CHAPTER III

MATERIALS AND METHODS

3.1 Study Area and Study Sites

Study Area in Phetchaburi Watershed

Phetchaburi Watershed is located between UTM 47 1500000 N, 500000 E and 1380000 N, 620000 E in Southwest Thailand The watershed is contagious to the Mae Klong Watershed in the north, Prachuab Khiri Khan Province in the south, the Gulf of Thailand in the east, and the international border of Burma in the west (Figure 3.1).

3.1.1 Materials for study selection

Base map

This study used the topographic map, scale 1 : 50,000 dated 2001 as base map for geographic database of the area (Royal Thai Survey Department,1991).

Thematic maps

1. The land use map of scale 1 : 50,000 of Phetchaburi, Ratchaburi and Samutsongkram Provinces, dated 2002 (Land Development Department, 2001).
2. The geological map 3D of scale 1 : 50,000 of Thailand, dated 2001 (Royal Thai Survey Department, 2001).
3. The soil map of scale 1 : 50,000 of Phetchaburi, Ratchaburi and Samutsongkram Provinces, dated 1988 (Land Development Department, 1988).

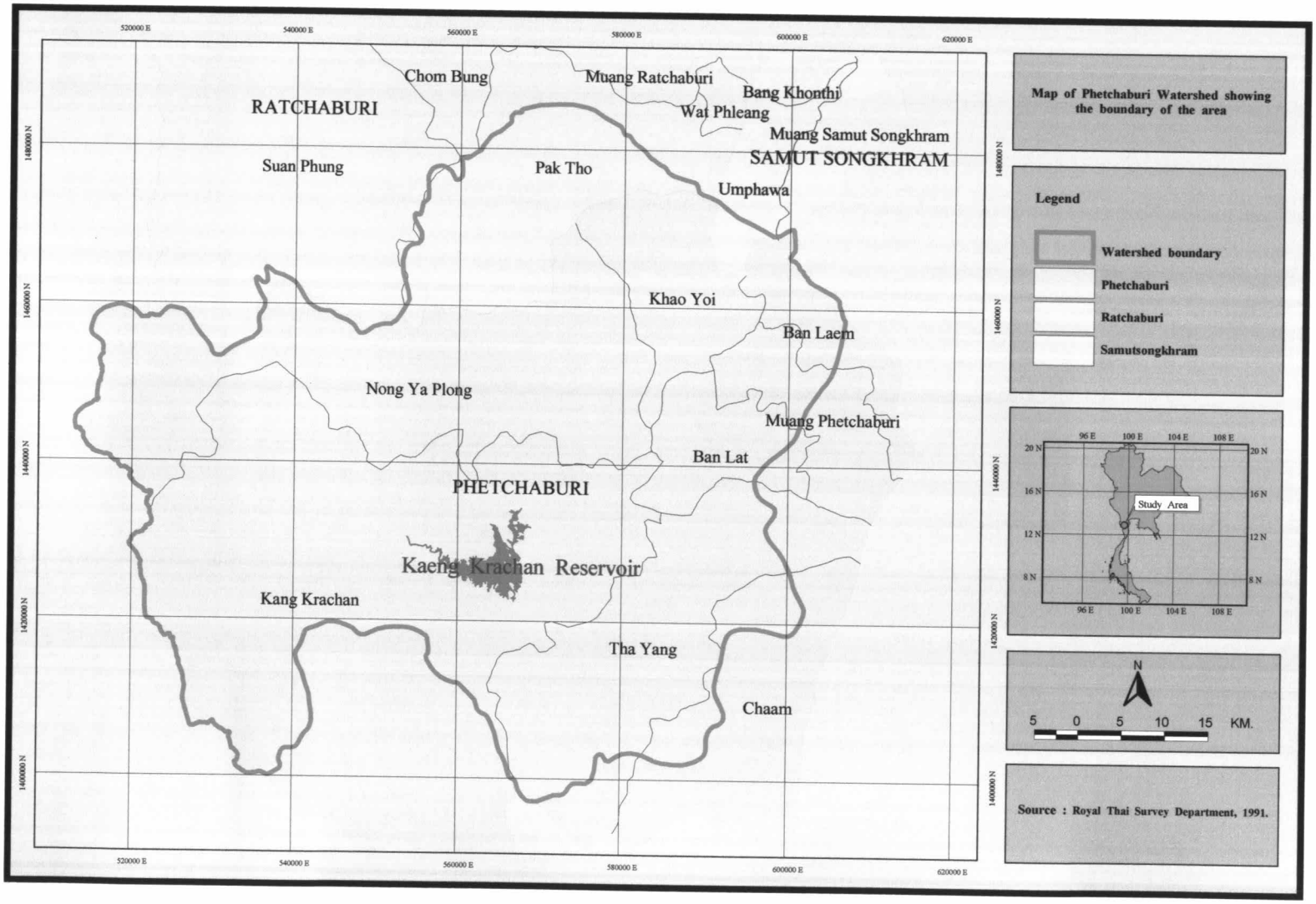


Figure 3.1 Location Map of Phetchaburi Watershed

3.1.2 Methods

1. The topographic map, scale 1 : 50,000 dated 1991 was used to define the watershed boundary by using PC ARC/VIEW 3 software.
2. The topographic map of Phetchaburi watershed, land uses map and soil map were overlaid (Figure 3.2).
3. The study sites were defined for collected samples.

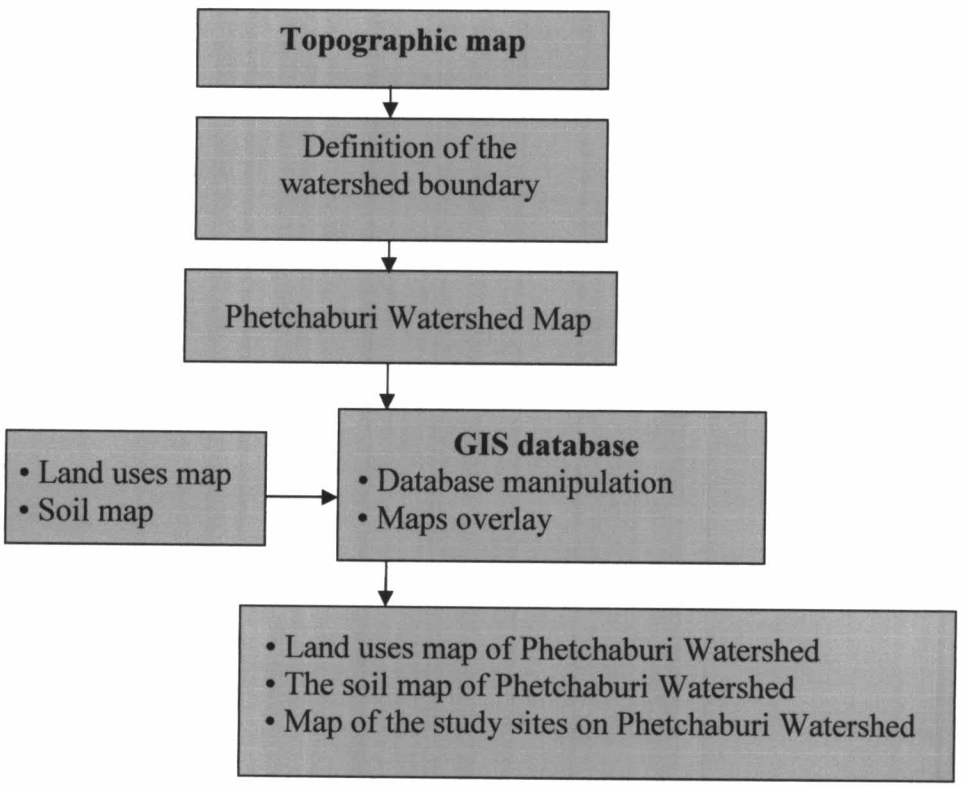


Figure 3.2 Flow chart of the boundary definition

The watershed boundary and the subsystems were defined base on the topographic information (Figure 3.3). The site selection was determined with regard to the information of land use pattern information and soil series that were obtained by interviews and reviews of secondary data (Chulalongkorn University, 1994; Land Development Department, 1988, 1999; National Statistical officer, 1999; Royal Forest Department, 1994) (Figure 3.4 and 3.5). Three subsystems and eleven stations were selected for the collection of ecological data that covers different land use patterns in the Phetchaburi Watershed. This study characterized Phetchaburi watershed into

forest areas, agricultural communities, water body, residential areas and miscellaneous areas, through aqua-cultural activities (Figure 3.5).

For the study, Phetchaburi Watershed was ecologically classified into 3 subsystems. Subsystem 1 covered the upstream area of the watershed, Subsystem 2 covered the area of the Kaeng Krachan Reservoir and Subsystem 3 covered the downstream area of the watershed from Kaeng Krachan Reservoir to the river mouths (Figure 3.3). Based on geographical information, each subsystem was located at the different elevations starting from higher than 600 m of mean sea level and declining toward the river mouth at sea level (msl) (Figure 3.6). The stations were designed according to the specific characteristics as follows:

- Subsystem 1 consisted of three stations (P1, P2 and P3)
- Subsystem 2 consisted of one station (P4) and three substations
- Substation 3 consisted of 7 stations (P5 – P11) with three substations in P11 at the river mouths

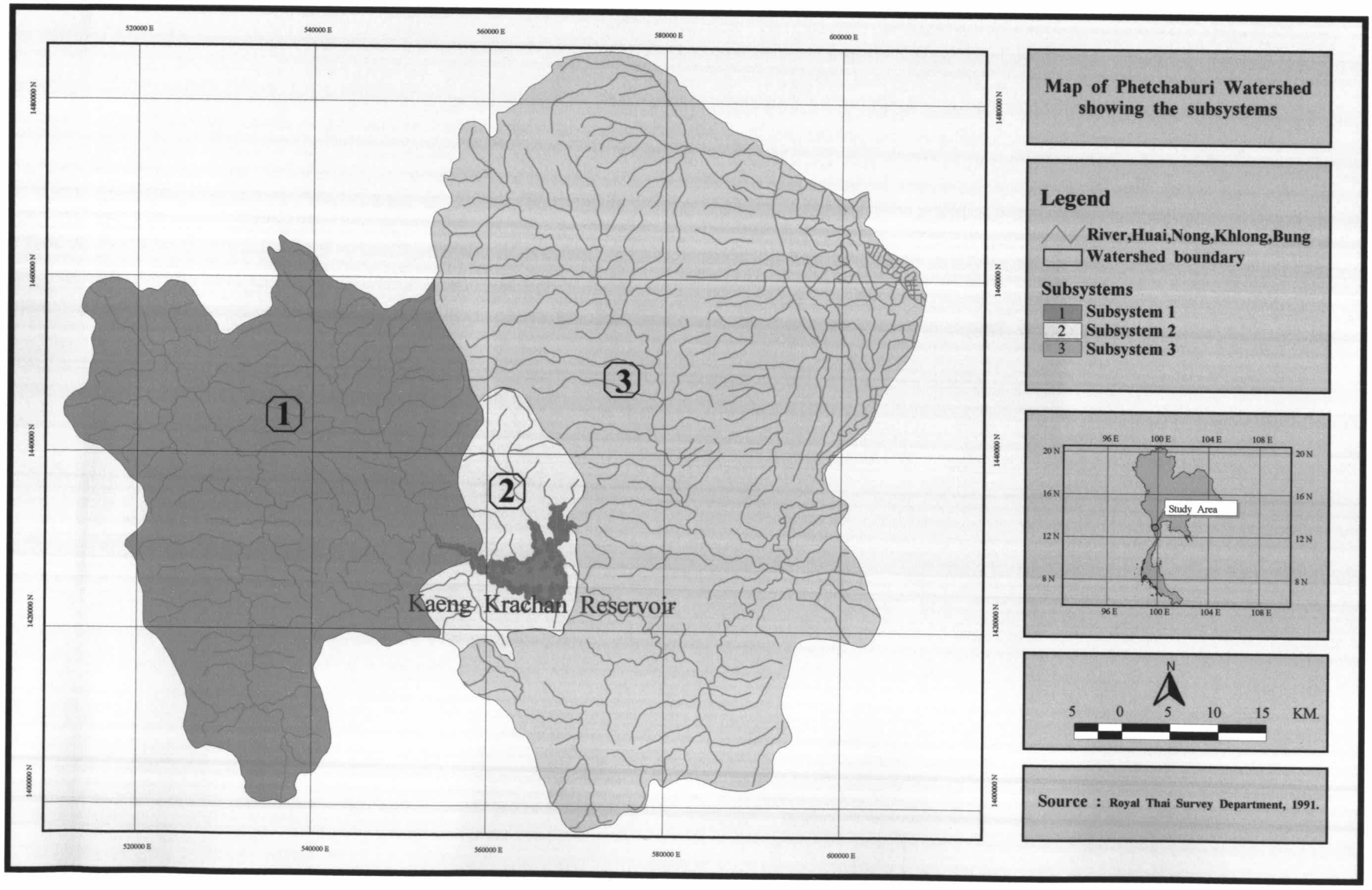


Figure 3.3 Location Map of the Subsystems on Phetchaburi Watershed

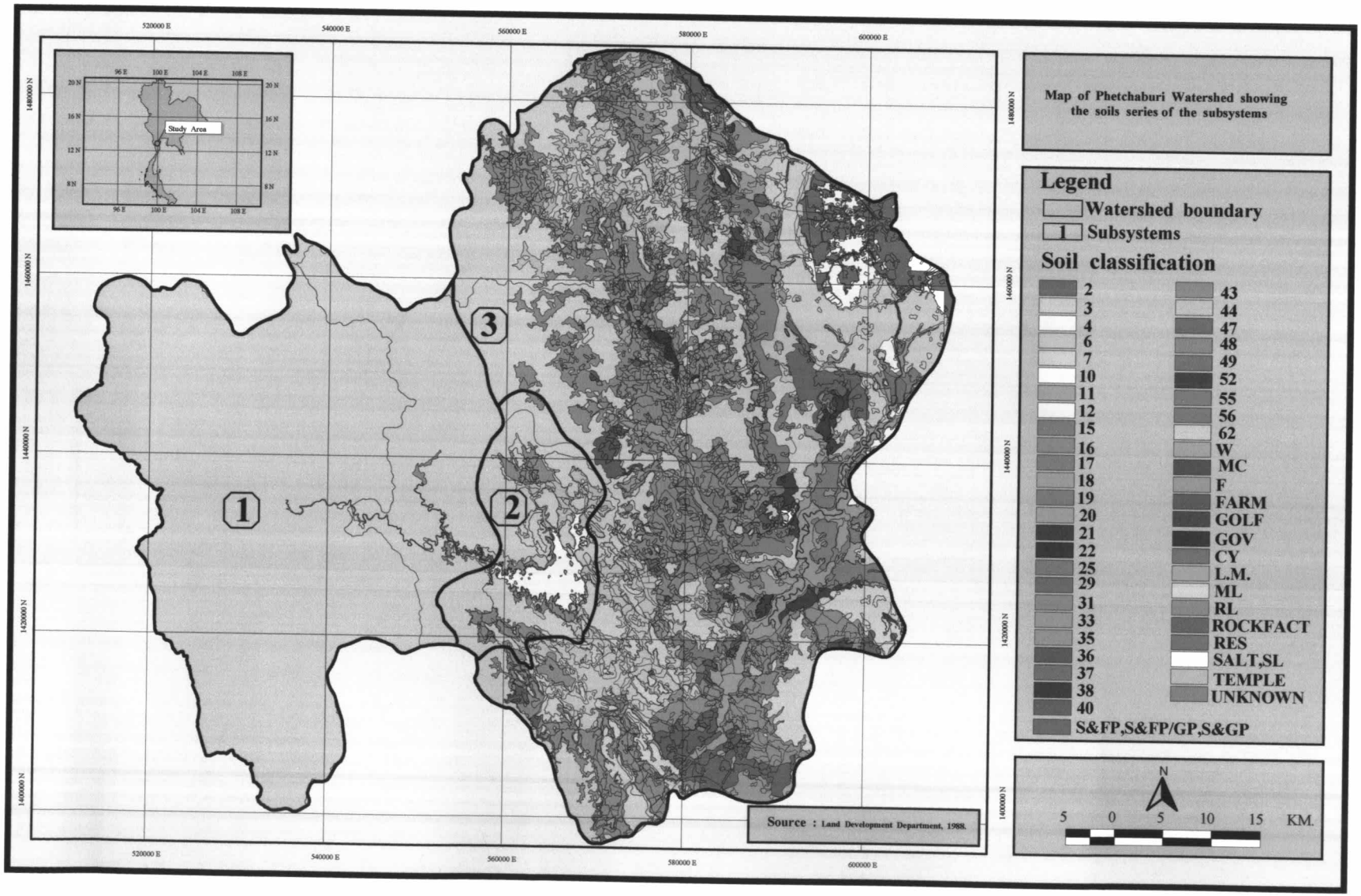


Figure 3.4 Soil Series Map of Phetchaburi Watershed

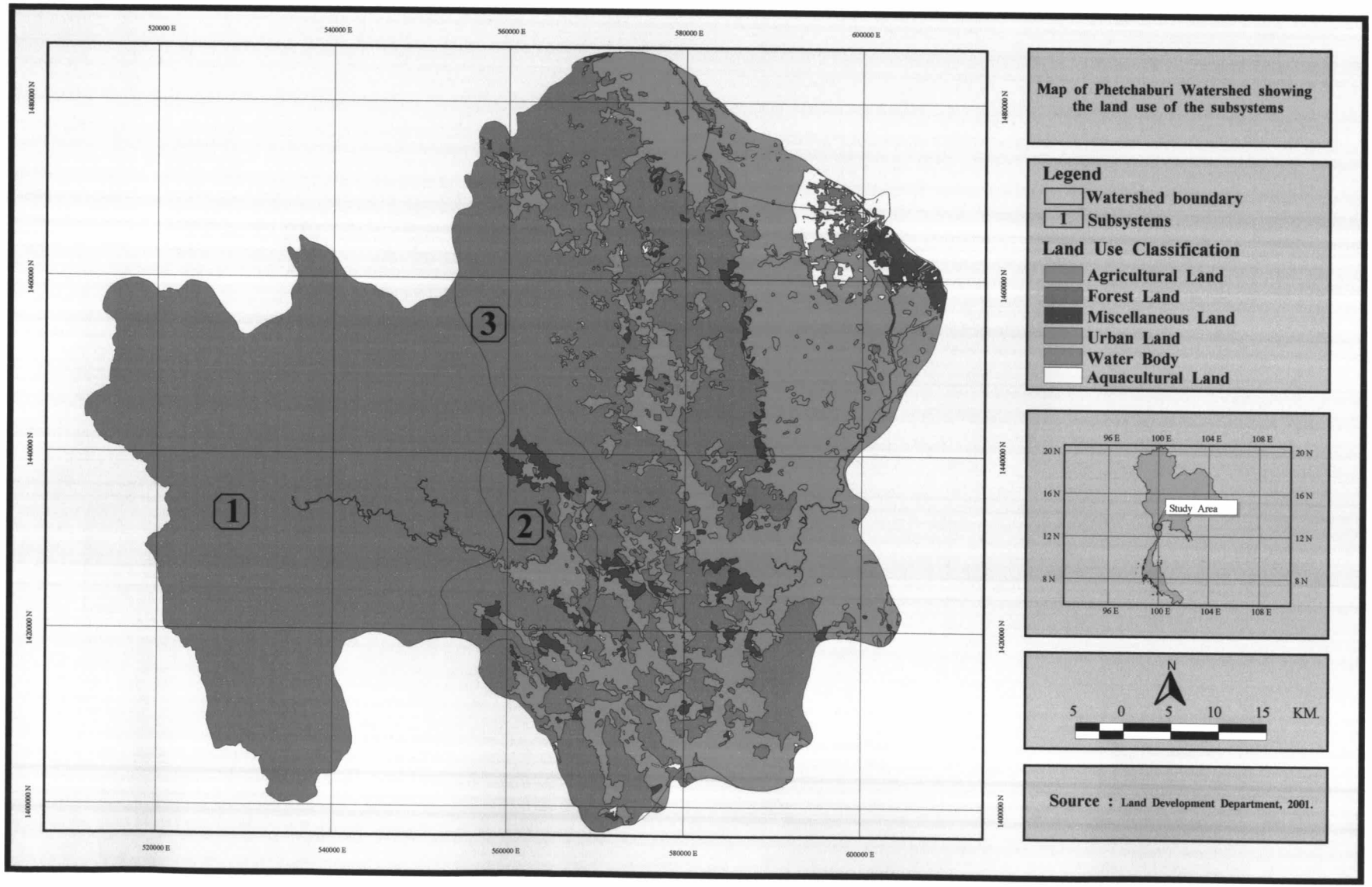


Figure 3.5 Land Use Map of Phetchaburi Watershed

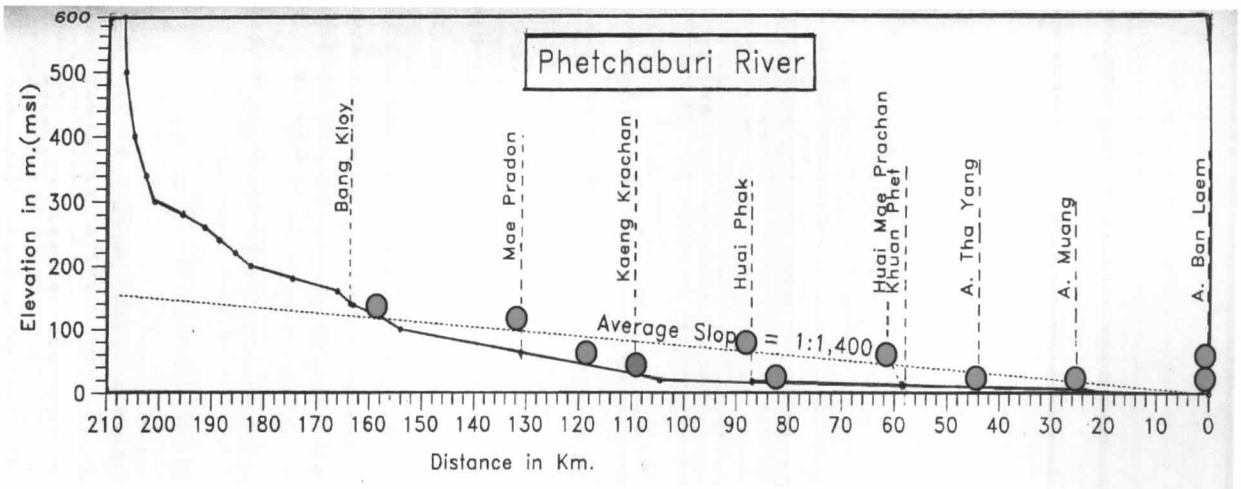


Figure 3.6 Topography of sampling station in Phetchaburi Watershed

(Source: Chulalongkorn University, 1994)

Note: Red circle represented Subsystem 1

Green circle represented Subsystem 2

Pink circle represented Subsystem 3

3.1.3 Study Sites

According to the ecological concepts, this watershed can be divided into three subsystems in which each subsystem represented the different aquatic ecosystem types (Figure 3.7) as the following:

Subsystem 1 represented the upstream area of the watershed as a lotic system. It consisted of 3 stations that were:

Station P1 - the primitive forest area at the headwater, Phetchaburi River: UTM 47P 1434379 N, 0537046 E (Figure 3.8)

Station P2 - agricultural area at the upstream, Mae Pradon Subwatershed, Phetchaburi Watershed: UTM 47P 1433849 N, 0552970 E (Figure 3.9)

Station P3 - agricultural area at the upstream, Phetchaburi River: UTM 47P 1427704 N, 0558851 E (Figure 3.10.)

Subsystem 2 represented the reservoir as a lentic system which consisted of the only 1 station divided into 3 substations that were:

Station P4 - Kaeng Krachan Reservoir: UTM 47P 1426194 N, 0564447 E (Figure 3.11)

Substation P4a - inlet water from upstream (Figure 3.12)

Substation P4b - water in the reservoir (Figure 3.13)

Substation P4c - outlet water from reservoir to downstream (Figure 3.14)

Subsystem 3 represented the downstream of the watershed as a lotic system. It consisted of 7 stations and 3 substations at the largest river mouth in P11 that were:

Station P5 - upstream of Phetchaburi River from Kaeng Krachan Reservoir: UTM 47P 1421131 N, 0577809 E (Figure 3.15)

Station P6 - proposed reservoir in the Huai Pak Subwatershed, Phetchaburi Watershed: UTM 47P 1417196 N, 0579646 E (Figure 3.16)

Station P7 - proposed reservoir in the Mae Prachan Subwatershed, Phetchaburi Watershed: UTM 47P 1429704 N, 0585007 E (Figure 3.17)

Station P8 - agriculture area at the downstream, Phetchaburi River: UTM 47P 1446479 N, 0602648 E (Figure 3.18)

Station P9 - domestic and industrial areas, Amphoe Maung, Phetchaburi Province; UTM 47P 1450564 N, 0603707 E (Figure 3.19)

Station P10 - aquaculture area at the Ban Lam Estuary: UTM 47P 1461741 N, 0607948 E (Figure 3.20)

Station P11 - aquaculture area at the Bang Taboon Estuary: UTM 47P 1466300 N, 0602443 E (Figure 3.21)

Substation P11a - at the left of the Bang Taboon Estuary

Substation P11b - in the middle of the Bang Taboon Estuary

Substation P11c - at the right of the Bang Taboon Estuary

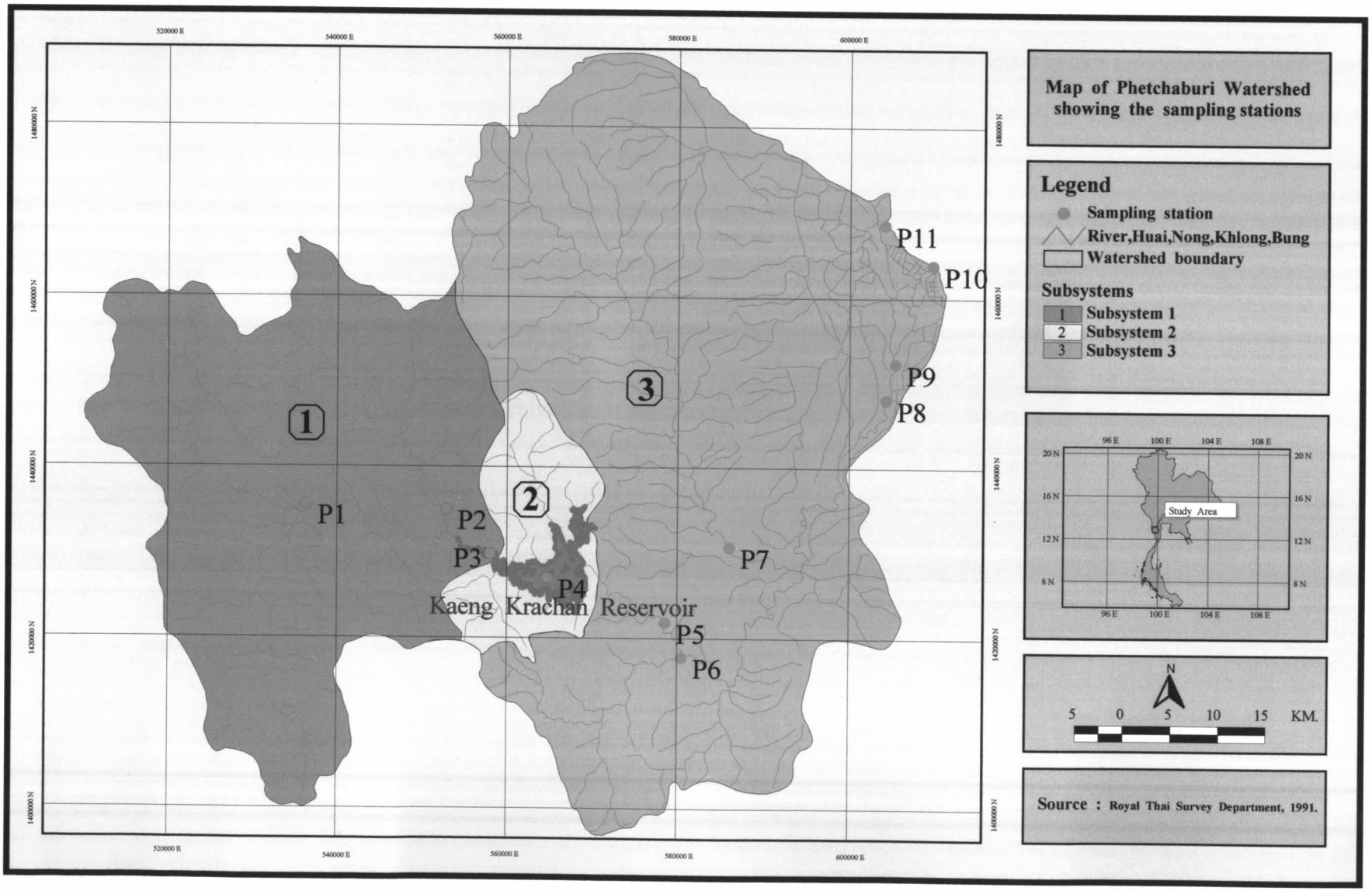
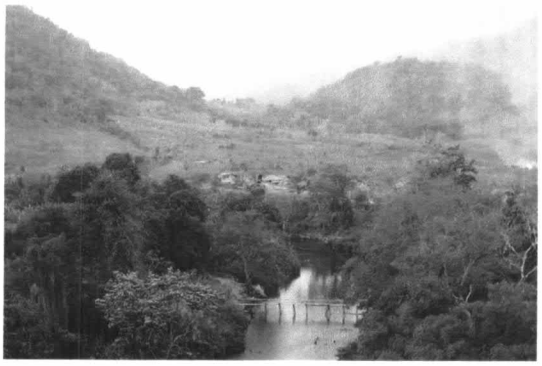
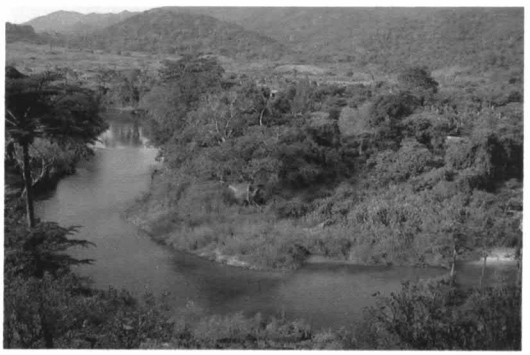


Figure 3.7 Location Map of Sampling Station on Phetchaburi Watershed



A



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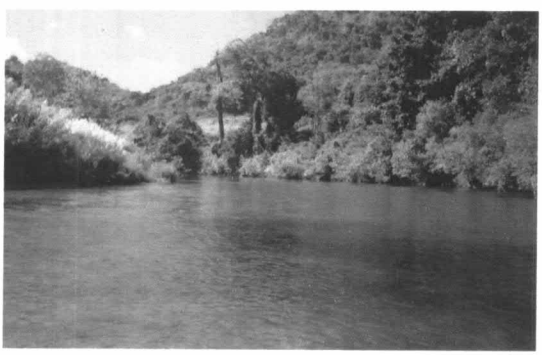

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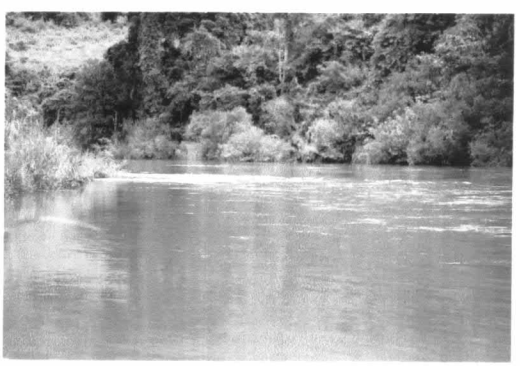


D

Figure 3.8 The area of station P1 is the primitive forest area at the headwater, Phetchaburi River, the headwater of Phetchaburi River in the dry season (A) and the wet season (B). Other photograph show station P1 in the dry season (C) and the wet season (D)

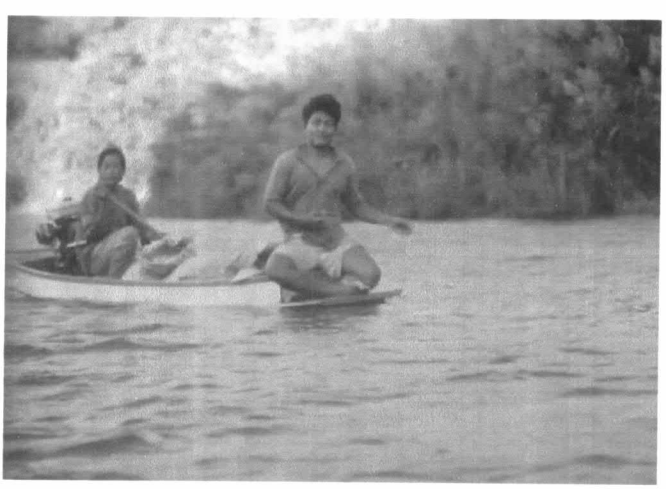


Figure 3.9 The geographical position of station P2 as agricultural area at the headwater, Mae Pradon subwatershed, Phetchaburi Watershed

A B

Figure 3.10 The geographical position of station P3 as the agricultural area at the headwater, Phetchaburi River, preparing culture (A) and banana orchard (B)

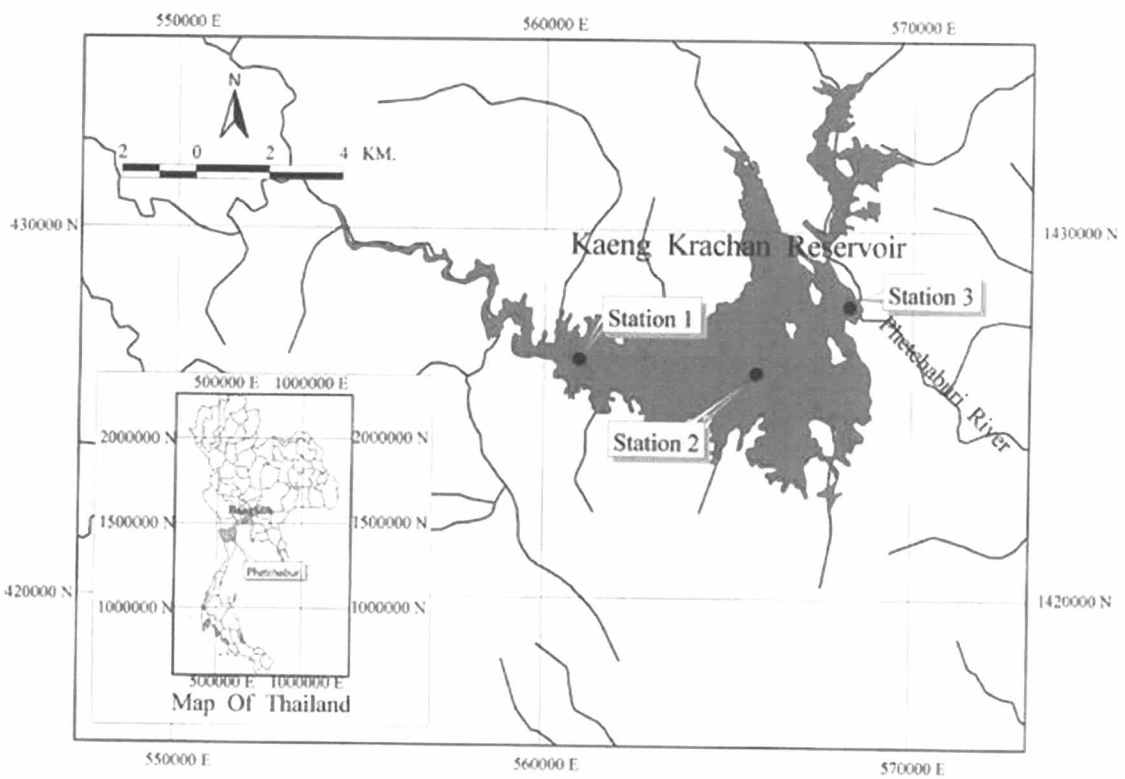
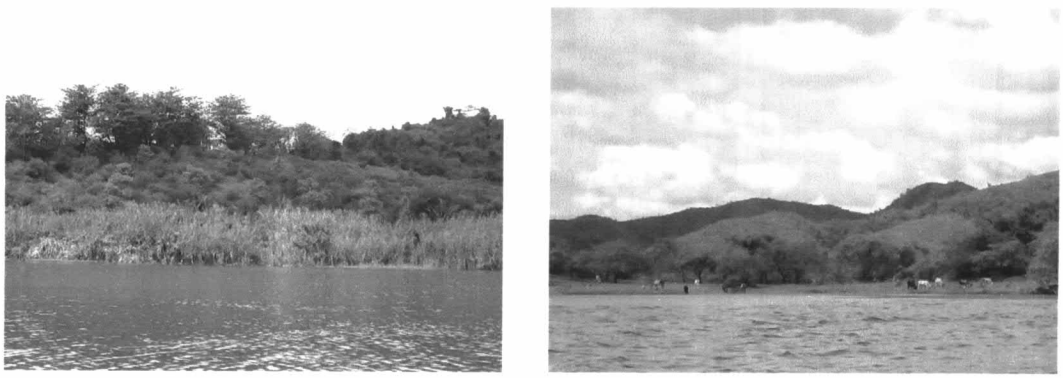


Figure 3.11 Map of substations in Kaeng Krachan Reservoir



A B

Figure 3.12 The geographical position of station P4a as water inlet from the upstream, lemon orchard (A) and lots of cattle on the island at the middle of the water inlet (B)

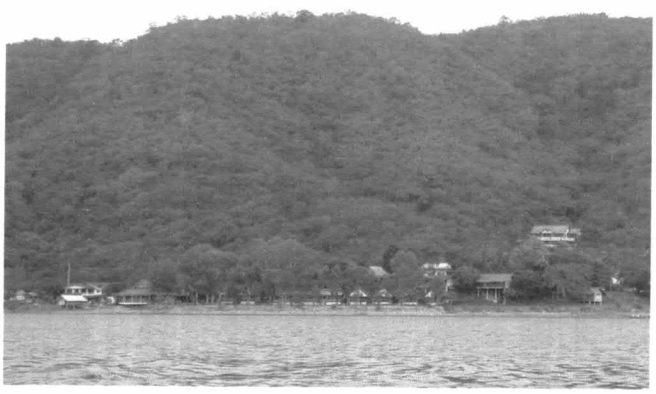


Figure 3.13 The geographical position of station P4b as the water in the reservoir

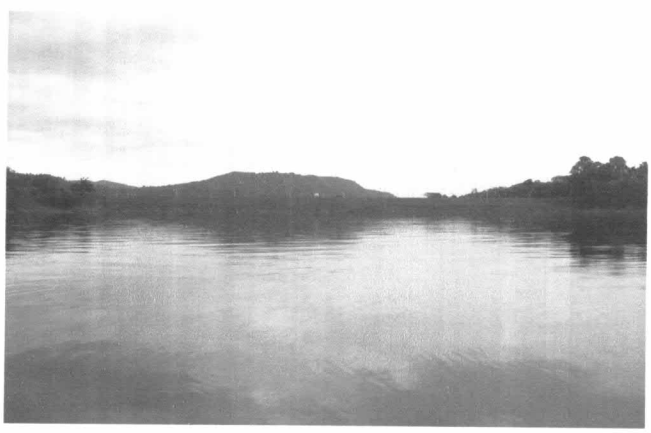
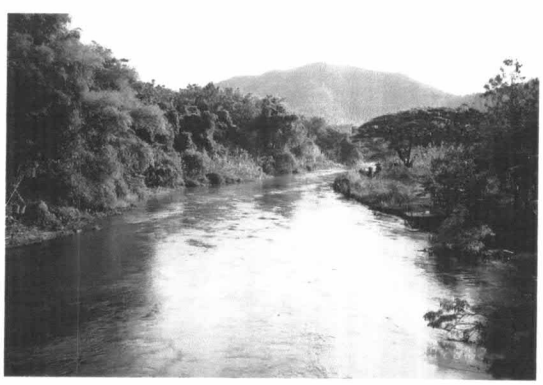


Figure 3.14 The geographical position of station P4c as the downstream water outlet from the reservoir

Figure 3.15 The geographical position of station P5 as the upstream of Phetchaburi River from the Kaeng Krachan Reservoir



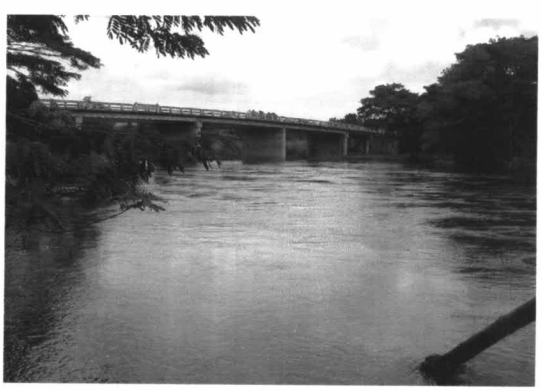


Figure 3.16 The geographical position of station P6 as proposed reservoir in Huai Pak Subwatershed, Phetchaburi Watershed

Figure 3.17 The geographical position of station P7 as proposed reservoir in Mae Prachan Subwatershed, Phetchaburi Watershed

Figure 3.18 The geographical position of station P8 as agriculture area at the downstream, Phetchaburi River

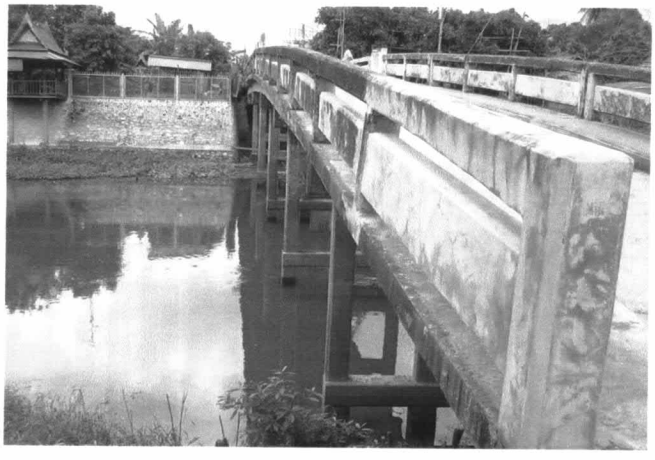


Figure 3.19 The geographical position of station P9 in domestic and industrial areas, Amphoe Maung, Phetchaburi Province

Figure 3.20 The geographical position of station P10 in an aquaculture area at Ban Lam Estuary

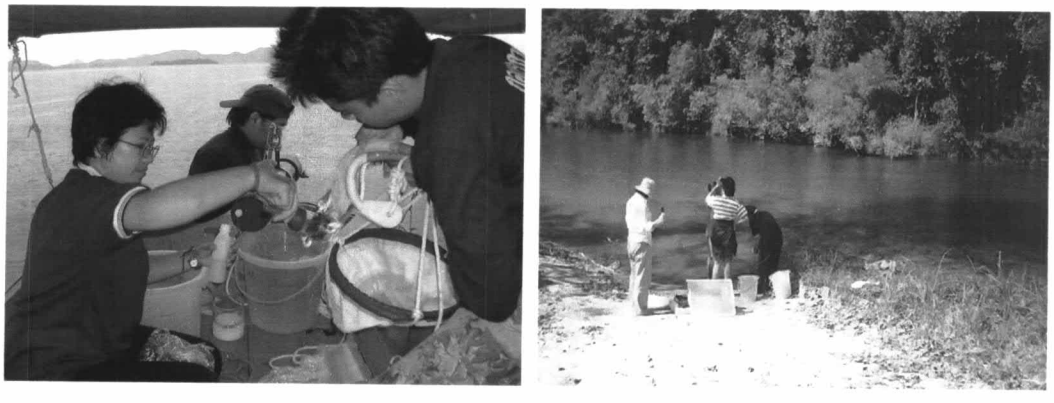
Figure 3.21 The geographical position of station P11 in an aquaculture area at Bang Taboon Estuary

3.2 Ecological Methodology

3.2.1 Water Sample Collection

Primary data was focused on the seasonal variation. Data collection was planned to be collect bimonthly. The investigation took one year (December 2001-October 2002). The method of sampling followed the limnological technique of Wetzel and Likens (2000).

A B



C D

Figure 3.22 Water samples being collected for biological analysis

Water samples and phytoplankton samples were collected at the middle of the flowing water by Van Don water samplers size 1 and 5-liter in volume (Figure 3.22 A). The water samples were planned and collected in relation to the depth at four levels as follows (Table 3.1):

- D1= at 0.5 m. depth below the surface
- D2= at the mid-point of transparency depth
- D3= at a depth of 5 m.
- D4= at 0.5 m above riverbed depth

Table 3.1 Water samples collection in the different depth

Station	Depth (m.)			
	D1	D2	D3	D4
1	√			
2	√			
3	√			
4	√	√	√	
5	√			
6	√			
7	√			
8	√			
9	√			
10	√			√
11	√			√

Station P1 to P3 and P5 to P9 were positioned to collect at D1, station P4 (Kaeng Krachan Reservoir) collected at D1, D2 and D3. Notably, the station 10 and 11 were designed to collect at D1 and D4 for the purpose of salt water intrusion impact. Therefore, the river ecosystem in subsystem 3 was assumed to be capable of recovering from tidal influence.

3.2.2. Water Analysis of Ecological Parameters

The water samples were analyzed and followed by the standard methods with regards to the parameters as follows:

3.2.2.1. Physical and Chemical Parameters

Some physical and chemical parameters of water were analyzed in the field (Figure 3.22 D) and some were brought back to the laboratory preserved (Table 3.2). The details of method were:

Table 3.2 Methodology of water analysis

Water Property		Preservation	Measure/Method
Physical factors:	Depth (m)	Field analysis	Plummet and measuring tape
	Transparency(cm)	Field analysis	Secchi disc
	Temperature (^{0}C)	Field analysis	DO meter
	pH	Field analysis	pH meter
Chemical factors:	Salinity (ppt)	Field analysis	Salinometer
	Dissolved Oxygen (mg/l)	Field analysis	DO meter
	Nitrogen:		
	Nitrate-nitrogen (ug/l)	4 ^{0}C	Spectophotometeric method#
	Nitrite-nitrogen(ug/l)	4 ^{0}C	Spectophotometeric method#
	Ammonium-nitrogen (ug/l)	4 ^{0}C	Spectophotometeric method#
	Phosphorus:		
	Phosphate-phosphorus(ug/l)	4 ^{0}C	Spectophotometeric method#
	Silica (mg/l)	4 ^{0}C	Spectophotometeric method#
Plant biomass :	Chlorophyll *a* (mg/m^3)	4^0 C	Spectophotometeric method*

Note: # APHA AWWA WEF (1995), * Parson *et al.* (1984 a)

3.2.2.2. Biological Parameters

This study was based on phytoplankton which plays a major important role as a producer in the aquatic ecosystem. Phytoplankton samples were collected by filtering 40 liters of fresh water and 20 liters of blackish water through a plankton net (mesh - size 20 micron) (Figure 3.22 B and C). All samples were preserved in 10% Lugol's solution for taxonomic identification, population density, and biovolume estimation in the laboratory. The water volume was calculated to estimate phytoplankton density.

Taxonomic identification was made by using x200 magnification under compound microscope and a Sedgwick-Rafter counting chamber (Figure 3.23).

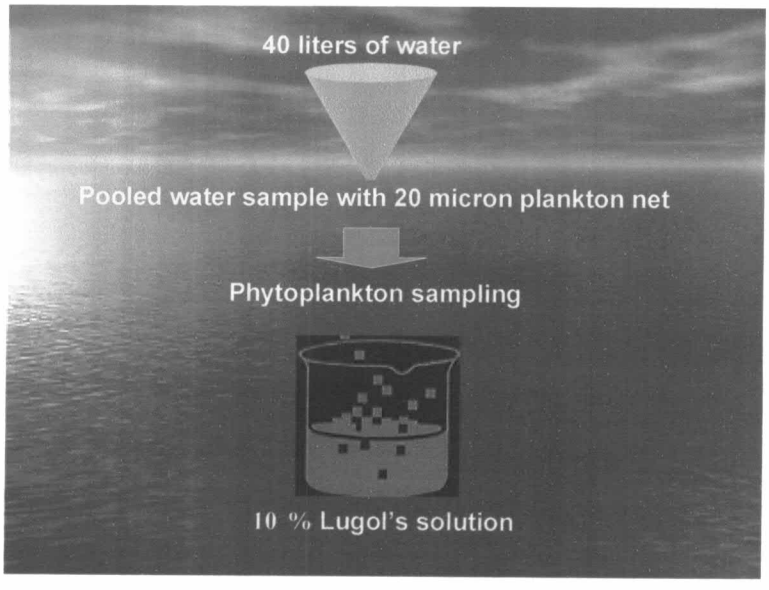


Figure 3.23 Sampling process of phytoplankton

For taxonomic identification, phytoplankton was identified to Genera and followed by Cupp (1943); Smith (1950); Prescott (1978); Yamagishi (1992); Cox (1996) and Thomas (1997). Phytoplankton was analyzed by using the Shannon-Wiener Index (Krebs, 1989) for species diversity index.

$$H' = - \Sigma [(n_i) \log (n_i / N)]$$

Where H' = Index of species diversity

n_i = Proportional abundance of the species = (n_i / N)

N = Species number in the sample

The number of phytoplankton was counted by using a Sedgwick-Rafter counting chamber under microscope. The thickness, length width and process of each phytoplankton were examined under microscope and the biovolume was calculated by using the Rott method (Rott, 1981) (Appendix B2). The volume of the total phytoplankton was calculated from the abundance and volume approximations for each species.

Chlorophyll *a* concentration analysis was followed by Wetzel and Likens (2000). The water samples were filtered through Millipore paper in pore size of 0.45 micron then the phytoplankton cell was broken by acetone in order to extract chlorophyll pigment from cell. The chlorophyll *a* content was measured by the spectrophotometer under the wavelength standard of the laboratory.

3.2.3 Socio-Economic Parameters

Socio–economic parameters were studied by using the interview–questionnaire method which was designed to pre–test 95 samples (Appendix C). After the analysis of pre-test the questionnaire was adjusted and a final questionnaire was produced to interview 5 groups of people in Phetchaburi Province who represented administrative zones (Amphoe) as follows:

Subsystem I

- Group 1 = Amphoe Kaeng Krachan (at the area of head water of the Phetchaburi river)

Subsystem II

- Group 2 = Amphoe Kaeng Krachan (Surrounding the Kaeng Krachan Reservoir)

Subsystem III

- Group 3 = Amphoe Muang
- Group 4 = Amphoe Kao Yoi
- Group 5 = Amphoe Nongyapong
- Group 6 = Amphoe Cha Am
- Group 7 = Amphoe Tha Yang
- Group 8 = Amphoe Ban Lad
- Group 9 = Amphoe Ban Laem

The total number of interview was 409 respondents who were selected for the purpose of natural resource use attitudes, concerns, and knowledge. The respondents were interviewed by well–trained interviewers. The questionnaires were coded for statistical analysis.

3.3 Data Analysis

3.3.1 All data was tested by ANOVA

3.3.2 Ecological data was tested and analyzed with T-test, one-way ANOVA and correlation analysis.

3.3.3 Socio-economic data were statistically analyzed as percentage and correlation analysis.

3.3.4 Analyzed the interrelationships between ecological indicators and land use activities.

Ecological indicators and land use patterns were integrated in order to develop a conceptual framework for sustainable watershed management of Phetchaburi Watershed.