thailand. From aerial interpretation, we can classify land use into two main types; forest and agricultural land. Based on the land use maps of 1954 and 1994, the forest cover in mountainous areas had been less converted to other types of land use than that in flat areas. However, forests in mountainous areas were continuously degraded during the study period. On the other hand, forest land use in flat areas decreased gradually from 1954 to 1974, and rapidly in 1974 and 1994 while agricultural land use increased. The changes of the forest cover in the mountainous and flat areas indicate that the topographic factors are related to the changes of land use and land cover in the area. In flat areas, the increase of the number of households in the two villages was an important factor for the conversion of the forest area to agricultural land. Therefore anthropogenic factors directly affected land use and land cover changes in the study area.

Introduction

Land use and land cover changes are occurring rapidly around the world. Changes, such as deforestation and degraded soil conditions not only assume a local dimension but also exert an impact on other forms of global changes such as long-term climate changes, changes in the composition of atmospheric chemistry and biological diversity (Schroeder, 1996). Land use and land cover changes are caused by a large number of processes associated with population growth and economic development in the tropical regions (Grepperud, 1996). Both natural and anthropogenic processes alter land use and land cover, which in turn directly affect the environment. During the past few decades, Thailand experienced a remarkable decline in its forest area. During the 1960-1995 period, the total forest area decreased from 53% to 26% (Royal Forest Department, 1960-1995). Land formerly covered by forest has been converted to other uses such as farmland and orchards while urbanization has progressed (Charuppat, 1992, Office of Agricultural Economics, 1976-1993).

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In this paper, the historical changes of land use and land cover at the research site of the Mae Klong Watershed Research Station (Lintin), Thongphaphum District, Kanchanburi Province will be described. Aerial photographs covering five different periods were used to study the characteristics of the changes of the forest cover in the study area, which extends over about 220 km^2. Questionnaire surveys and interviews of key informants were also conducted to obtain additional data for a broader understanding of the characteristics of the changes of land use and land cover at the provincial level.

Historical land use changes in the study site

Five different time series of aerial photographs were used to interpret and produce land use/cover maps over the period of 1954, 1969, 1974, 1986 and 1994 to illustrate the landscape changes in the study area. The scales of the aerial photographs were 1/50,000, 1/50,000, 1/15,000, 1/20,000 and 1/50,000, respectively. For the interpretation of the aerial photographs, 34 ground sample points were surveyed within the study site. Then based on aerial photograph interpretation, we classified land use into two main types; forest land use and farming land use. Within the forest types, 5 classes of forest cover were identified: 1) high density forest (crown closure> 80 %), 2) medium density forest (crown closure between 50 % to 80 %), 3) low density forest (crown closure between 20 to 50 %), 4) secondary forest and 5) bamboo forest. Secondary forest is defined as a forest which was generated after slash and burn for shifting cultivation. The farming land use types are divided into: 1) grass-bush land, 2) agricultural land, 3) orchard, 4) plantation, and 5) community. Plantations in this area are mainly established in farmland.

Summarized statistics of changes in the land use/cover in the Mae-Klong Watershed Area landscape are presented in Table 1 and Table 2. High density forest cover decreased from 17.4% of the landscape in 1954 to 5.9% in 1974 and 4.5% in 1994. On the other hand, low density forest area increased from 22.2% in 1954 to 33.4% in 1974, and decreased to 20.1% in 1994. Medium density forest area remained unchanged from 1954 to 1974, then decreased from 23.1% in 1974 to 10.3% in 1986. Secondary forest area remained stable during the period 1954-1974 and increased from 29.8% in 1976 to 39.3% in 1986. Then the land use/cover maps show the degradation of forests which occurred during the period 1954-1976 and deforestation which was observed from 1974 to 1986. While the agricultural land area remained stable from 0.56% in 1954 to 1.9% of the total area in 1974, it drastically increased in 1974 and 1986. Thus, the period 1954-1974 resulted in an annual rate of expansion of agricultural land of 0.07%, and the period of 1974-1994 showed an expansion rate of 0.64%. Percentage of land use types is indicated in Table 1.

Additional summarized statistics of changes in the land use/cover conditions in the study area are presented

Table 1 Percentages of land use types in 1954, 1968, 1974, 1986 and 1994

Land use types	1954	1968	1974	1986	1994
High density forest	17.4 %	9.6 %	5.9 %	4.1 %	4.5 %
Medium density forest	23.1 %	19.5 %	23.1 %	10.3 %	10.0 %
Low density forest	22.2 %	31.8 %	33.4 %	21.2 %	20.1 %
Secondary forest	28.8 %	24.8 %	29.8 %	39.3 %	40.1 %
Bamboo forest	0.6 %	2.0 %	2.0 %	1.9 %	0.8 %
Grass-Bush land	7.3 %	10.4 %	3.6 %	12.5 %	7.3 %
Agricultural land	0.5 %	1.7 %	1.9 %	10.0 %	14.7 %
Orchard	0.0 %	0.0 %	0.2 %	0.5 %	1.8 %
Plantation	0.0 %	0.0 %	0.0 %	0.2 %	0.3 %
Community	0.0 %	0.0 %	0.0 %	0.1 %	0.6 %
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Table 2 Landscape statistics

	Statistics	1954	1968	1986	1994
High density forest	No. of patches	29	20	3	3
	Average (area, $m^2 \times 1000$)	1348.232	1081.069	3031.669	3327.582
	Standard deviation	3967.312	2462.758	4442.38	5398.64
Medium density forest	No. of patches	56	63	34	43
	Average (area, $m^2 \times 1000$)	929.3204	697.7656	681.1114	519.0296
	Standard deviation	1500.457	1283.647	1123.951	853.5038
Low density forest	No. of patches	65	48	91	122
	Average (area, $m^2 \times 1000$)	767.7296	1492.583	522.4151	368.6442
	Standard deviation	1345.431	4032.783	1459.907	758.0647
Secondary forest	No. of patches	63	73	74	83
	Average (area, $m^2 \times 1000$)	1027.408	764.6977	1193.022	1082.628
	Standard deviation	2460.554	1878.699	6916.159	7514.845
Bamboo forest	No. of patches	11	45	37	25
	Average (area, $m^2 \times 1000$)	128.177	100.9969	114.6797	68.4235
	Standard deviation	101.5859	71.11532	106.8624	76.33166
Grassland	No. of patches	124	127	169	170
	Average (area, $m^2 \times 1000$)	133.2439	185.1105	165.4805	96.14032
	Standard deviation	278.611	565.6285	492.6452	161.8635
Agricultural land	No. of patches	59	91	181	166
	Average (area, $m^2 \times 1000$)	20.56149	42.84758	123.5572	198.1395
	Standard deviation	21.15213	61.03603	307.9496	480.7714
Orchard	No. of patches	0	1	32	93
	Average (area, $m^2 \times 1000$)	0	7.01359	36.22474	42.73656
	Standard deviation	0	0	32.36403	45.20618
Plantation	No. of patches	0	0	12	16
	Average (area, $m^2 \times 1000$)	0	0	29.91464	35.79498
	Standard deviation	0	0	19.59545	26.98204
Community houses	No. of patches	0	0	43	147
	Average (area, $m^2 \times 1000$)	0	0	7.562754	9.420592
	Standard deviation	0	0	5.59234	8.988504

in Table 2. Since the aerial photographs of 1974 were not clear due to the smoke caused by swidden operations and the quality of some aerial photographs in 1974 was too low to analyze patch shape, land use/cover maps of four different periods except for 1974 were utilized for deriving statistics. The number of high density forest patches declined from 29 in 1954 to 3 in 1994, while the number of low density forest patches increased from 65 in 1954 to 122 in 1994. Except for the high density forest, the average patch size of the forests decreased. On the other hand, the average patch size of agricultural land increased from 20,561m^2 in 1954 to 198,140m^2 in 1994.

The study site is composed of mountainous and flat areas which are divided into various areas based on aerial photograph interpretation and a topographic map. Mountainous and flat areas account for 69% and 31% of the total area, respectively. In 1954, although there were already agricultural areas in the study site both in the mountainous and flat areas, the total area of farmland was small compared to the total study area. These findings indicate that there were already some resettlements both in the mountainous and flat areas. While agricultural areas have expanded from time to time, the forest areas decreased. Based on interviews, we learned that, during the Second World War, railway construction in this area could have affected the changes in land use and land cover. The land use types over the period of study in three different years, 1954, 1986 and 1994 are shown in Fig.1-a to 1-c.

Based on the aerial photographs of 1977, we detected a road for logging operations connecting the highway

in the study area and more roads can be observed from aerial photographs taken in 1986 and 1994, as confirmed by interviews of the key informants who lived in the mountainous area. The presence of logging roads had affected the quality of the forest cover because trees were harvested during logging operations. It was also reported that logging operations in the area accelerated the degradation of the forest cover. The logging roads were also used by rural people to reach the forest areas.

The land use maps of 1954 and 1994 showed that the forest cover in the mountainous area had been less converted to other types of land use than that in the flat area. Therefore, the study site was divided into 2 areas; 1) mountainous area and 2) flat area, in relation to the topographical characteristics in order to better analyze the changes in the land use and land cover.

Two villages, Nong Bang and Lam Ma Ke are located in the Mae Klong Watershed area. Nong Bang village is closer to the forest compared to Lam Ma Ke which is located next to Nong Bang but close to a highway.

Mountainous area

The agricultural area accounted for 0.22 %, 0.15 %, 0.49 %, 0.73 % and 2.99 % of the mountainous area in 1954, 1968, 1986 and 1994, respectively. Based on interviews of the villagers, we learned that during the Second World War already some people had settled down in the mountainous area. About twenty years ago, they moved down to live in Nong Bang village for unknown reasons. Since people moved to the flat area, forestland was converted to agricultural land to some extent in the mountainous area as mentioned above. However, some of the Nong Bang villagers have recently started to cultivate crops on gentle slopes in the mountainous area. Villagers have used logging roads to reach farmland in the mountainous area and some of them have commuted from Nong Bang village to their agricultural area in the mountains.

Even though the people in this area moved to the flat area about 20 years ago, the forest cover was degraded from 1954 to 1994. The high density forest area changed from 19.6% in 1954 to 9.9%, 7.5%, 5.9% and 6.4% of the total mountainous area in 1968, 1974, 1986 and 1994, respectively. The area of medium and low density forest has tended to become degraded over the study period. However, secondary forest area changed in opposite direction and increased from 26.9% in 1954 to 47.8% in 1994. The percentage of secondary forest area markedly increased from 29.7% in 1974 to 43.5% in 1986 and 47.8% in 1994. Fig.2 shows the changes in the forest types in the mountainous area. The trend indicates that forests have been continuously degraded even in the mountainous area.

Flat area

Forest cover in the flat area has been converted to other land use types more than in the mountainous area. From 1954 to 1974, forest land use types decreased gradually while farming types of land use increased. Forest land use types decreased rapidly in 1986 and 1994 while the farming land use types increased. These findings indicate that forest land use types in the flat area were converted to farming land use types. Figures 3 and 4 show the changes in the forest types and farming land uses in the flat area over the time series.

The changes in the forest cover in the mountainous and flat areas show that the topographic factors are related to the changes of land use and land cover in this watershed area. In the flat area, the increase of the number of households in the two villages has been the major factor for the conversion of forest areas to agricultural land. Therefore anthropogenic factors directly affect land use and land cover changes in the area. However, to better understand the mechanism of land use and land cover changes in the area, a questionnaire survey was conducted in the Nong Bang and Lam Ma Ke villages.

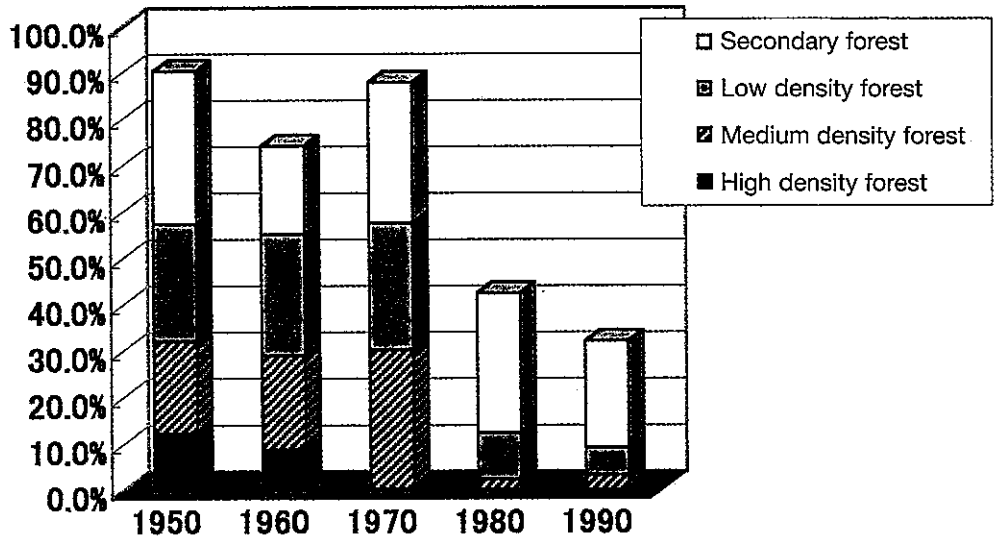


Fig. 2 Changes of forest types in mountainous area

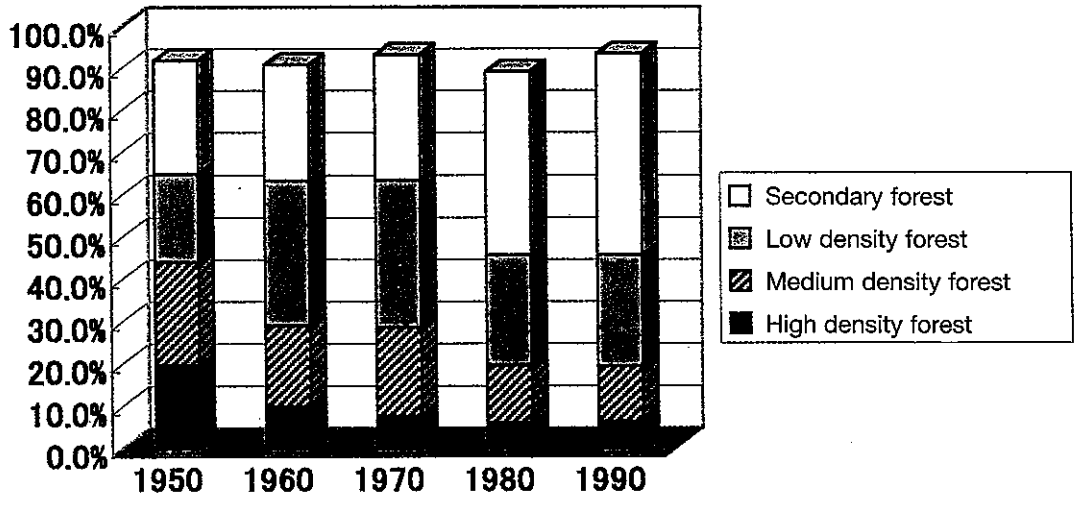


Fig. 3 Changes of forest types in flat area

Socio-economic background of Mae Klong

To better understand the land use dynamics in the flat area, socioeconomic conditions as well as cropping types and cropping systems in the study area must be considered. The conversion of forest area to agricultural land in the flat area is a direct result of the population increase in the two nearby villages. To analyze how these anthropogenic activities influenced the land use and land cover changes, a questionnaire survey was carried out in the Nong Bang and Lam Ma Ke villages. In addition, the survey aimed at analyzing the changes of socioeconomic conditions in the past. The questionnaire and the interviews involved 10 households in Nong Bang and 9 households in Lam Ma Ke. The results of the questionnaire showed that the Nong Bang village was established about 60 years ago. Most of the villagers originated from a local area in the Thongphaphum District

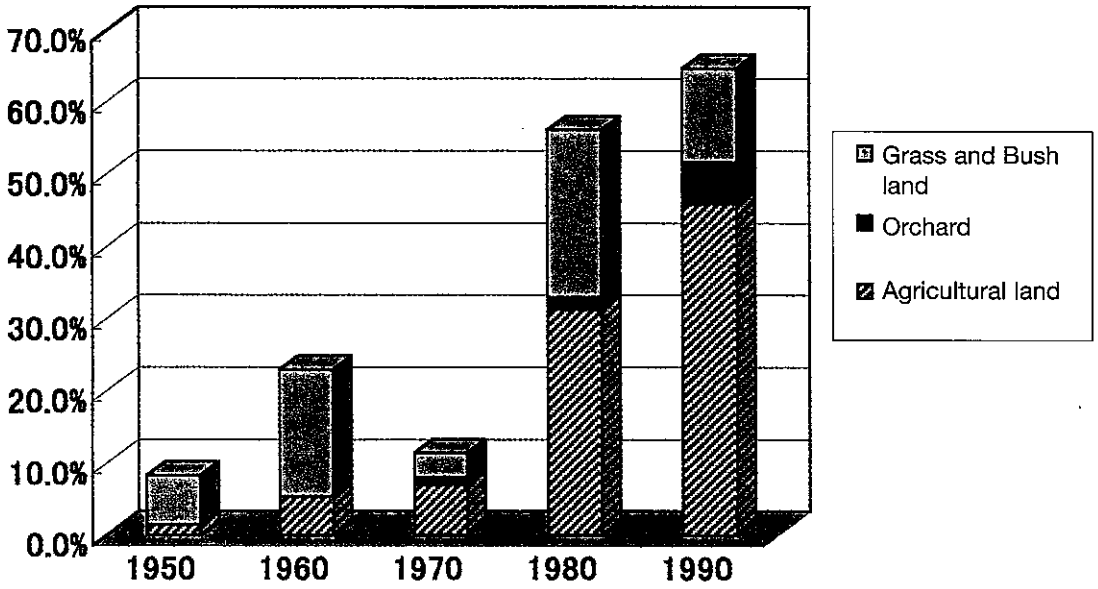


Fig. 4 Changes of farming area in flat land

of Kanchanaburi Province. In the survey, the villagers were asked to record the number of households observed during a specific year such as during childhood, when they were married or when their children were born. (As the answers were based on memory, a variance was used when plotting the results). According to the questionnaire survey, the number of households in Nong Bang increased rather slowly; there were approximately 40 households 10 years ago while presently there are about 57 households. Lam Ma Ke village was established in the 1950s about 20 years after Nong Bang village. The survey also showed that many of the villagers in Lam Ma Ke migrated from other districts and provinces. The number of households increased significantly, especially from 1976 to 1986 and from 1990 to 1996. There were approximately 60 households in 1976 and around 180 households in 1996.

The difference in the trends in household numbers and locations of the two villages were reflected in the types of land use changes. Nong Bang is located in a narrow valley and therefore farmland can not be readily expanded. This condition also restricts the number of additional households. On the other hand, since Lam Ma Ke is located in a flat area, farmland could expand along with the increase in the population. Because Lam Ma Ke is quite accessible, it attracted people from the Nong Bang village and beyond. Due to large migrations during the period from 1974 to 1986, the Lam Ma Ke village witnessed a remarkable increase in the amount of land used for farming, especially for agriculture. The largest number of migrations occurred in 1986. These changes in the forest area in the flat region are clearly visible in the aerial photographs used to make the time series land use maps.

The remaining agricultural land use in Nong Bang and Lam Ma Ke was studied and is shown in Table 3. In Nong Bang, most of the land consists of orchards, followed by cash crops, land leased to other tenants, paddy

Table 3 Differences in agricultural land use types between two villages

Nong Bang	%	Lam-ma-ke	%
Paddy fields	10	Paddy fields	36
Crops	28	Crops	44
Orchard	38	Orchard	6.2
Residence	8.4	Residence	5.2
Lease to others	16	Mixed farmland	7.9

fields and finally, land used for residences. In Lam Ma Ke, the order is slightly different, more land is used for cash crops, then paddy fields, followed by mixed farmland, orchards, and again the least amount of land is used for residences.

Conclusion

Because Thailand experienced nationwide economic growth and a rapid increase in population during the past decades, it also lost a great deal of its forests. Although there are many national statistics about deforestation in Thailand, no suitable model to explain the process of this phenomenon has been developed. Land use maps made five times over a 40-year period clearly show the actual progression of degradation of forests and deforestation in the Mae Klong watershed area. The results of this study indicate that anthropogenic activities based on socioeconomic factors are the main driving forces for changes in land use and land cover types. The topographical features also played a key role, as they determined where land use and land cover changes would not occur. Because of the physical characteristics of the highland forest area, most of the changes occurred in the lowland region. Although farming could not be carried out on sloping terrain, some degradation of the forestland occurred there because of anthropogenic activities resulting from population growth and migration into the area.

By quantifying the spatial and temporal patterns of tropical forest changes, we attempted to analyze how the landscape in these highland tropical forests is controlled by physical and economic parameters. Models for the prediction of global climatic changes include the effect of tropical deforestation and this study shows how deforestation and degradation proceed in the tropical regions.

References

1) Charuppat, T. (1992): An Analysis of Forest Situation in Thailand from LANDSAT Imagery. Office of Remote Sensing Survey and Mapping, Royal Forest Department, Bangkok, Thailand, 81p.
2) Grepperud, S. (1996): Population Pressure and Land Degradation: The Case of Ethiopia. J. of Environmental Economics and Management, 30, 18-33.
3) Office of Agricultural Economics (1975-1991): Agricultural Land Utilization in Thailand. Center for Agricultural Statistics, Bangkok, Thailand.
4) Office of Agricultural Economics (1976-1993): Agricultural Statistics of Thailand Crop. Center for Agricultural Statistics, Bangkok, Thailand.
5) Royal Forest Department (1960-1995): Forestry Statistics of Thailand 1995. Bangkok, Thailand.
6) Schroeder, P. (1996): A carbon budget for Brazil: Influence of future land-use change. Climate Change, 33, 369-383.

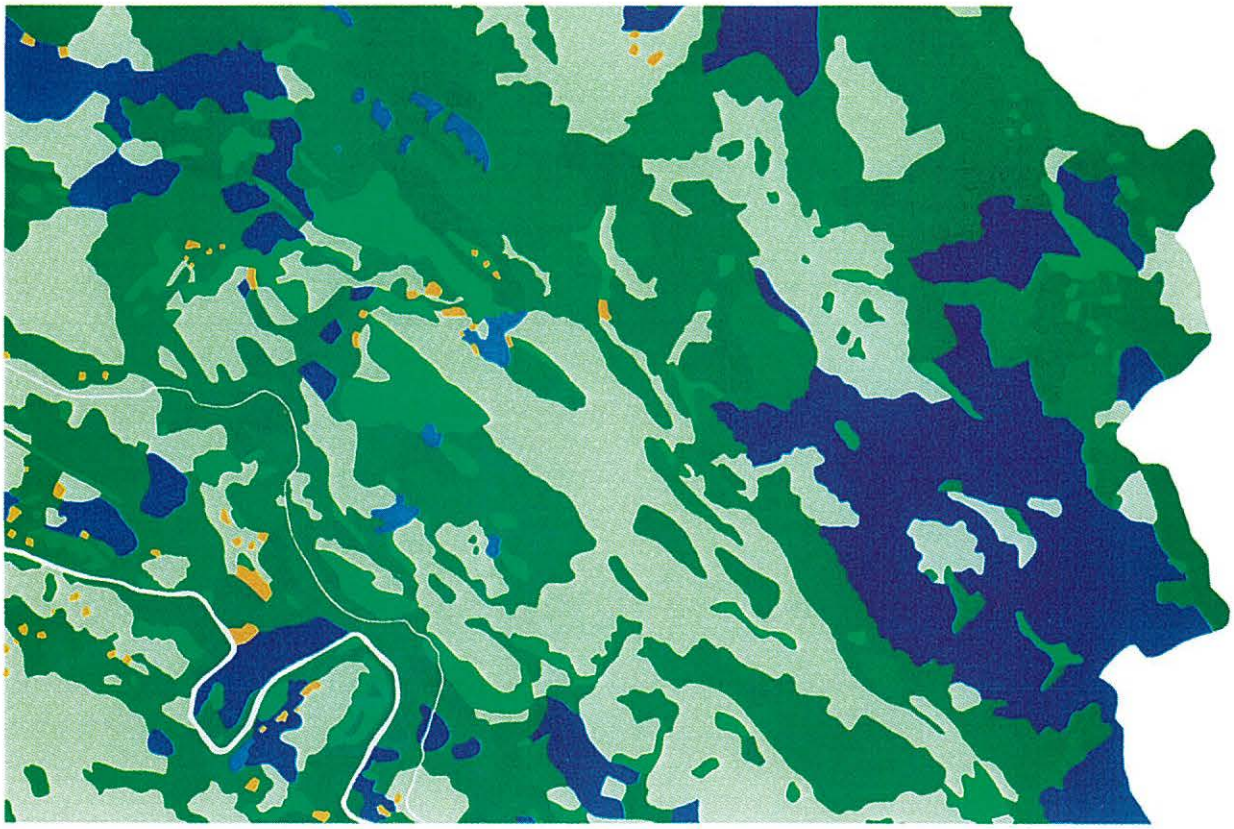


Fig. 1a Land use map of Mae Klong watershed area in 1954

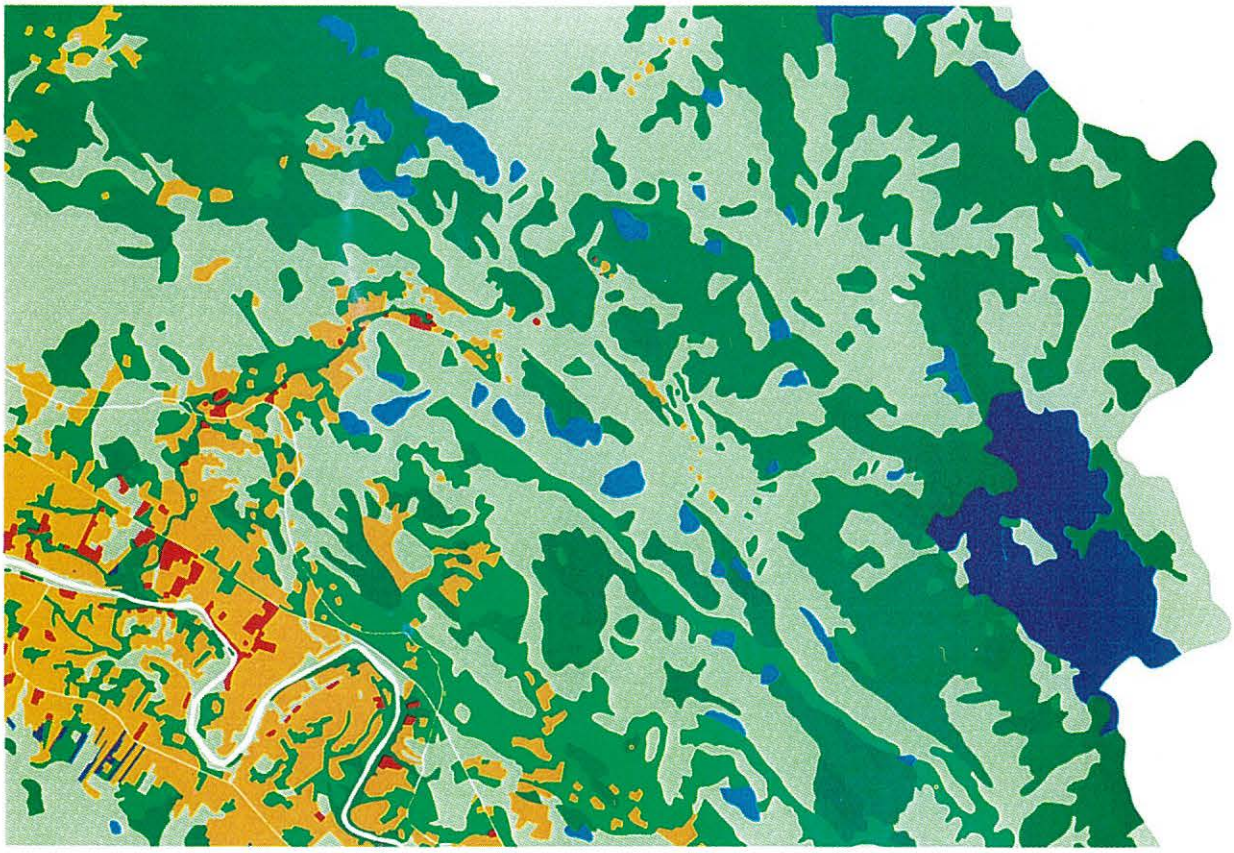


Fig. 1b Land use map of Mae Klong watershed area in 1986

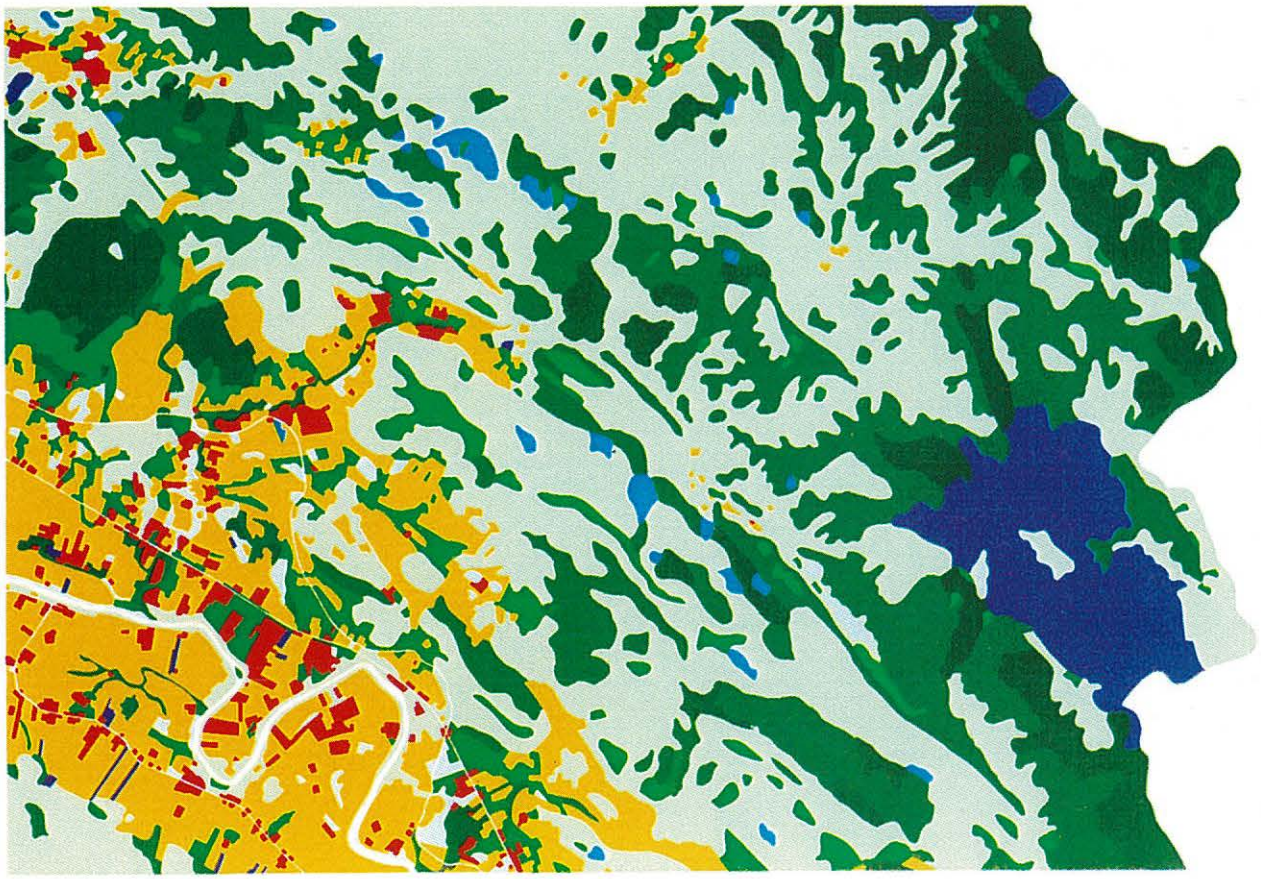
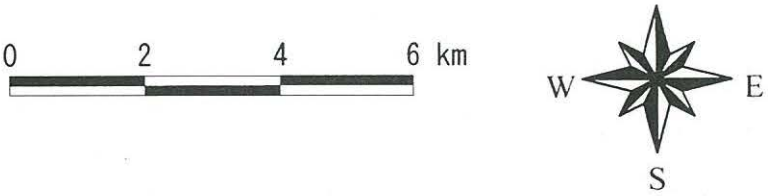


Fig. 1c Land use map of Mae Klong watershed area in 1994



Legend

- Forest (crown closure 80% –)
- Forest (crown closure 50 – 80%)
- Forest (crown closure 20 – 50%)
- Forest (crown closure 20 – 50%) with bamboo understorey
- Secondary forest
- Bamboo forest
- Grass and Bush land
- Agricultual land
- Plantation
- Orchard
- Community
- Water