3. Supplement Study

3 Supplementary Study

3.1 Water Quality Analysis

3.1.1 Objective

The objective of the supplementary study is to conduct water quality analysis in order to grasp the current pollution conditions in both model provinces. Location of sampling and analysis items are subject to the local conditions and discussion was held with C/P and each PEO. Therefore, the location and analysis items are different in the two provinces, as outlined below.

- Ayutthaya Province is located at the center of Thailand and belongs to the investment promotion zone 2. There are a lot of factories in the province. Therefore, the analysis target is the discharged water from these factories.
- There are not many factories in Samut Songkhram Province, so water quality analysis was done for surface water of the Mae Klong River.

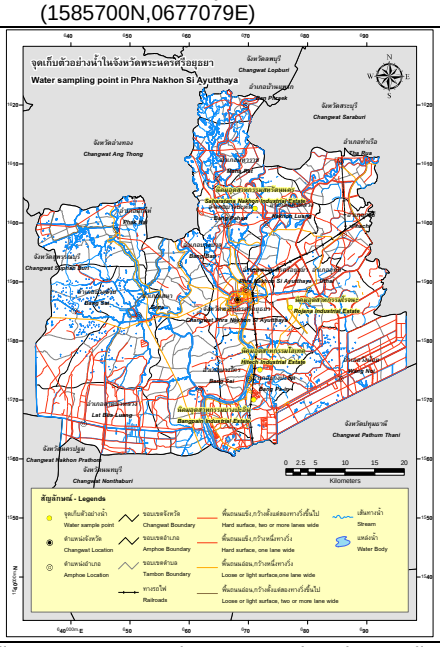
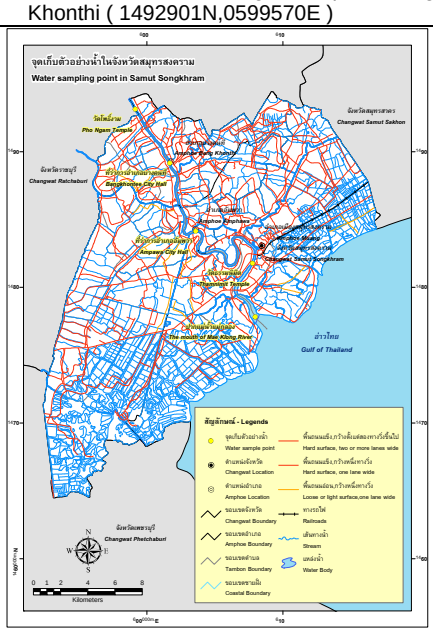
Table 3-1: Survey Target and Item of Analysis

	Ayutthaya	Samut Songkhram
Survey targets	Treated industrial effluent	River water
Item of Analysis	Survey items are classified into two groups: (i.e. general index and heavy metal index). General index ・ Air and water temperature ・ pH, DO ,BOD, Fecal ・ Total Coliform Bacteria ・ T-P, TKN, Oil and Grease, TS, TDS, SS Heavy metal index ・ Pb, Cd, Cr,Hg, Ni, Cu, Z, Mg	Survey items are classified into two groups: (i.e. general index and heavy metal index). General index ・ Air and water temperature ・ pH, DO ,BOD, Fecal ・ Total Coliform Bacteria ・ T-P, TKN, Oil and Grease, TS, TDS, SS Heavy metal index ・ Cd, Pb

3.1.2 Method

Methods of sampling and analysis are shown in the table below.

Table 3-2: Methods of Sampling and Analysis

	Ayutthaya	Samut Songkhram
Sampling procedure	Using the Kemmerer water sampler and/or dipper for the sampling to the center and with the half depth of the river or stream for most of the parameters. ・ The samples for coliform bacteria were collected at the surface level and kept in glass bottles. ・ For oil and grease parameters, the samples were collected at a depth of 30cm in the glass bottles. ・ The samples for the rest of the parameters were kept in polyethylene bottles. All water samples were stored at 4 degrees Celsius, and transported to the laboratory on the same day.	
Location of sampling point	Location: Industrial areas in Ayutthaya Date : August 28, 2007 (B.E. 2550) ・ Station 1: Effluent Pumping Station of Bangpa-In Industrial Estate (1570062N,0670864E) ・ Station 2: Effluent Pumping Station of Ban-Wa (Hi-Tech) (1575132N,0671936E) ・ Station 3: Effluent Pumping Station of Saharatananakorn Industrial Estates (1602451N,0671101E) ・ Station 4: Effluent Pumping Station of Suan Autasahakham Rojana Industrial Zone (1585700N,0677079E)	Location: Mae Klong River in the Samut Songkhram area Date : August 27, 2007 (B.E. 2550) ・ Station 1: River mouth at Amphoe Muang Samut Songkhram (1477214N,0608627E) ・ Station 2: At Wat Thamanitti Amphoe Muang Samut Songkhram (1481563N,0608105E) ・ Station 3: At the office of Amphoe Amphawa (1483897N,0603961E) ・ Station 4: At the office of Amphoe Bang Khonthi (1488783N,0602048E) ・ Station 5: At Wat Pho Ngam Amphoe Bang Khonthi (1492901N,0599570E)
		
Analysis method	All wastewater samples were analyzed according to the Standard Methods for Examination of Water and Wastewater, published by the American Public Health Association, the American Water Work Association and Water Pollution Control Federation. Some parameters, such as water and atmospheric temperature, pH and DO were measured at the sampling locations. The rest of the samples were transferred to be analyzed at the laboratory.	

3.1.3 Results

a. Ayutthaya

Results of analysis for AYP are shown in the table below.

Table 3-3: Results of Water Quality Analysis in AYP

Parameter	Unit	Sampling Point				Industrial Effluent Standards*
		1	2	3	4	
Air Temperature	°C	30.0	30.0	31.0	30.0	-
Water Temperature	°C	28.4	28.9	34.2	28.4	≤ 40
pH	-	7.98	7.60	8.40	7.73	5.5 to 9.0
D O	mg/l	0.45	2.45	7.65	5.27	-
BOD	mg/l	13.00	16.50	12.50	8.80	≤ 20
S S	mg/l	2.0	12.0	2.0	2.0	≤ 50
T S	mg/l	1,128.0	590.0	2,244.0	758.0	-
TDS	mg/l	1,126.0	578.0	2,242.0	756.0	≤ 3,000
Sulfide	mg/l	0.27	0.27	0.13	0.27	-
T-kN	mg/l	2.24	12.60	14.84	6.72	≤ 100
Oil & Grease	mg/l	<0.1	<0.1	<0.1	<0.1	≤ 5.0
T C B	MPN/100 ml	8,000	1,700	30,000	240,000	-
F C B	MPN/100 ml	1,400	500	1,100	34,000	-
Lead	mg/l	0.017	0.048	0.018	0.043	≤ 0.2
Cadmium	mg/l	<0.001	<0.001	0.004	0.005	≤ 0.03
Chromium	mg/l	<0.001	<0.001	<0.001	<0.001	≤ 0.75 (Cr^{+3})
Mercury	mg/l	0.003	<0.001	0.001	0.003	≤ 0.005
Nickel	mg/l	<0.001	<0.001	0.002	<0.001	≤ 1.0
Copper	mg/l	0.041	0.031	0.033	0.045	≤ 2.0
Zinc	mg/l	0.122	0.081	0.063	0.141	≤ 5.0
Manganese	mg/l	0.158	0.004	0.024	0.076	≤ 5.0
Remark : Station 1: Effluent Pumping Station of Bangpa-In Industrial Estate Station 2: Effluent Pumping Station of Ban-Wa (Hi-Tech) Station 3: Effluent Pumping Station of Saharatananakorn Industrial Estates Station 4: Effluent Pumping Station of Suan Autasahakham Rojana Industrial Zone						*Source : PCD web page http://www.pcd.go.th/info_serv/en_reg_std_water04.html#s1

b. Samut Songkhram

Results of water quality analysis for Samut Songkhram are shown in the table below.

Table 3-4: Results of water quality analysis in SKP

Parameter	Unit	Sampling Station					Surface water quality standard*		
		1	2	3	4	5	Class2	Class3	Class4
Air Temperature	°C	29.5	30.2	30.0	32.0	32.2	-		
Water Temperature	°C	28.0	29.5	28.0	30.2	30.4	-		
pH	-	7.80	7.84	7.81	7.86	7.88	5 to 9		
DO	mg/l	4.79	5.11	5.02	5.59	5.56	≥ 6.0	≥ 4.0	≥ 2.0
BOD	mg/l	2.50	2.20	2.70	2.30	2.00	≤ 1.5	≤ 2.0	≤ 4.0
T C B	MPN/100 ml	9,000	2,200	5,000	7,000	8,000	≤ 5,000	≤20,000	-
F C B	MPN/100 ml	800	300	1,100	2,200	2,300	≤ 1,000	≤ 4,000	-
NO_3-N (Nitrate)	mg/l	0.016	0.017	0.017	0.015	0.016	≤ 5.0		
Cadmium[2/]	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	≤0.005		
Lead[2/]	mg/l	0.033	0.018	0.049	0.022	0.012	≤ 0.05		
TDS	mg/l	404.0	208.0	130.0	126.0	134.0	-		
SS	mg/l	28.0	34.0	36.0	32.0	32.0	-		
TS	mg/l	432.0	242.0	166.0	158.0	166.0	-		
T-kN	mg/l	1.96	1.96	0.84	0.60	1.12	-		
Oil & Grease	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	-		
Phosphate	mg/l	0.361	0.274	0.300	0.269	0.200	-		
Remark: Station 1: River mouth at Amphoe Mueang Samut Songkhram Station 2: At Wat Thamanitti Amphoe Mueang Samut Songkhram Station 3: At the office of Amphoe Amphawa Station 4: At the office of Amphoe Bang Khonthi Station 5: At Wat Pho Ngam Amphoe Bang Khonthi							*Source : PCD web page http://www.pcd.go.th/info_serv/en_reg_std_water05.html#s3		

3.1.4 Findings

Results of water quality analysis in both provinces are within the relevant standard.

3.2 Examination of Change of Land Use in Model Provinces

3.2.1 Ayutthaya

a. Terms of References for the Development of Land Use Map using Satellite Image

a.1 Objective

Satellite images were used to develop Land Use Maps for conditions 20 years ago, 10 years ago and current conditions in order to grasp the change of environmental conditions such as vegetation, and so on.

a.2 Study Area (Model Province)

Phra Nakhon Si Ayutthaya Province: around 50 km × 50 km

a.3 Scope and Contents of the Work

1) Change of land use: 20 years ago, 10 years ago, and current

LANDSAT-5 data for current conditions (2007), 10 years ago (1997), and 20 years ago (1987) were used for developing land use maps. In case data for the exact year were not available, data of the previous year were used. Type of land use is as follows.

- Urban and Built-up Land
- Agricultural Land
- Forest Land
- Water Bodies
- Others

For Phra Nakhon Si Ayutthaya Province, historical area (world heritage area) shall be differentiated.

2) Development of Detailed Current Land Use Map

Detailed current land use maps were developed using SPOT-5 satellite data (2007) using the same methods of implementation as above. Satellite Data: SPOT-5, Pan-sharpened image with resolution 5 m, Ortho-rectified, UTM Projection. Type of land use: as follows

Table 3-5: Type of land use for detailed current land use map

Category	Code Number	Land use
Urban and Built-up Land	U01	City, Town, Commercial and Services
	U02	Villages
	U03	Institutional
	U04	Transportation, Communication and Utilities
	U05	Industrial
	U06	Others
Agricultural Land	A01	Paddy Field
	A02	Field Crops
	A03	Perennial
	A04	Orchards
	A05	Horticultural
	A06	Swidden Cultivation
	A07	Pasture and Farmhouse
	A08	Aquatic Plant
	A09	Aquacultural Plants
	A10	Integrated Farming
Forest Land	F01	Evergreen Forest
	F02	Deciduous Forest
	F03	Forest Plantation
	F04	Agro forestry
	F05	Mangrove
Water Bodies	W01	Natural Water Bodies
	W02	Reservoirs (Built up)
Miscellaneous Land	M01	Rangeland
	M02	Wetland
	M03	Extractive
	M04	Others

a.4 Outcome

1) Change of land use （LANDSAT-5 data）

- Three land use maps (1:50,000) of Phra Nakhon Si Ayutthaya province in a GIS vector format and the area of each land use type.

- Trend analysis of land use changes according to the dates of the satellite data in Phra Nakhon Si Ayutthaya Province.

- Processed Digital LANDSAT-5 data of Phra Nakhon Si Ayutthaya provinces at 1:50000 scale.

2) Detailed Current Land Use Map (SPOT-5)

- Two land use maps (1:50,000) of Phra Nakhon Si Ayutthaya province in a GIS vector format from the SPOT-5 data in the year 2007.

- Processed digital SPOT-5 data of Phra Nakhon Si Ayutthaya province at 1:50,000 scale.

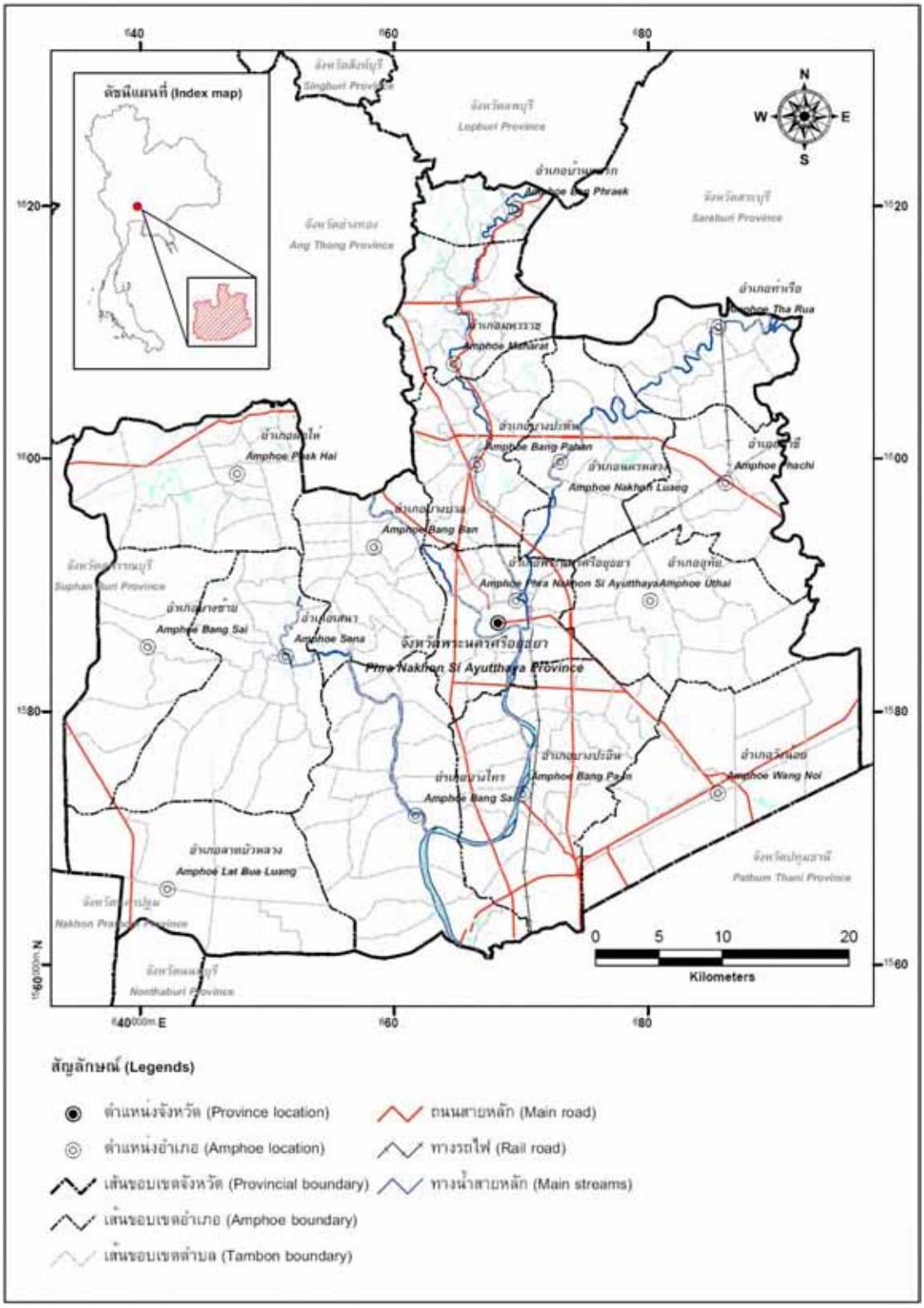


Figure 3-1: Study Area: Ayutthaya Province

b. Satellite Imagery Processing

Satellite imagery processing for Phra Nakhon Si Ayutthaya province is composed of the following steps:

b.1 SPOT-5 and LANDSAT-5 Satellite Imagery Preparation

Satellite imagery of Phra Nakhon Si Ayutthaya province is obtained from Geo-Informatics and Space Technology Development Agency (Public Organization). The complete imageries are selected according to the actual date needed for the study:

1) SPOT-5 satellite imagery recorded in December 13, 2005 in Green wave [Band 1], Red wave [Band 2], NIR wave [Band3] and SWIR wave [Band 4]

2) LANDSAT-5 satellite imagery recorded in January 30, 2007, March 10 , 1998 ,and March 30,1988 at path 129 , row 51 in Green wave (Band2), Red wave (Band3), NIR wave (Band4) and SWIR wave (Band5)

All satellite imageries have to be recorded in ".img" format of ERDAS IMAGINE software.

b.2 Ground Control points: GCPs

The satellite imagery from SPOT-5 employed for this study is level 2A which was already adjusted for geometric system error through data of distance, angle and surface of WGS584 without employing GCPs. Geographic model at high level over Ellipsoid is employed as a reference in order to generate SPOT-5 satellite imagery being near to coordinates with the reference coordinate. This will lead to more a precise study especially on the coordinate of the study area in the earth under UTM on WGS 84. The relationship between the coordinate system of satellite imagery and real coordinate on the earth is explained through a mathematical model. For this method, coordinate searching from ground center is needed through color author map on a scale of 1:25,000 which is rigid on one meter position and two meter vertical. Data on the position are needed for the calculation of the polynomial model.

Good and proper selection for ground control points will help the imagery adjustment be smoother with less error from reference data. The ground control point can be found through the model as:

$$N = \frac{(t+1)(t+2)}{2}$$

When N is the number of ground control points

t is the degree of Polynomial model

The study area in Phra Nakhon Si Ayutthaya province is mainly composed of flat plains with no extreme diversification. Thus, the degree of the model is equal to 1 and the ground control points can be calculated through the equation 1.1 as:

Number of ground control points = (1+1)(1+2)/2

= 3

Theoretically, three ground control points needed for the province but in practical terms, enough ground control points should be provided to calculate the parameters in the polynomial model. Thus, this study set 10 ground control points for the province.

b.3 Radiometric correction

Radiometric correction is a method to correct the error which occurred from reflection of satellite imagery through the Histogram Equalization method. This correction is aimed at generate clearer imagery.

b.4 Mosaic images

There are three images obtained from SPOT-5 satellite used for explaining the study area. Thus mosaic images are needed to connect all three images as one as shown in Figure 3-2

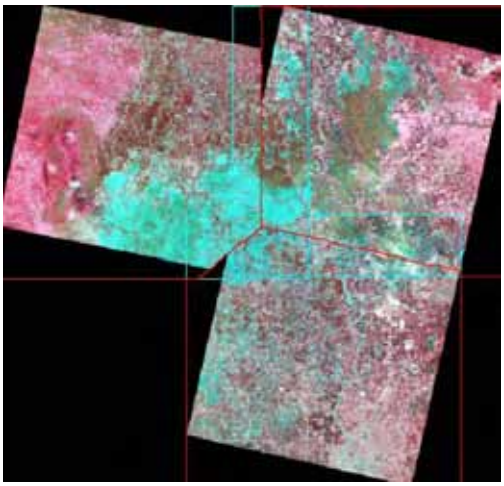


Figure 3-2: Mosaic images

b.5 Geometric correction

b.5.1. SPOT- 5 satellite imageries

Geometric correction for SPOT-5 satellite imageries is aimed to correct and adjust satellite imageries to be in accordance with terrestrial reference coordinates. The study area is a flat plain where there is no difference in geographical position, so Polynomial Degree 1 is employed to calculate the Polynomial Degree 1 model in Phra Nakhon Si Ayutthaya Province by providing 10 points of coordinate value obtained from ground control points. These 10 points are scattered on the imagery. When the position has been changed, the digital number must be changed accordingly and one more round of calculation is needed. Thus, grey data on the imagery must be corrected through the Nearest Neighbor Interpolation method. This method offers one strong point of being able to maintain the digital number closely before and after correction without any effect to the digital number obtained from the satellite data.

b.5.2. LANDSAT-5 satellite imageries

Geometric correction for LANDSAT-5 satellite imageries is done because of the imageries obtained from the LANDSAT-5 satellite are 1G systematic correction images which have already been corrected but are not yet complete. The 1G systematic correction is done by employing an approximate value of the satellite orbit parameter to be a reference coordinate

under UTM. Technical data shows that the position obtained from 1G imagery level has 5-8 points of error or 150-250 meters which need to be corrected. Thus, LANDSAT-5 satellite imageries need to be corrected in order to generate closer coordinates with SPOT-5 satellite imageries through Image Registration. This registration has to employ Polynomial Degree 1 to transform the coordinate system of SPOT-5 satellite to LANDSAT-5 by 9 control points scattered throughout the images and then grey color of satellite imageries will be adjusted by Nearest Neighbor Interpolation.

b.6 Sub-setting images

Sub-setting images are done for both images obtained from SPOT-5 and LANDSAT-5 in order to cut off the areas out of Phra Nakhon Si Ayutthaya province.

b.7 Band combination

Bands from SPOT-5 and from LANDSAT-5 can be combined to be various band combinations as:

- Image from SPOT-5 is combined in RGB Composite to be RGB: 321 which is beneficial for unsupervised classification,

- Image from LANDSAT-5 is combined in RGB Composite to be RGB: 453 as shown in Figure 3-2.

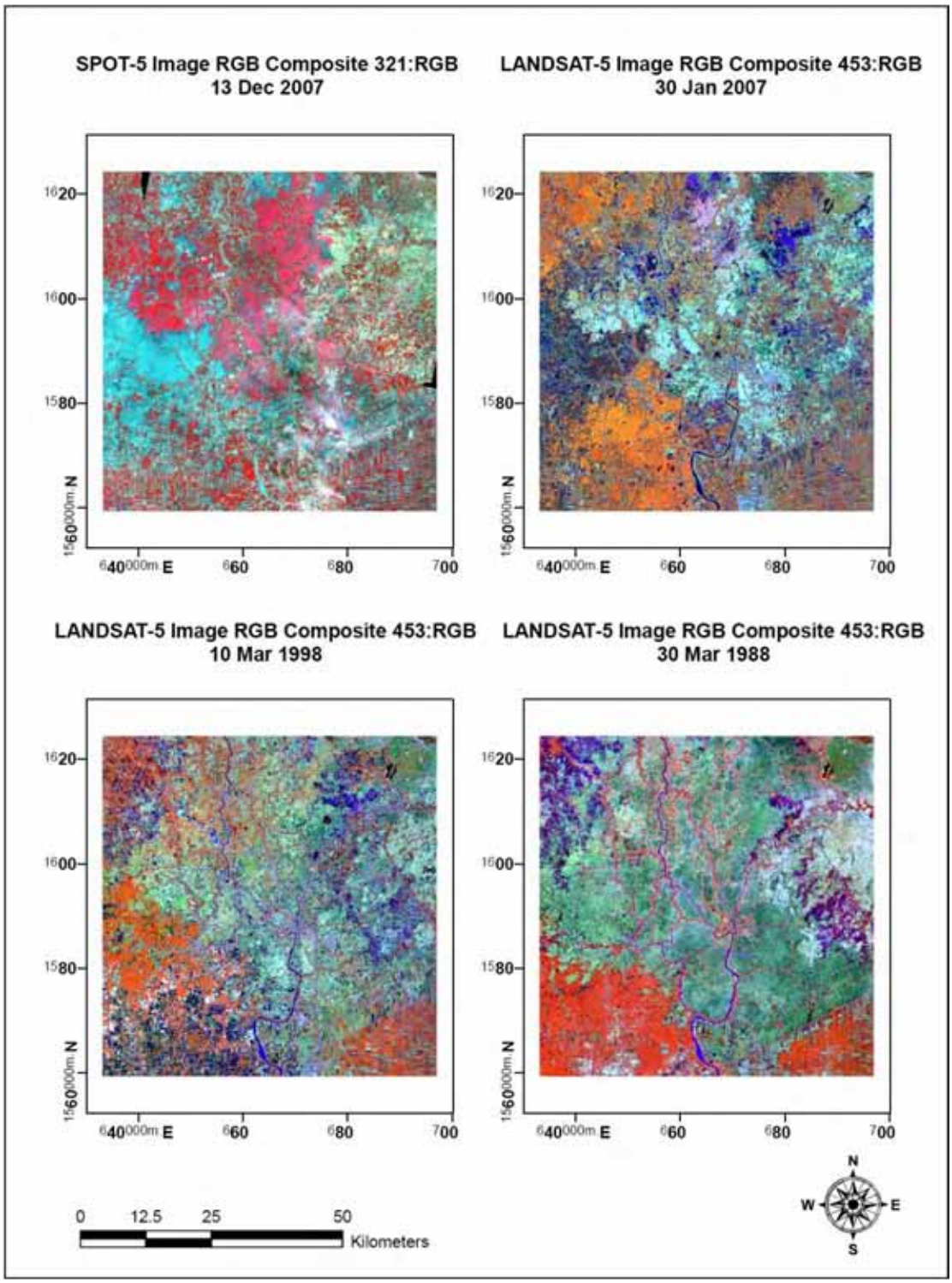


Table 3-6: Images from SPOT-5 and LANDSAT-5 satellites

b.8 Unsupervised Classification

Unsupervised classification is a method for grouping similar data as one through the ISODATA technique. Data grouping must be done through duplication by 10 at a 95 percent consistency of classification. To classify them, Standard Deviation for each level of data is

equal to 1.0, 30 strata of data are set and a program is ordered to classify them. In fact, there are some differences on data in the study area and the land use plan of Land Development Department shows that there are 15 land use types in the province. Thus, the number of data groups is more than the number expected and these groups will be used as additional data for supervised classification in further steps.

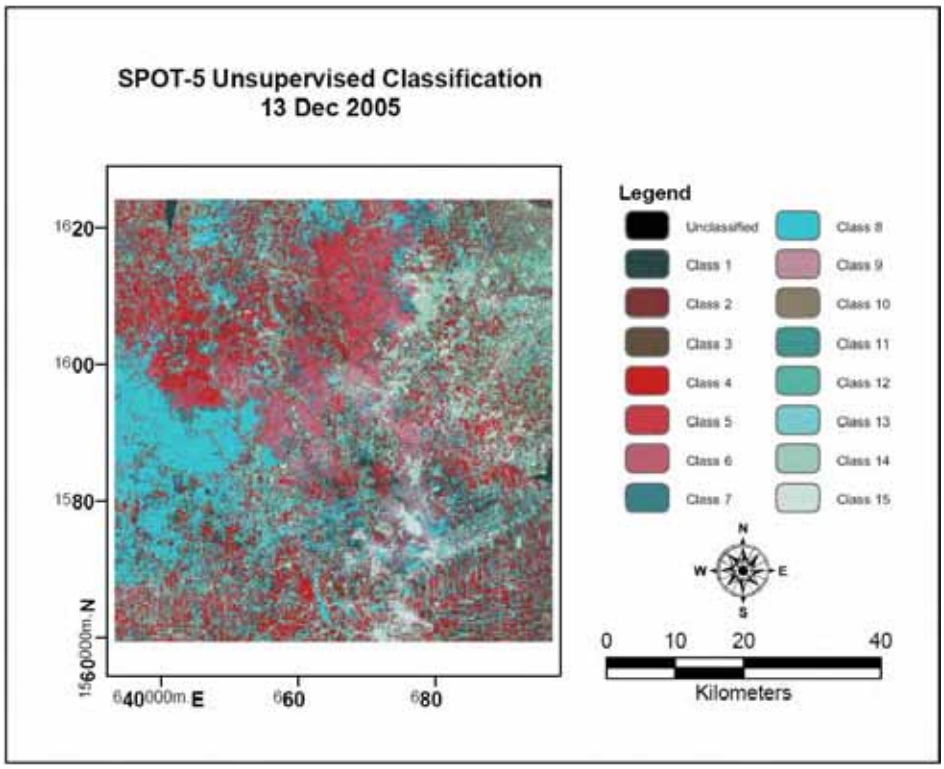


Figure 3-3: SPOT-5 satellite image classified by unsupervised classification

b.9 Field survey

The type of classification is set using the digital number of similar data with emphasis on unsupervised classification and land use classification which has been determined by the Land Development Department.

The field survey aimed to collect data in order to establish an area for training and a test point. The field survey must be based on images classified by unsupervised classification and road information to access the area. Handheld GPS connected with a computer will access the area and survey position, and record all images used to explain field characteristics.

For this study, the field survey was done on September 9, 2007.

b.10 Supervised classification

b.10.1. Training area selection

Selecting the training area is a step for setting the area for each type of data based on its digital number. It means that the digital number of the same data should be combined and

scattered throughout the study/training area. When the training area is selected, statistical calculation is needed for every point and band and in every training area classified by data type in order to clearly separate them.

b.10.2. Spectral evaluation

This step is done as statistical analysis through Min-Max, Mean, Standard deviation, variance and covariance for each type of data in the training area. Spectral Signature evaluation is the next thing done to find the representative value of each data type in order to clarify the types separately. The spectral signature evaluation is analyzed by a Separability Value which is employed for data separation.

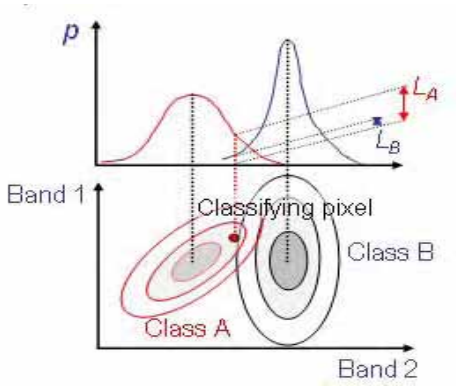
b.10.3. Maximum Likelihood Classification

This step employs the statistical principle obtained from the training area as an indicator for imagery pixel classification. Thus, imagery pixel is always defined as the data of most interest where the longer the distance means less probability. In any case, using the method of maximum likelihood, the Decision Boundary is not clear since the possible area equal to zero covers an infinite range from the mean. Thus, using this method presents no problem in relating to unclassified pixels since every image can be recognized. However, the rule for decision must be followed step by step, as follows:

1) Calculation for possibility value at imagery pixel x , or p(x) is revealed in every class since 1-n

2) Comparing p(x1), p(x2), p(x3)…p(xn) which are obtained from calculation in every class

3) Setting the target imagery pixel in class A if p(YA) is the highest value



L_A is $p(X_A)$ probability where data are classified into Class A

L_B is $p(X_B)$ probability where data are classified into Class B

Figure 3-4: Supervised classification by maximum likelihood classification[1]

[1] Source: Shunji Murai. Maximum Likelihood Method : Basin of Remote Sensing. 2004

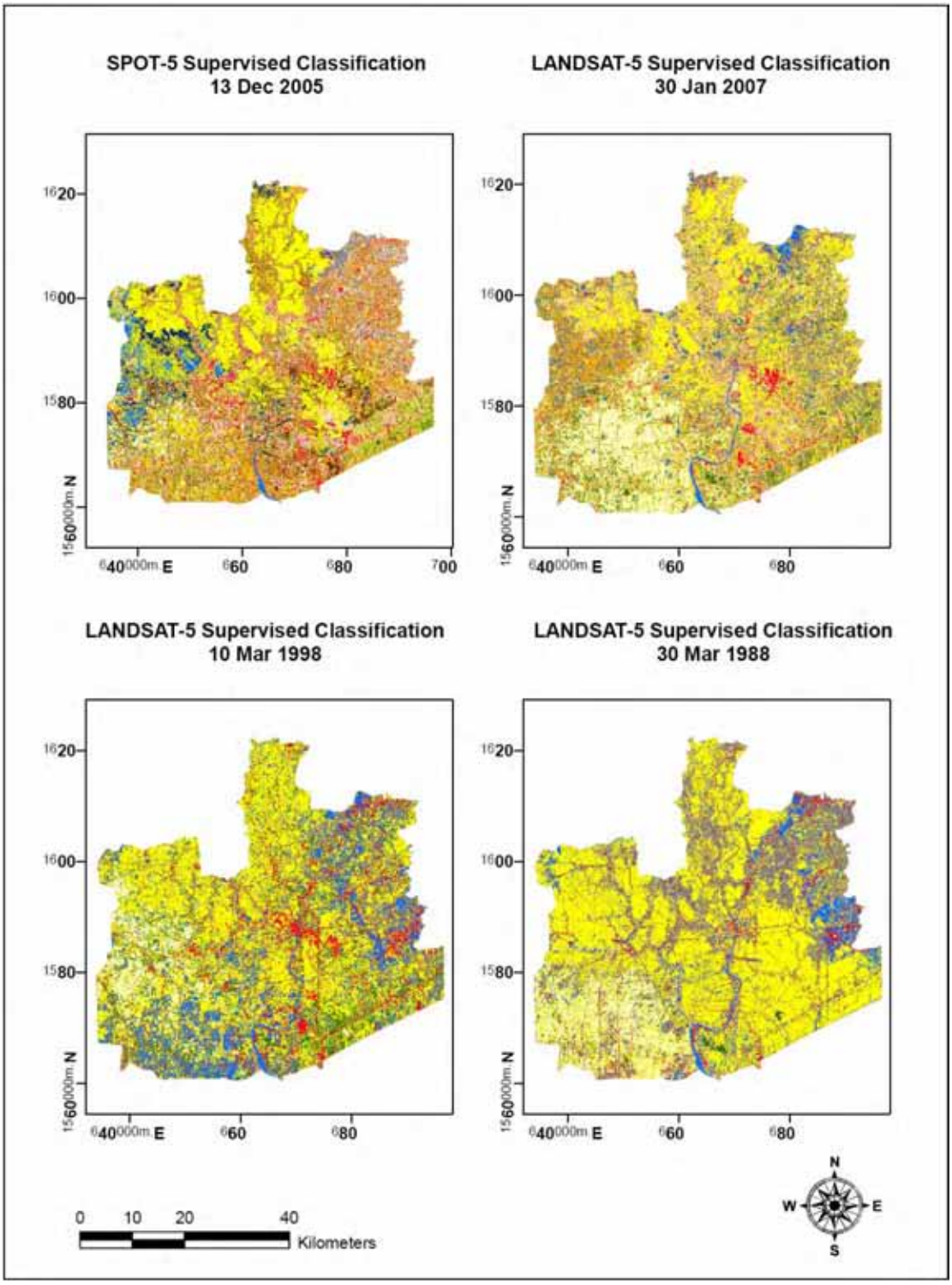


Figure 3-5: SPOT-5 and LANDSAT-5 satellite imagery classified through supervised classification

b.11 Post-classification and Recode image

This step is aimed to delete “noise” and gather the same group of data as well as classify data which are not separated from each other through the computer program. Figure 3-6 shows satellite imagery classified by supervised classification.

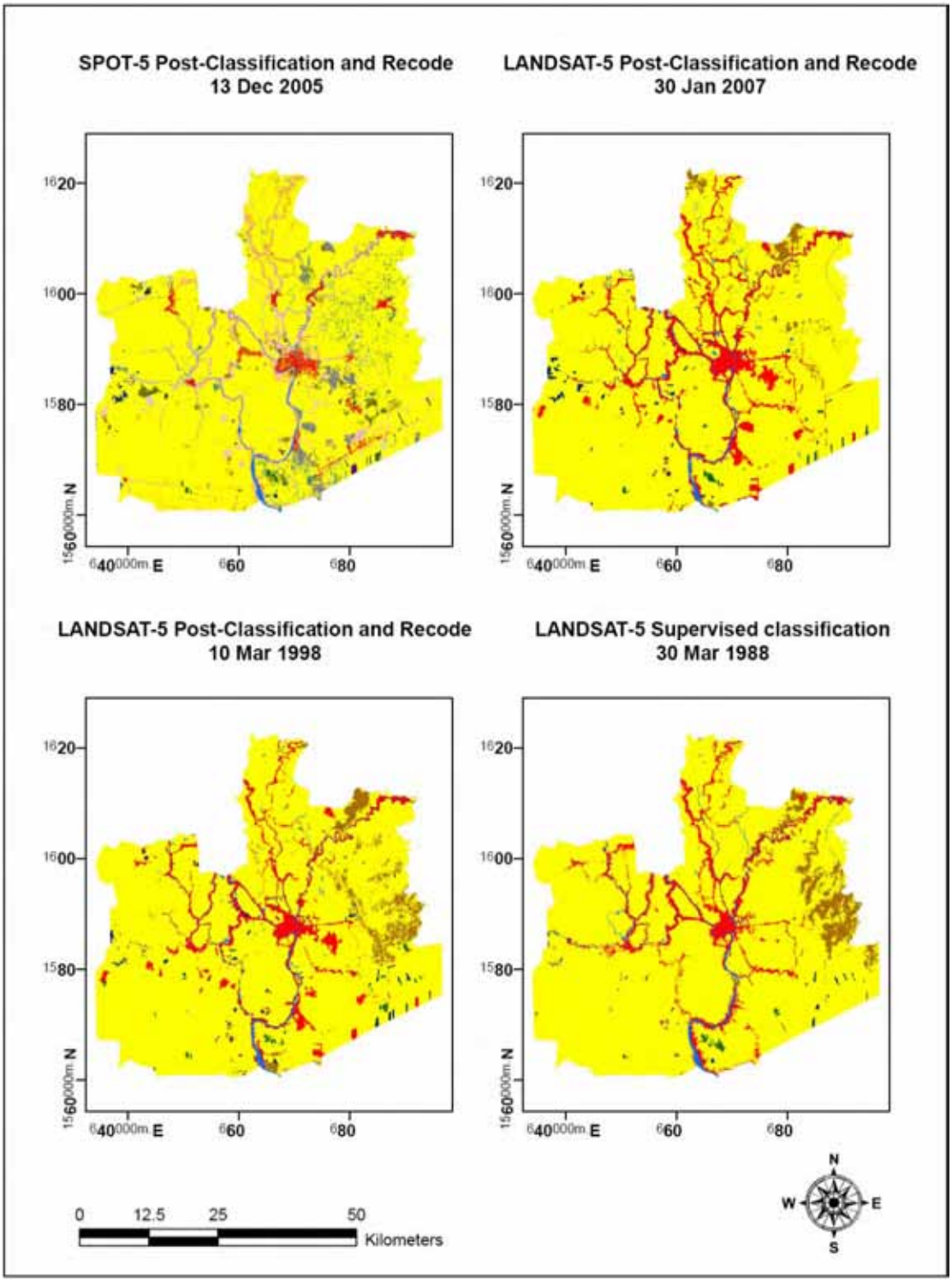
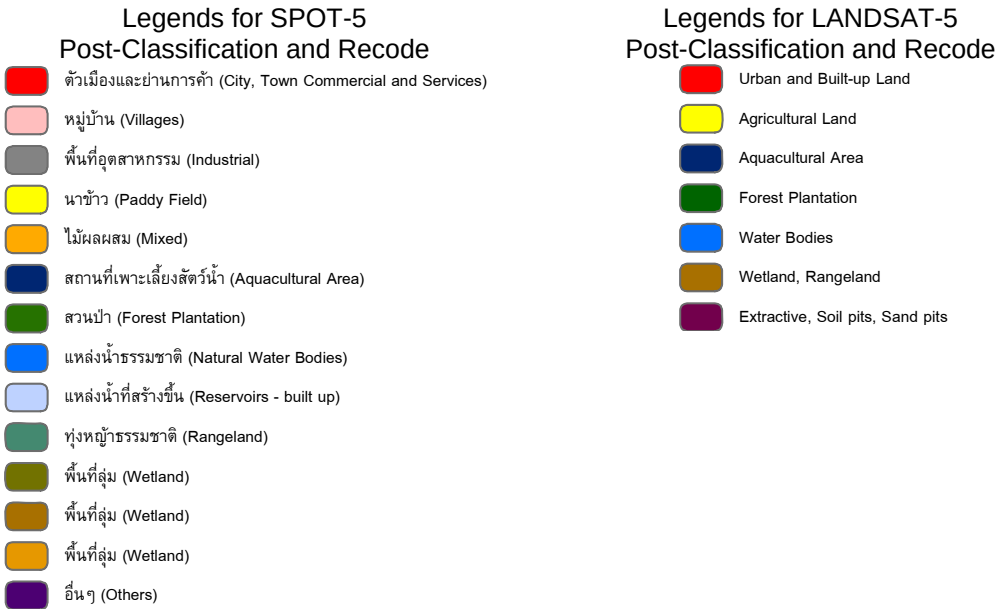


Figure 3-6: SPOT-5 and LANDSAT-5 satellite imagery classified through Post-Classification and Recode



b.12 Summary of methods

The framework shown in Figure 3-7 can be concluded based on the steps and methods shown in satellite imagery processing as shown above.

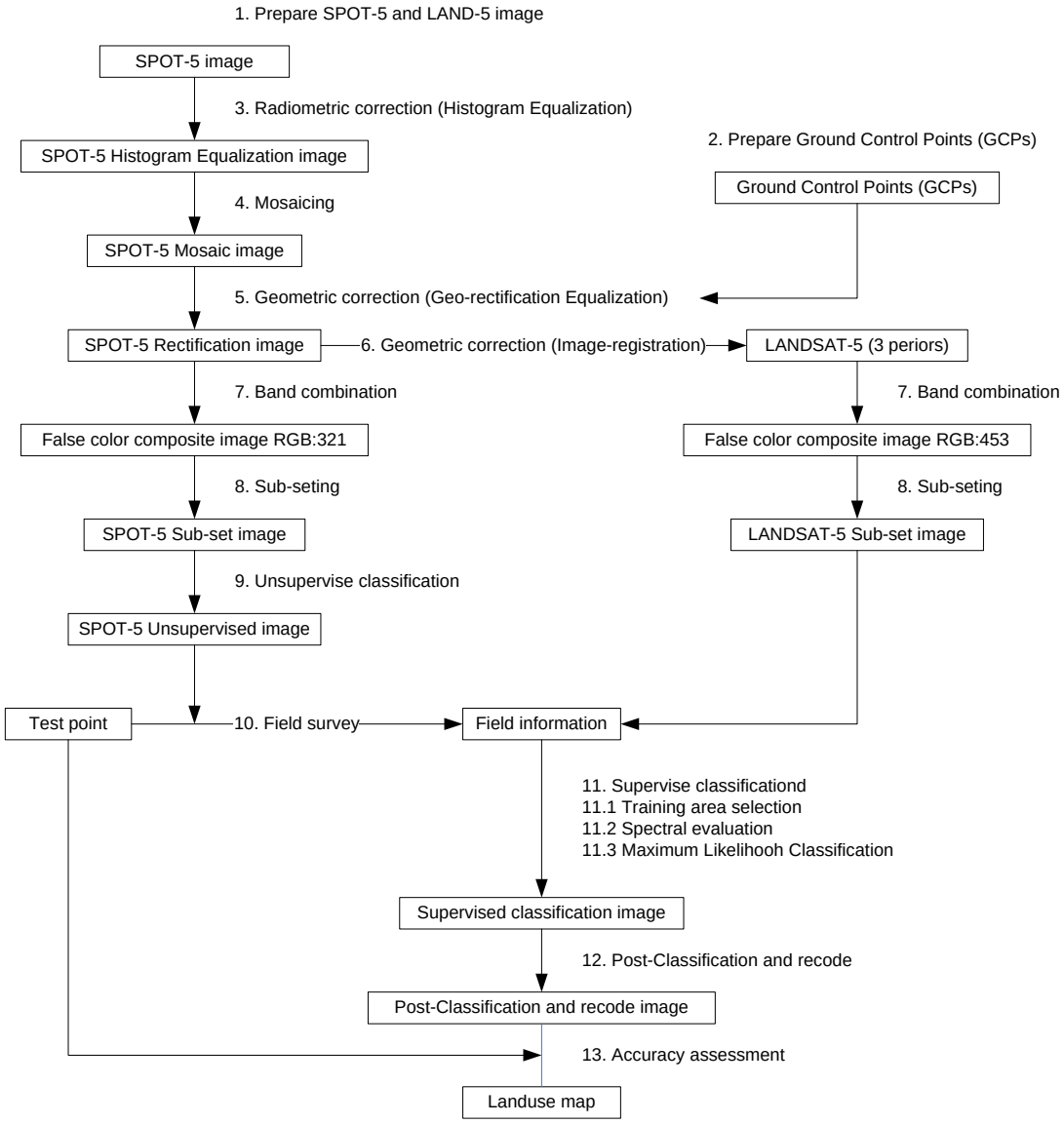


Figure 3-7: Step and method applied for satellite imagery processing

c. Results

c.1 Land use by SPOT-5 satellite imagery interpretation

Satellite imagery was interpreted to provide a land use map (2005) of Phra Nakhon Si Ayutthaya province. Data obtained from pan-sharpened images with resolution 5 m recorded on December 13, 2005 and survey data recorded on September 9, 2007 are shown in detail in Table 3-7 and Figure 3-8.

Table 3-7: Land use by SPOT-5 satellite imagery interpretation in Phra Nakhon Si Ayutthaya province

Land Utilization	Area (sq.km)	percentage
City, Town, Commercial and Services	44.81	1.76
Villages	142.83	5.61
Industrial	41.37	1.62
Paddy Field	2,076.24	81.55
Mixed Plantation	68.95	2.71
Aquaculture Area	12.71	0.50
Green Area	4.36	0.17
Natural Water Bodies	39.12	1.54
Reservoirs – built up	19.71	0.77
Rangeland	47.50	1.87
Wetland	46.50	1.83
Others	1.92	0.08
Total	2,546.00	100.00

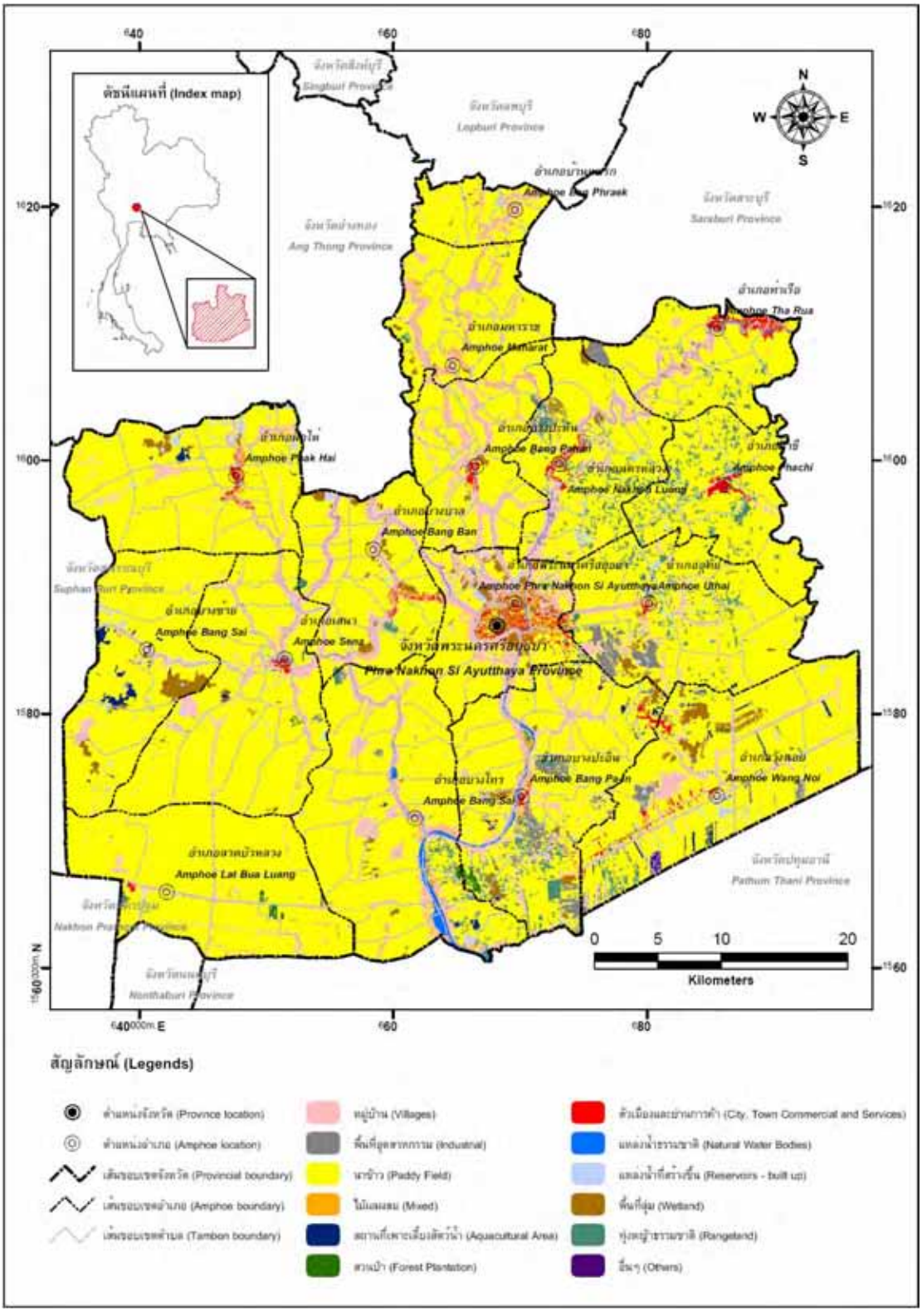


Figure 3-8: Land use map by SPOT-5 satellite imagery interpretation of Phra Nakhon Si Ayutthaya province, recorded on December 13, 2005

c.2 Land use by LANDSAT-5 satellite imagery interpretation

The study of changes in land use in Phra Nakhon Si Ayutthaya province compared with ten and twenty years ago was done through the interpretation of LANDSAT-5 satellite imagery. The land use changes were recorded on January 30, 2007, March 10, 1998 and March 30, 1988 and then interpreted by a computer program. These data were used with field survey data on September 9, 2007, as well as 2000 and 1988 land use maps from the Land Development Department; the details are shown in Table 3-8 and Figure 3-9, Figure 3-10, Figure 3-11.

Table 3-8: Land use by LANDSAT-5 satellite imagery interpretation In Phra Nakhon Si Ayutthaya province

Land use	March 30, 1988		March 10, 1998		January 30, 2007	
	Area (sq. km.)	percent	Area (sq. km.)	percent	Area (sq. km.)	percent
Urban and built up land	170.81	6.7	170.79	6.7	219.18	8.6
Agricultural Land	2,228.39	87.43	2,219.11	87.06	2,222.85	87.21
Aquaculture Area	6.6	0.26	12.38	0.49	14.08	0.55
Forest Plantation	6.07	0.24	8.09	0.32	4.06	0.16
Water body	39.61	1.55	39.39	1.55	42.61	1.67
Wetland, Rangeland	95.99	3.77	91.41	3.59	39.18	1.54
Extractive, Soil pits, Sand pits	1.37	0.05	7.68	0.3	6.88	0.27
Total	2,548.84	100	2,548.84	100	2,548.84	100

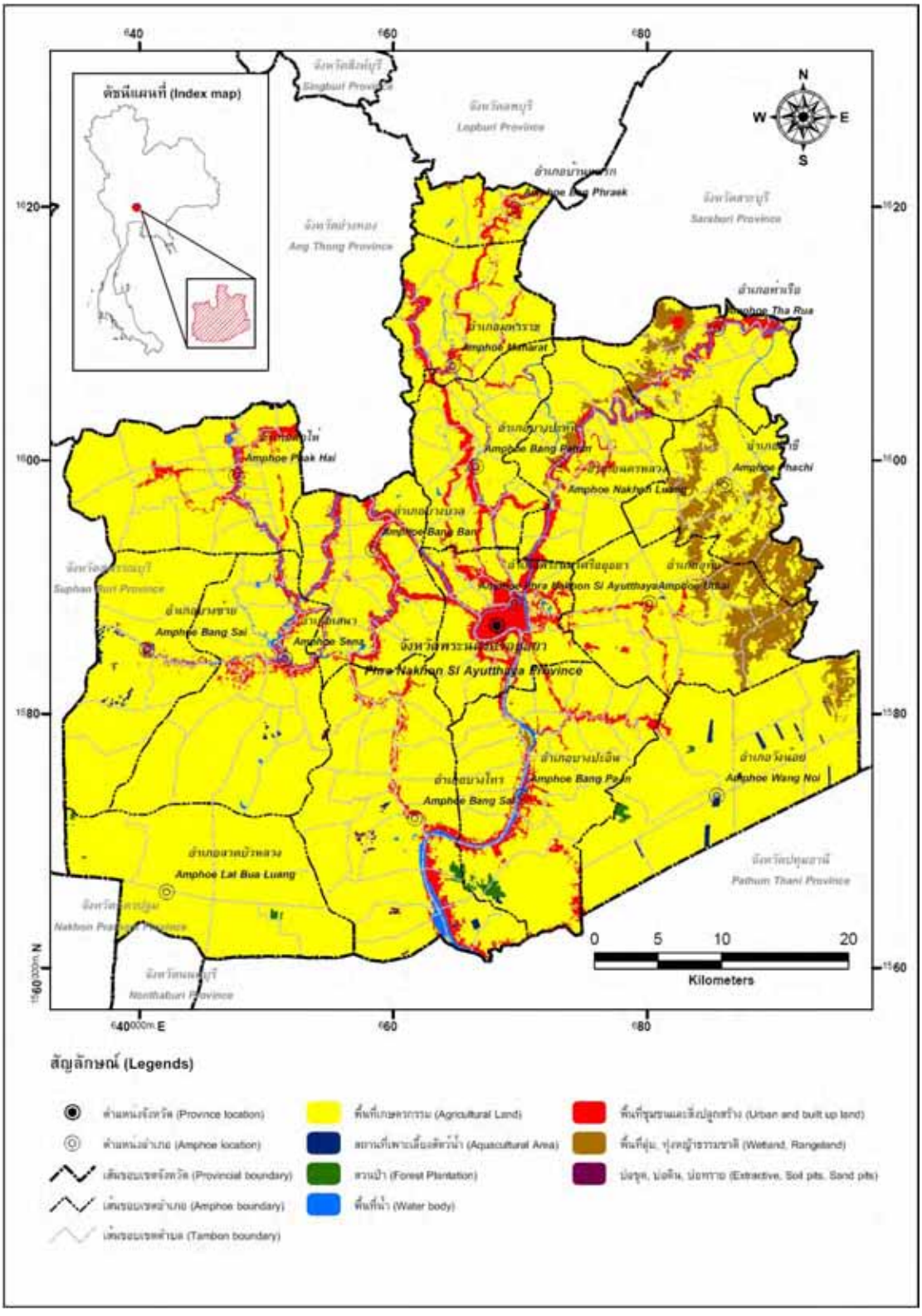


Figure 3-9: Land use map by LANDSAT-5 satellite imagery interpretation, recorded on March 30, 1988 of Phra Nakhon Si Ayutthaya province

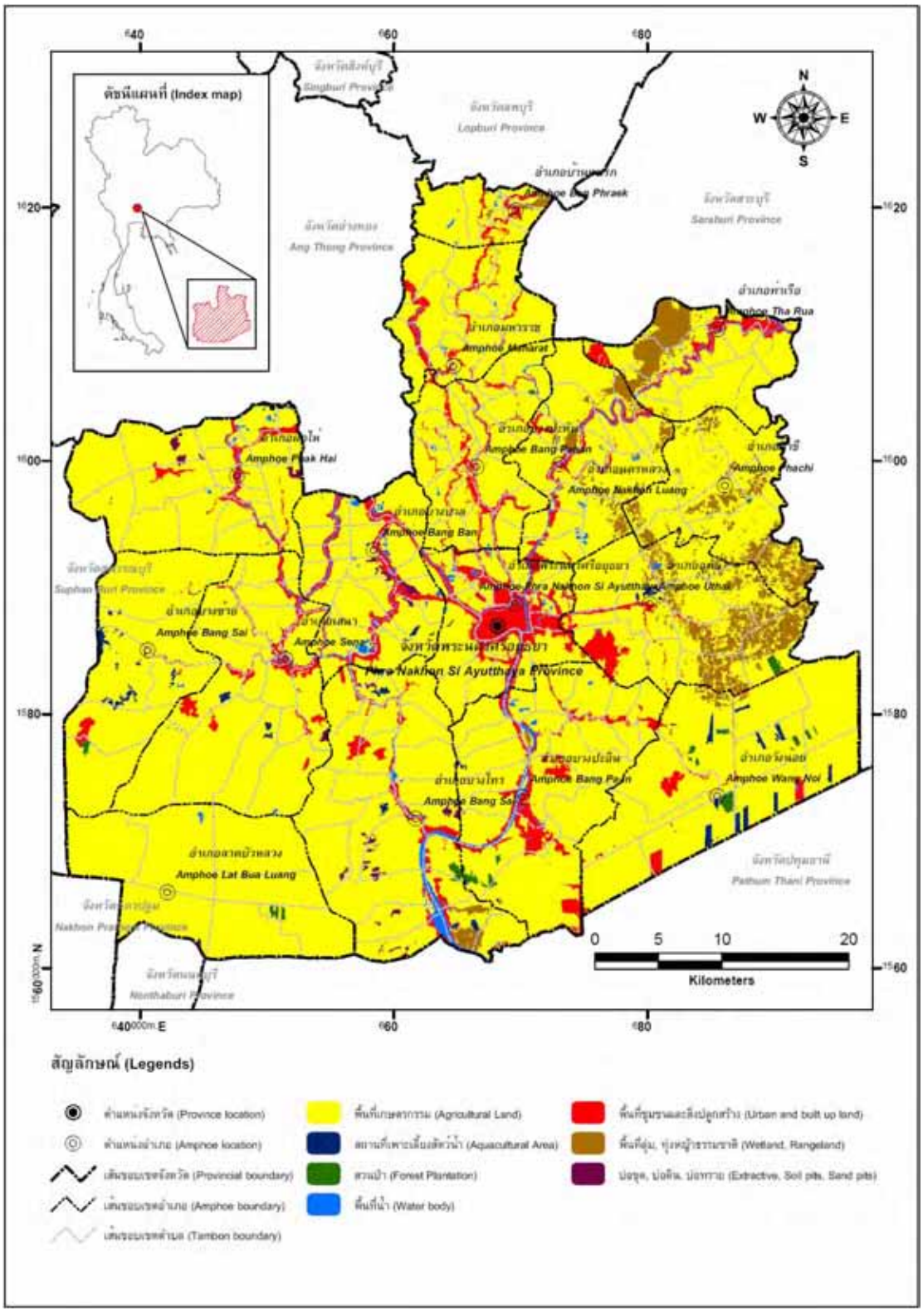


Figure 3-10: Land use map by LANDSAT-5 satellite imagery interpretation, recorded on March 10, 1998 of Phra Nakhon Si Ayutthaya province

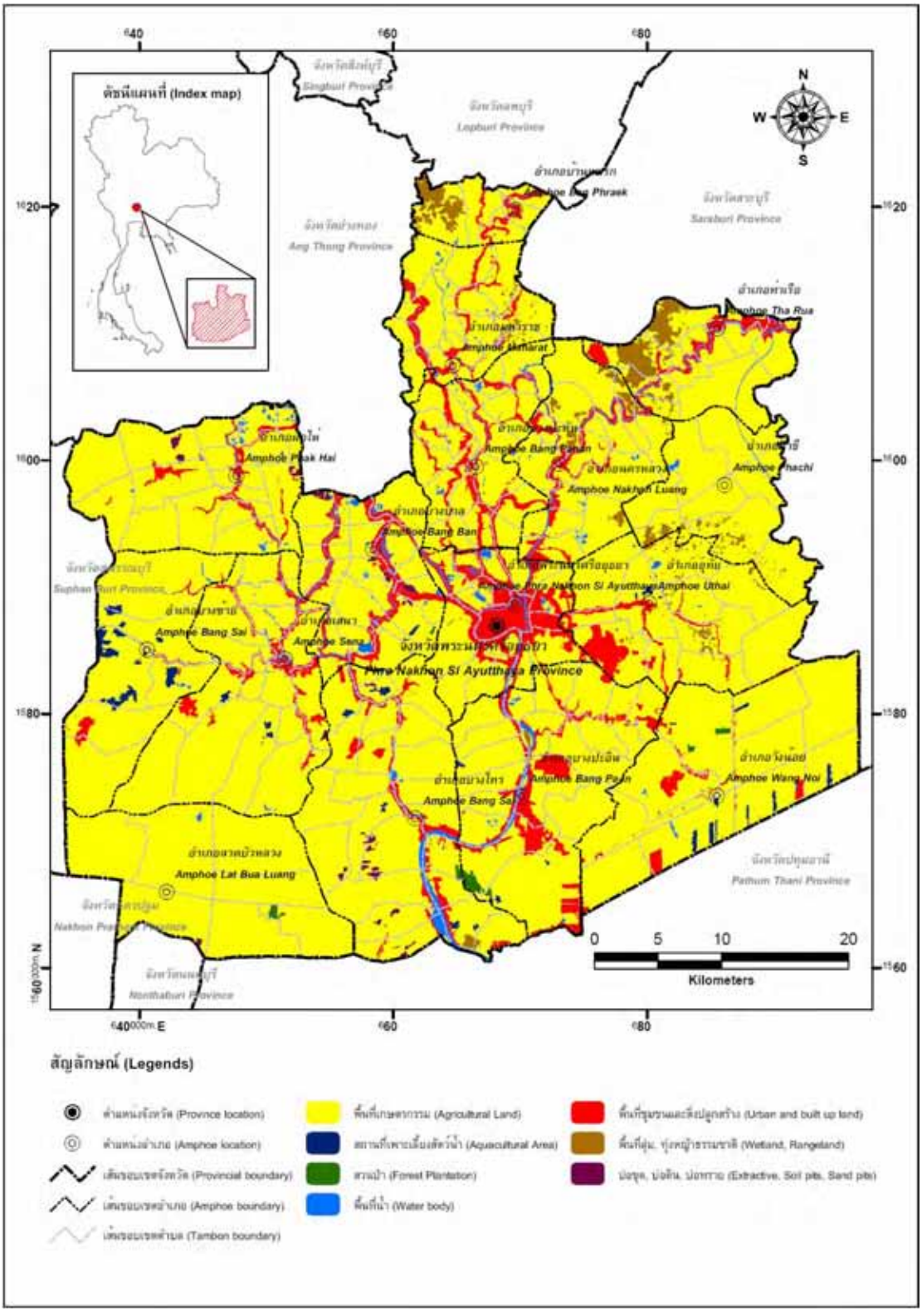


Figure 3-11: Land use map by LANDSAT-5 satellite imagery interpretation, recorded on January 30, 2007 of Phra Nakhon Si Ayutthaya province

d. Findings

Changes in land use in Phra Nakhon Si Ayutthaya province since 1988 to 2007 as shown in Table 3-9.

Table 3-9: Changes in Land Use in Phra Nakhon Si Ayutthaya since 1988 to 2007

Land use	Area (sq.km.)			Percentage (%)		
	1988	1998	2007	1988	1998	2007
Urban and built up land	170.81	170.79	219.18	6.7%	6.7%	8.6%
Agricultural Land	2,228.39	2,219.11	2,222.85	87.4%	87.1%	87.2%
Aquaculture Area	6.60	12.38	14.08	0.3%	0.5%	0.6%
Forest Plantation	6.07	8.09	4.06	0.2%	0.3%	0.2%
Water body	39.61	39.39	42.61	1.6%	1.5%	1.7%
Wetland/Rangeland	95.99	91.41	39.18	3.8%	3.6%	1.5%
Extractive (soil pits/sand pits)	1.37	7.68	6.88	0.1%	0.3%	0.3%
Total	2,548.84	2,548.84	2,548.84	100%	100%	100%

1) Urban and Built up land

There is no increase between 1988 and 1998, but a significant increase was observed since 1998 with around 50 km^2 converted to urban and built up areas in the last 10 years. According to the land use map, development of industrial estates was the main factor of this increase.

2) Agricultural Land

This is the most prevalent use of land in Ayutthaya Province with over 87% used for agricultural purposes. There has been no change in the percentage from 1988 to the present.

3) Aquaculture Area

The area doubled from 1988 to 1998 and new aquaculture land was developed near the border with Pathum Thani Province. There has been a slight increase from 1998 to 2007, but the percentage of aquaculture land use in the whole province is less than 1 percent.

4) Forest Plantation

There is a very small forest area in Ayutthaya Province of merely 0.2 to 0.3% of the whole province. Among this area, the largest forest plantation area is located in Amphoe Bang Sai. Furthermore, a decrease is marked with half the forest area of 1998 seen in 2007.

5) Water body

There is not much change observed for this area.

6) Wetland and Rangeland

There is a significant change from 1998 to 2007 and the area decreased to less than half. According to the land use map in 1988, there were big wet lands in Amphoe Phachi and Uthai but the area was largely reduced and converted to agricultural land.

7) Extraction

There is a large increase between 1988 and 1998 though it has been stable from 1998 to 2007. A pit was dug for the supply of construction materials.

3.2.2 Samut Songkhram

a. Terms of References for the Development of Land Use Map using Satellite Image

a.1 Objective

Satellite images were used to develop Land Use Maps for conditions 20 years ago, 10 years ago and current conditions in order to grasp the change of environmental conditions such as vegetation, and so on.

a.2 Study Area (Model Province)

Samut Songkhram Province: around 20 km × 20 km (include the wet land)

a.3 Scope and Contents of the Work

1) Change of land use: 20 years ago, 10 years ago, and current

LANDSAT-5 data for current conditions (2007), 10 years ago (1997), and 20 years ago (1987) were used for developing land use maps. In case data for the exact year were not available, data of the previous year were used. Type of land use is as follows.

- Urban and Built-up Land
- Agricultural Land
- Forest Land
- Water Bodies
- Others

For Samut Songkhram, Mangrove and wet land area shall be differentiated.

2) Development of Detailed Current Land use Map

Detailed current land use maps were developed using SPOT-5 satellite data (2007) using the same methods of implementation as above. Satellite Data: SPOT-5, Pan-sharpened image with resolution 5 m, Ortho-rectified, UTM Projection. Type of Land Use: As follows

Table 3-10: Type of land use for detailed current land use map

Category	Code Number	Land use
Urban and Built-up Land	U01	City, Town, Commercial and Services
	U02	Villages
	U03	Institutional
	U04	Transportation, Communication and Utilities
	U05	Industrial
	U06	Others
Agricultural Land	A01	Paddy Field
	A02	Field Crops

	A03	Perennial
	A04	Orchards
	A05	Horticultural
	A06	Swidden Cultivation
	A07	Pasture and Farmhouse
	A08	Aquatic Plant
	A09	Aquacultural Plants
	A10	Integrated Farming
Forest Land	F01	Evergreen Forest
	F02	Deciduous Forest
	F03	Forest Plantation
	F04	Agro forestry
	F05	Mangrove
Water Bodies	W01	Natural Water Bodies
	W02	Reservoirs (Built up)
Miscellaneous Land	M01	Rangeland
	M02	Wetland
	M03	Extractive
	M04	Others

a.4 Outcome

1) Change of land use （LANDSAT-5 data）

- Three land use maps (1:50,000) of Samut Songkhram province in a GIS vector format and the area of each land use type.

- Trend analysis of land use changes according to the dates of the satellite data in Samut Songkhram Province.

- Processed Digital LANDSAT-5 data of Samut Songkhram province at 1:50,000 scale.

2) Detailed Current Land Use Map (SPOT-5)

- Two land use maps (1:50,000) of Samut Songkhram province in a GIS vector format from the SPOT-5 data in year 2007.

- Processed digital SPOT-5 data of Samut Songkhram province at 1:50,000 scale.

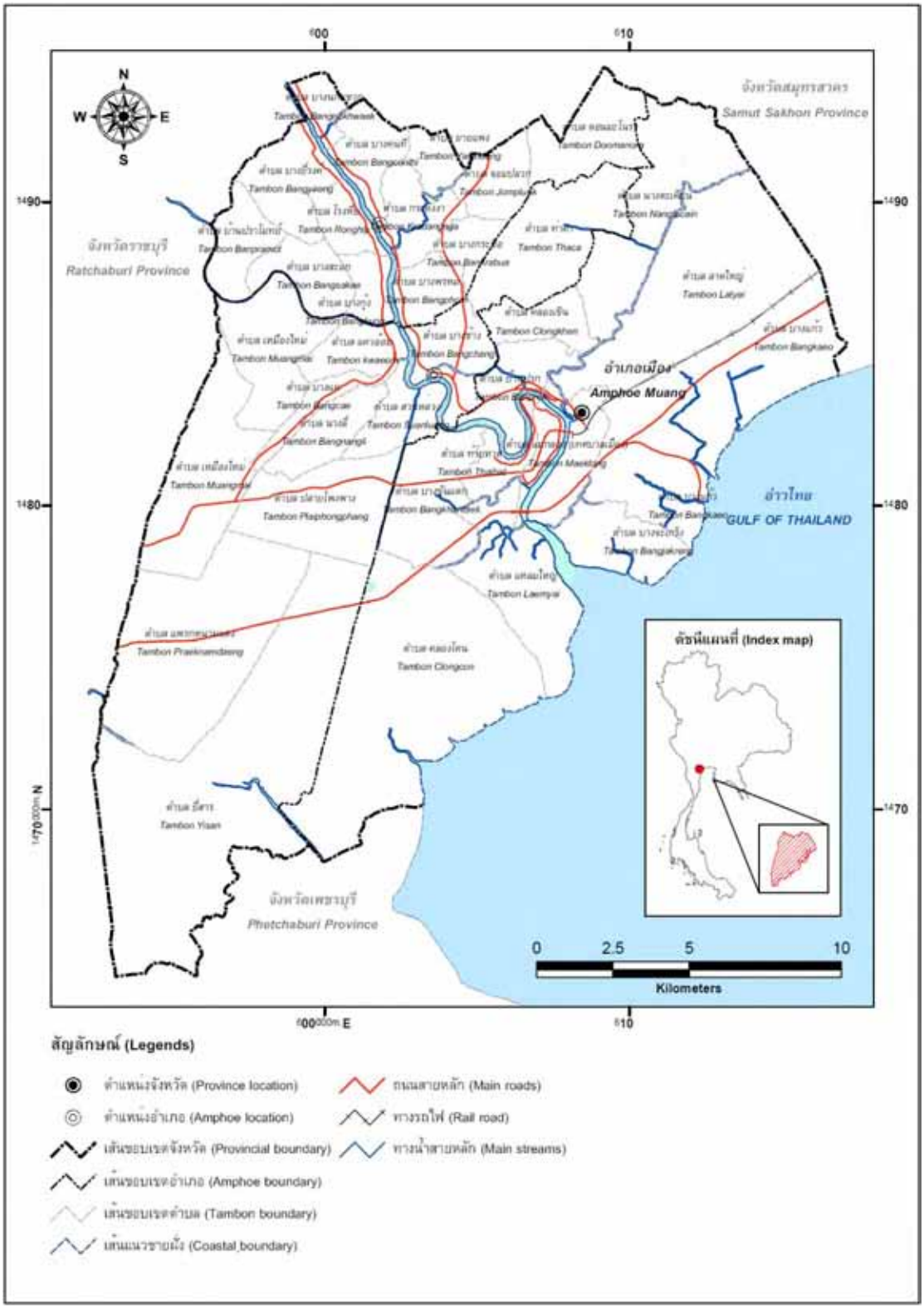


Figure 3-12: Study Area: Samut Songkhram Province

b. Satellite Imagery Processing

Satellite imagery processing for Samut Songkhram province is composed of the following steps:

b.1 SPOT-5 and LANDSAT-5 satellite imagery preparation

Satellite imagery of Samut Songkhram province is obtained from Geo-Informatics and Space Technology Development Agency (Public Organization). The complete imageries are selected according to the actual dates needed for study as;

1) SPOT-5 satellite imagery recorded in March 30, 2007 in Green wave [Band 1], Red wave [Band 2], NIR wave [Band3] and SWIR wave [Band 4]

2) LANDSAT-5 satellite imagery recorded in February 15, 2007, January 2, 1997 ,and March 30,1988 at path 129 , row 50 in Green wave (Band2), Red wave (Band3), NIR wave (Band4) and SWIR wave (Band5)

All satellite imageries have to be recorded in ".img" format of ERDAS IMAGINE software

b.2 Ground Control points: GCPs

The satellite imagery from SPOT-5 employed for this study is level 2A which was already adjusted its geometric system error through data of distance, angle and surface of WG584 without employing GCPS. Geographic model at high level over Ellipsoid is employed as a reference in order to generate SPOT-5 satellite imagery being near to coordinates with the reference coordinate. This will lead to more a precise study especially on the coordinate of the study area in the earth under UTM on WGS 84. The relationship between coordinate system of satellite imagery and real coordinate on the earth is explained through a mathematical model. For this method, coordinate searching from ground center is needed through color author map on scale of 1:25,000 which is rigid on one meter position and two meter vertical. Data on the position are needed for the calculation of the polynomial model.

Good and proper selection for ground control points will help the imagery adjustment be smoother with less error from reference data. The ground control point can be found through the model as:

$$N = \frac{(t+1)(t+2)}{2}$$

When N is number of ground control points

t is degree of Polynomial model

The study area in Samut Songkhram province is mainly composed of a flat plain with no extreme diversification. Thus, the degree of the model is equal to 1 and the ground control points can be calculated through the equation 1.1 as

$$\text{Number of ground control points} = (1+1)(1+2)/2$$
$$= 3$$

Theoretically, there are three ground control points needed for the province, but in practical terms enough ground control points should be provided to calculate the parameters in polynomial model. Thus, this study set 10 points as the ground control points for the province.

b.3 Radiometric correction

Radiometric correction is a method to correct the error occurrence from reflection of satellite imagery through the Histogram Equalization method. This correction aims to generate clearer imagery.

b.4 Geometric correction

b.4.1. SPOT- 5 satellite imageries

Geometric correction for SPOT-5 satellite imageries is aimed to correct and adjust satellite imageries to be in accordance with in their terrestrial reference coordinates. The study area is flat plain with no difference in geographical position, so Polynomial Degree 1 is employed to calculate the Polynomial Degree 1 model in Samut Songkhram Province by providing five points of coordinate value obtained from ground control points. These five points are scattered on the imagery. When a position has been changed, digital number must be changed accordingly and one more round of calculation is needed. Thus, grey data on the imagery must be corrected using the Nearest Neighbor Interpolation method. This method offers one strong point of being able to maintain the digital number closely before and after correction without any effect to the digital number obtained from the satellite data.

b.4.2. LANDSAT-5 satellite imageries

Geometric correction for LANDSAT-5 satellite imageries is done because of the imageries obtained from LANDSAT-5 satellite are 1G systematic correction images which have already been corrected but are not yet complete. The 1G systematic corrections is done by employing approximate value of satellite orbit parameter to be reference coordinate under UTM. Technical data shows that the position obtained from 1G imagery level has 5-8 points of error or 150-250 meters which need to be corrected. Thus, LANDSAT-5 satellite imageries need to be corrected in order to generate the closer coordinate with SPOT-5 satellite imageries through Image Registration. This registration has to employ Polynomial Degree 1 to transform the coordinate system of SPOT-5 satellite to LANDSAT-5 by 9 control points scattered throughout the images and then grey color of satellite imageries will be adjusted by Nearest Neighbor Interpolation.

b.5 Sub-setting images

Sub-setting images are done for both images obtained from SPOT-5 and LANDSAT-5 in order to cut off the areas out of Samut Songkhram province.

b.6 Band combination

Bands from SPOT-5 and from LANDSAT-5 can be combined to be various band combinations as,

- Image from SPOT-5 is combined in RGB Composite to be RGB: 321 which is beneficial for unsupervised classification

- Image from LANDSAT-5 is combined in RGB Composite to be RGB: 453 as shown in Figure 3-13

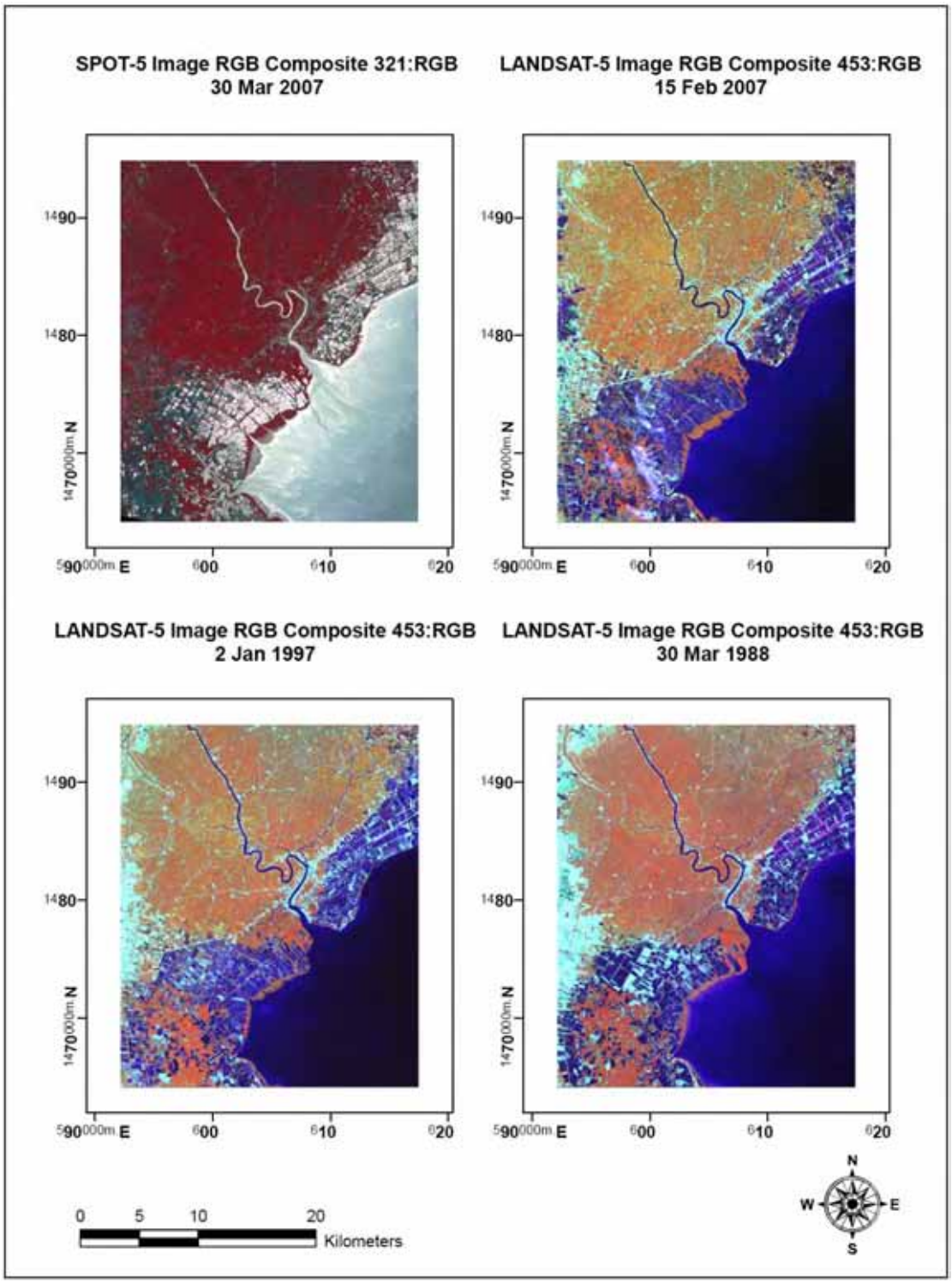


Figure 3-13: Images from SPOT-5 and LANDSAT-5 satellites

b.7 Unsupervised classification

Unsupervised classification is a method for grouping similar data as one through the ISODATA technique. Data grouping must be done through duplication by 10 at a 95 percent consistency of classification. Standard Deviation for each level of data is equal to 1.0 and 30 strata of data are set and program is ordered to classify them. In fact, there are some differences on data in the study area and land use plan of the Land Development Department shows that there are 15 land use types in the province. Thus, the number of data groups is more than expected and these groups will be used as additional data for supervised classification in further steps.

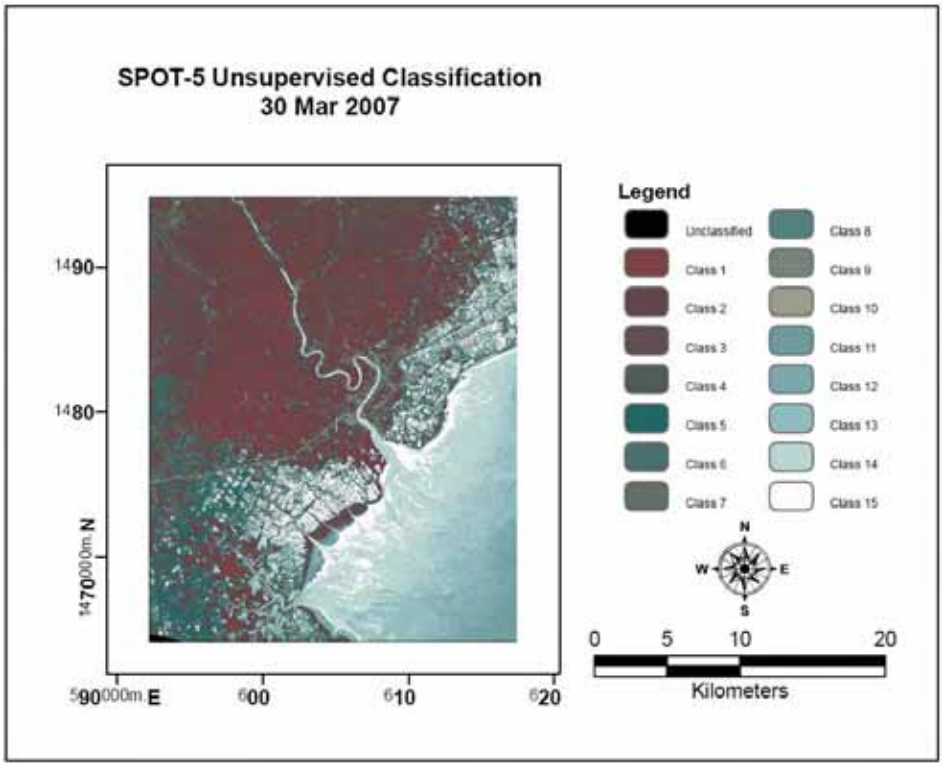


Figure 3-14: SPOT-5 satellite image classified by unsupervised classification

b.8 Field survey

The type of classification is set using the digital number of similar data with emphasis on unsupervised classification and land use classification which has been determined by the Land Development Department.

The field survey aimed to collect data in order to establish an area for training and a test point. The field survey must be based on images classified by unsupervised classification and road information to access the area. Handheld GPS connected with a computer will access the area and survey position, and record all images used to explain field characteristics.

For this study, the field survey is done on September 8, 2007.

b.9 Supervised classification

b.9.1. Training area selection

Selecting the training area is a step for setting the area for each type of data based on its digital number. It means that the digital number of the same data should be combined and scattered throughout the study/training area. When the training area is selected, statistical calculation is needed for every point and band and in every training area classified by data type in order to clearly separate them.

b.9.2. Spectral evaluation

This step is done as statistical analysis through Min-Max, Mean, Standard deviation, variance and covariance for each type of data in the training area. Spectral Signature evaluation is the next thing done to find the representative value of each data type in order to clarify the types separately. The spectral signature evaluation is analyzed by a Separability Value which is employed for data separation.

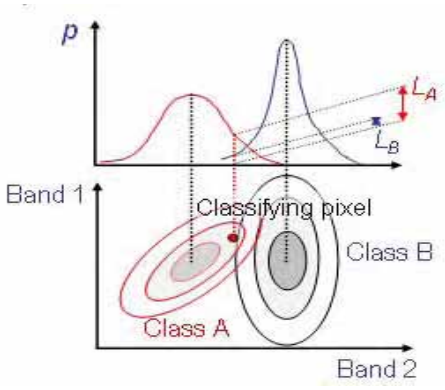
b.9.3. Maximum Likelihood Classification

This step employs the statistical principle obtained from the training area as an indicator for imagery pixel classification. Thus, imagery pixel is always defined as the data of most interest where the longer the distance means less probability. In any case, using the method of maximum likelihood, the Decision Boundary is not clear since the possible area equal to zero covers an infinite range from the mean. Thus, using this method presents no problem in relating to unclassified pixels since every image can be recognized. However, the rule for decision must be followed step by step, as follows:

1) Calculation for possibility value at imagery pixel x , or p(x) is revealed in every class since 1-n

2) Comparing p(x1), p(x2), p(x3)…p(xn) which are obtained from calculation in every class

3) Setting the target imagery pixel in class A if p(YA) is the highest value



L_A is $p(X_A)$ probability where data are classified into Class A

L_B is $p(X_B)$ probability where data are classified into Class B

Figure 3-15: Supervised Classification by Maximum Likelihood Classification[2]

[2] Source: Shunji Murai. Maximum Likelihood Method : Basin of Remote Sensing. 2004

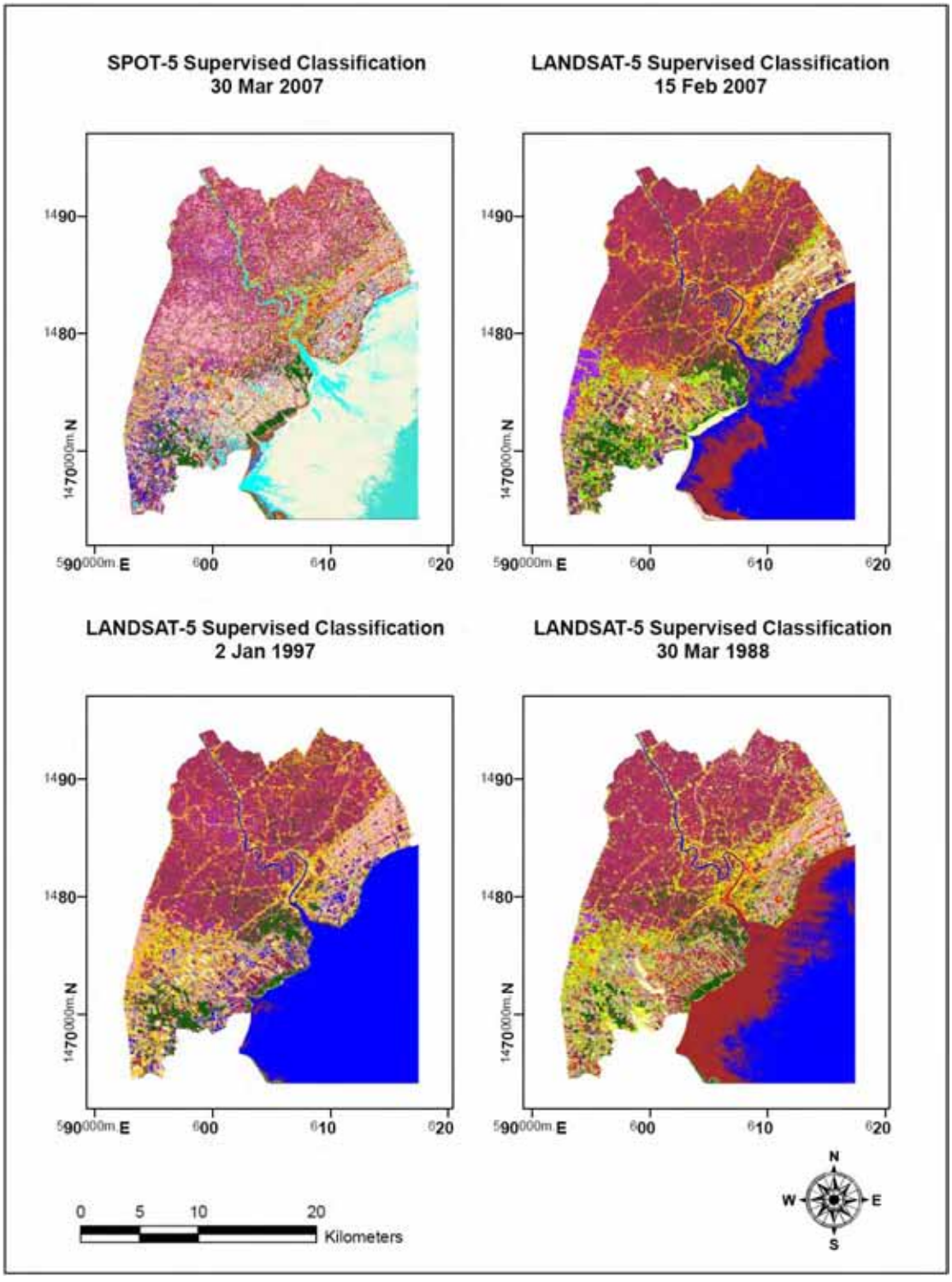
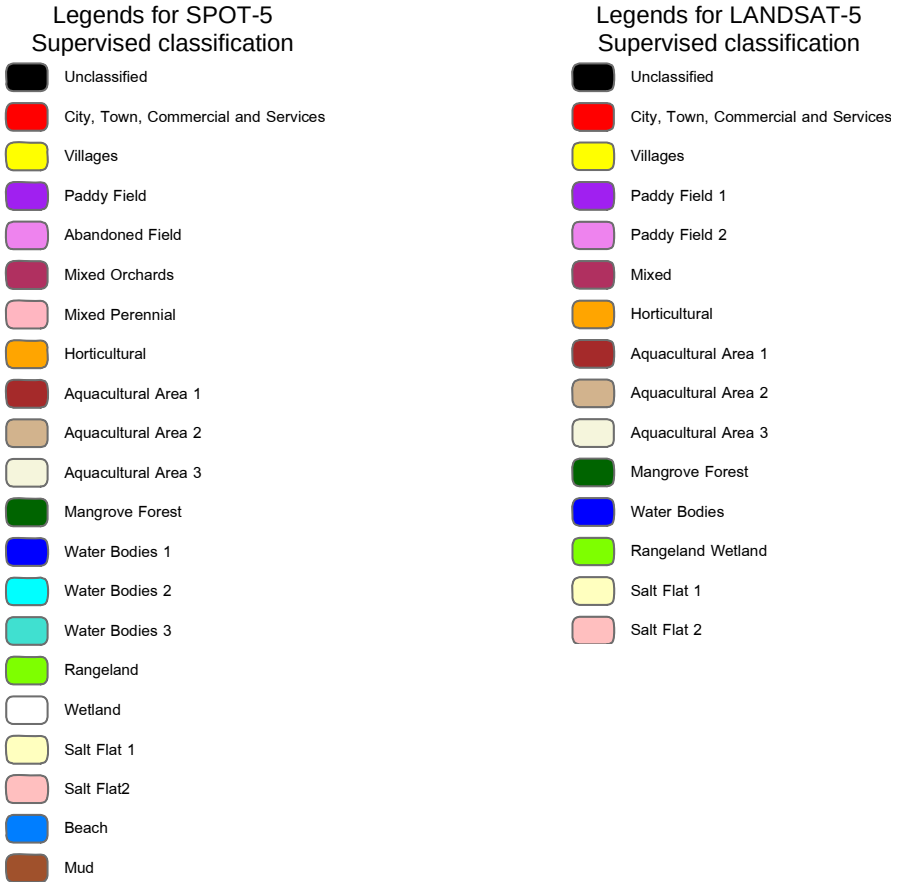


Figure 3-16: SPOT-5 and LANDSAT-5 satellite imagery classified through Supervised Classification



b.10 Post-classification and Recode image

This step is aimed to delete “noise” and gather data of the same groups as well as classify data which are not separated from each other through the computer program. Figure 3-17 shows satellite imagery classified by supervised classification.

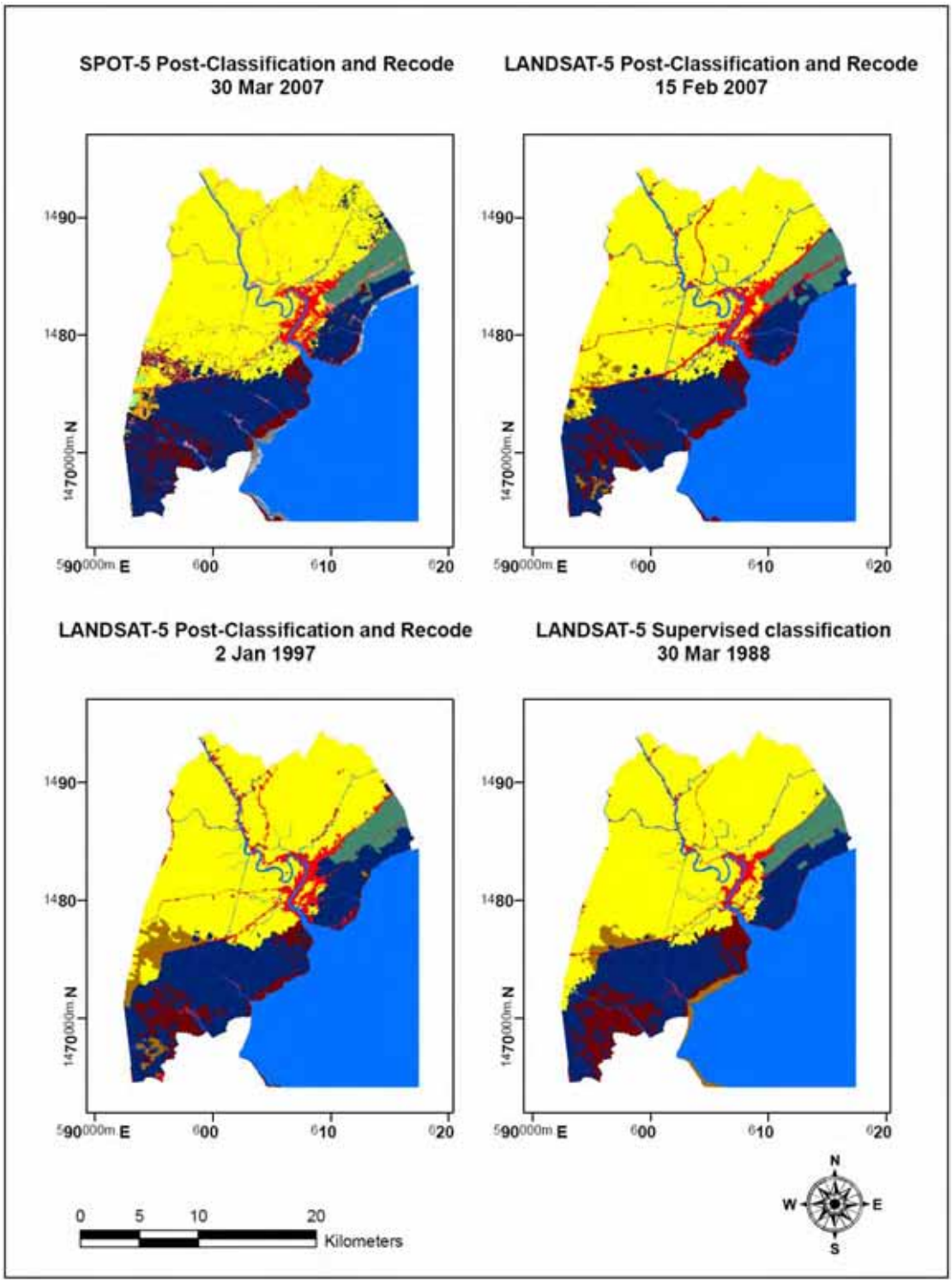
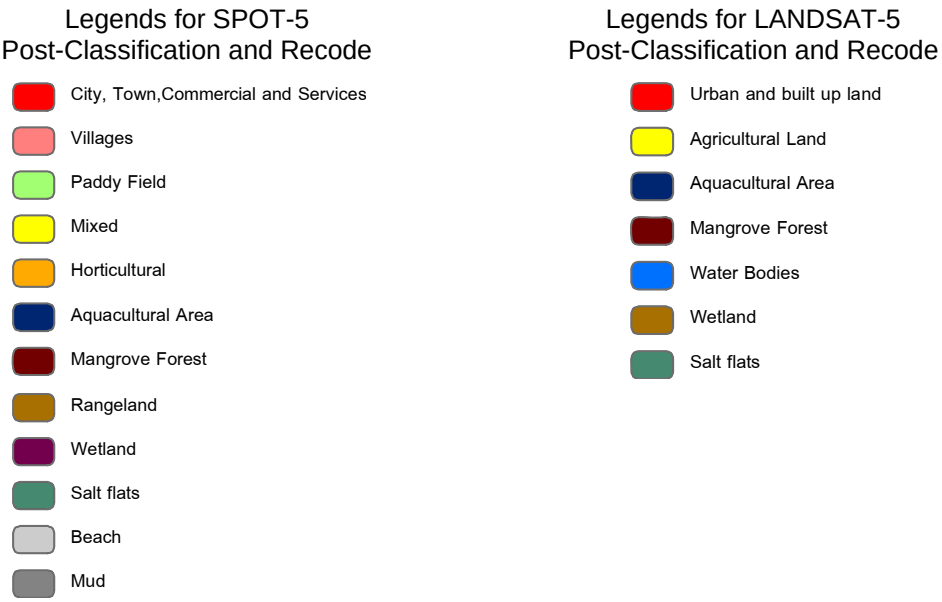


Figure 3-17: SPOT-5 and LANDSAT-5 satellite imagery classified through Post-Classification and Recode



b.11 Summary of methods

The framework shown in Figure 3-18 can be concluded based on the steps and methods shown in satellite imagery processing as shown above.

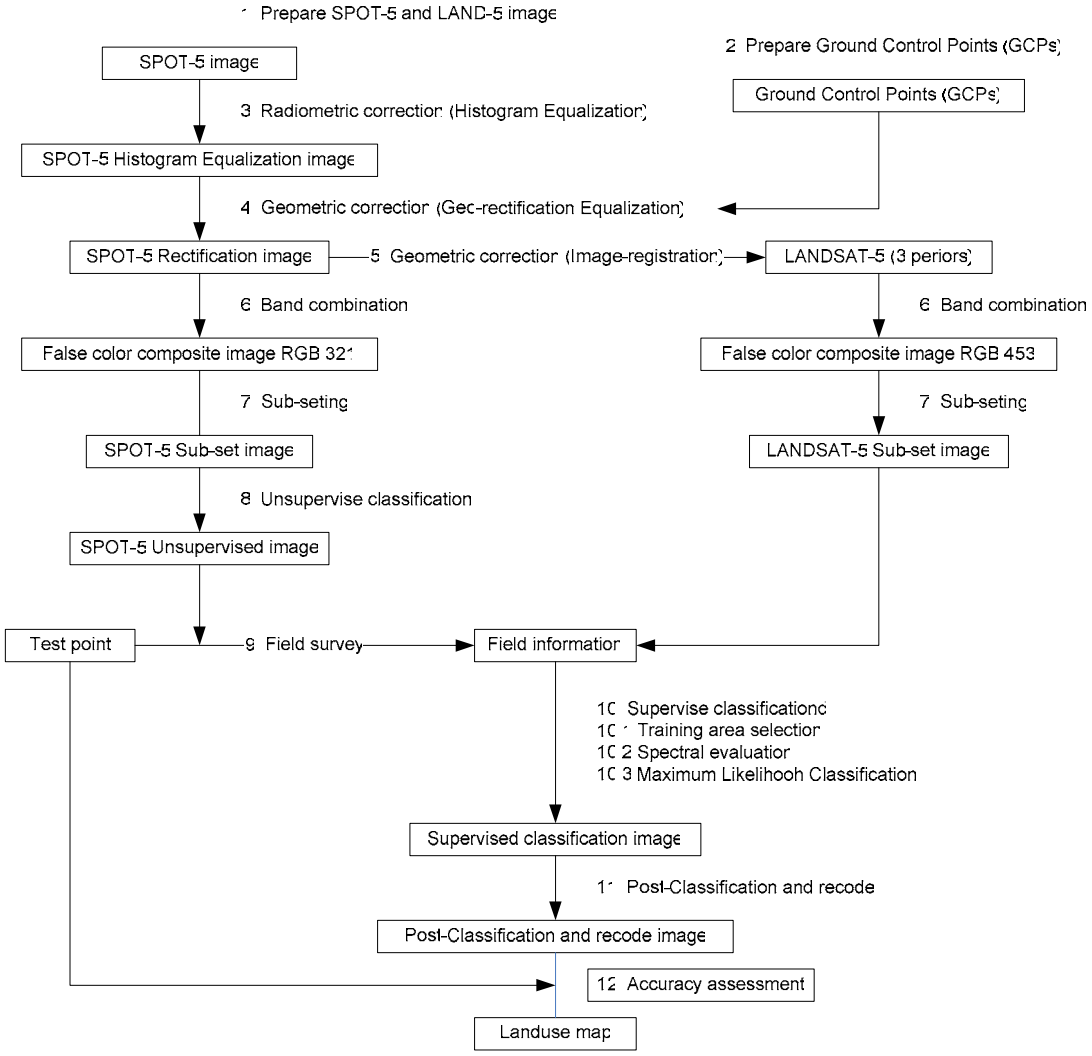


Figure 3-18: Step and method applied for satellite imagery processing

c. Results

c.1 Land use by SPOT-5 satellite imagery interpretation

Satellite imagery interpretation is employed to provide land use map (2007) of Samut Songkhram province. Data obtained from pan-sharpened image with resolution 5 m recorded on March 30, 2007 and survey data recorded on September 8, 2007 are shown in detail in Table 3-11 and Figure 3-19.

Table 3-11: Land use by SPOT-5 satellite imagery interpretation in Samut Songkhram province

Land Utilization	Area (sq. km.)	percentage
City, Town, Commercial and Services	11.79	2.84
Villages	8.22	1.98
Paddy Field	1.45	0.35
Mixed	213.94	51.48
Horticultural	5.45	1.31
Aquaculture Area	107.64	25.90
Mangrove Forest	26.30	6.33
Natural Water Bodies	9.83	2.36
Reservoirs (built-up)	0.38	0.09
Rangeland	2.72	0.65
Wetland	6.02	1.45
Salt flats	17.87	4.30
Beach, Mud	3.95	0.95
Total	415.56	100.00

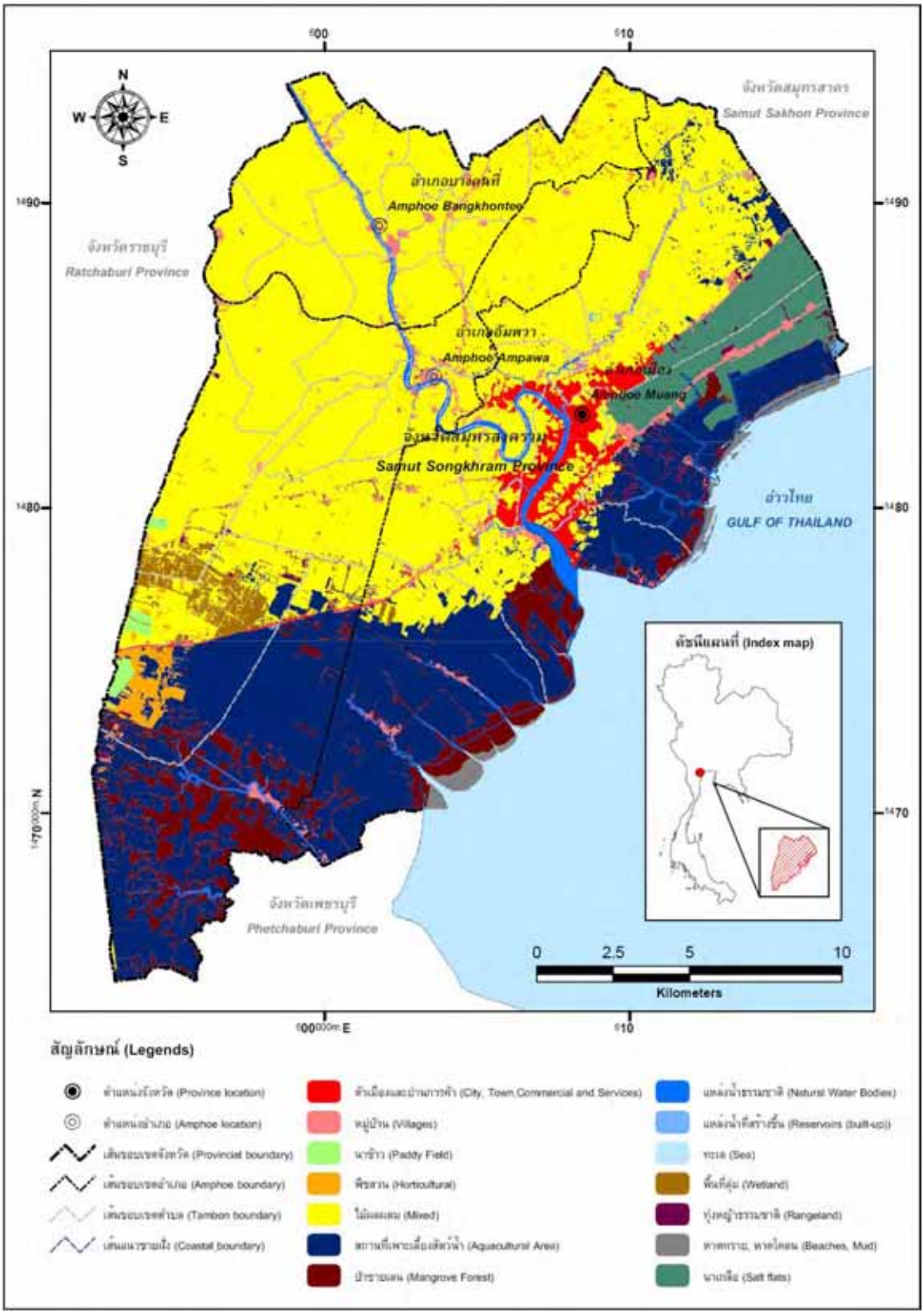


Figure 3-19: Land use map by SPOT-5 satellite imagery interpretation of Samut Songkhram province, recorded on March 30, 2007

c.2 Land use by LANDSAT-5 satellite imagery interpretation

The study of land use changes in Samut Songkhram province in ten and twenty years ago were done by LANDSAT-5 satellite imagery interpretation. The land use changes were recorded on February 15, 2007, January 2, 1997 and March 30, 1988 and then they were interpreted by a computer program. These data were used with field survey data on September 8, 2007 and 2001 and 1988 land use maps of Land Development Department. Details are shown in Table 3-12 and Figure 3-20, Figure 3-21, and Figure 3-22.

Table 3-12: Land use by LANDSAT-5 satellite imagery interpretation In Samut Songkhram province

Land use	March 30, 1988		January 2, 1997		February 15, 2007	
	Area (sq. km.)	percent	Area (sq. km.)	percent	Area (sq. km.)	percent
Urban and built up land	12.09	2.93	21.85	5.33	22.14	5.37
Agricultural Land	235.08	56.97	220.48	53.75	223.98	54.37
Aquaculture Area	95.38	23.11	104.32	25.43	100.6	24.42
Mangrove Forest	34.20	8.29	23.15	5.64	26.97	6.55
Water body	9.84	2.38	9.87	2.41	12.64	3.07
Wetland	8.77	2.13	14.93	3.64	6.2	1.50
Salt flats	17.30	4.19	15.61	3.81	19.45	4.72
Total	412.66	100	410.21	100.00	411.98	100

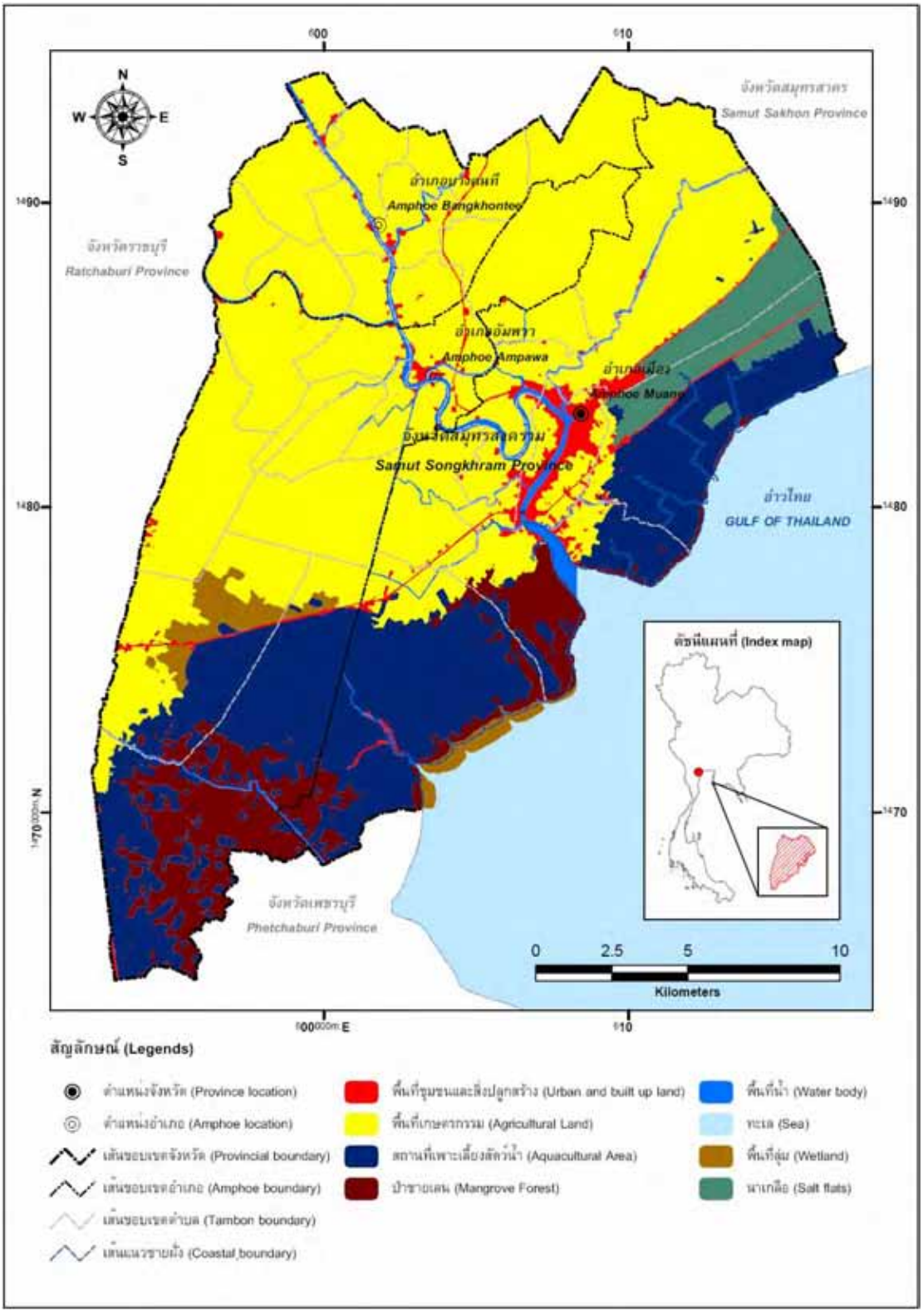


Figure 3-20: Land use map by LANDSAT-5 satellite imagery interpretation, recorded on March 30, 1988 of Samut Songkhram province

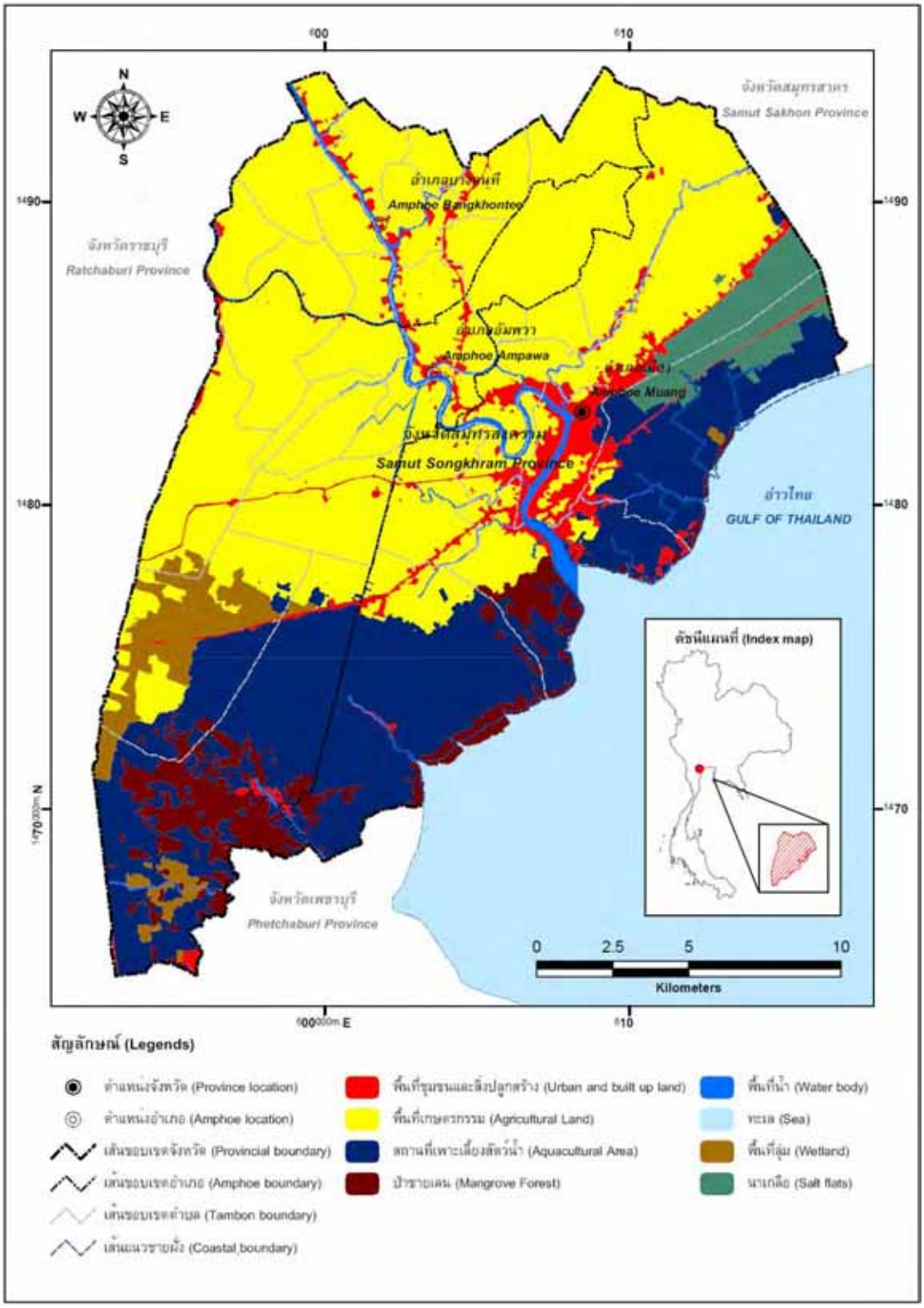


Figure 3-21: Land use map by LANDSAT-5 satellite imagery interpretation, recorded on January 2, 1997 of Samut Songkhram province

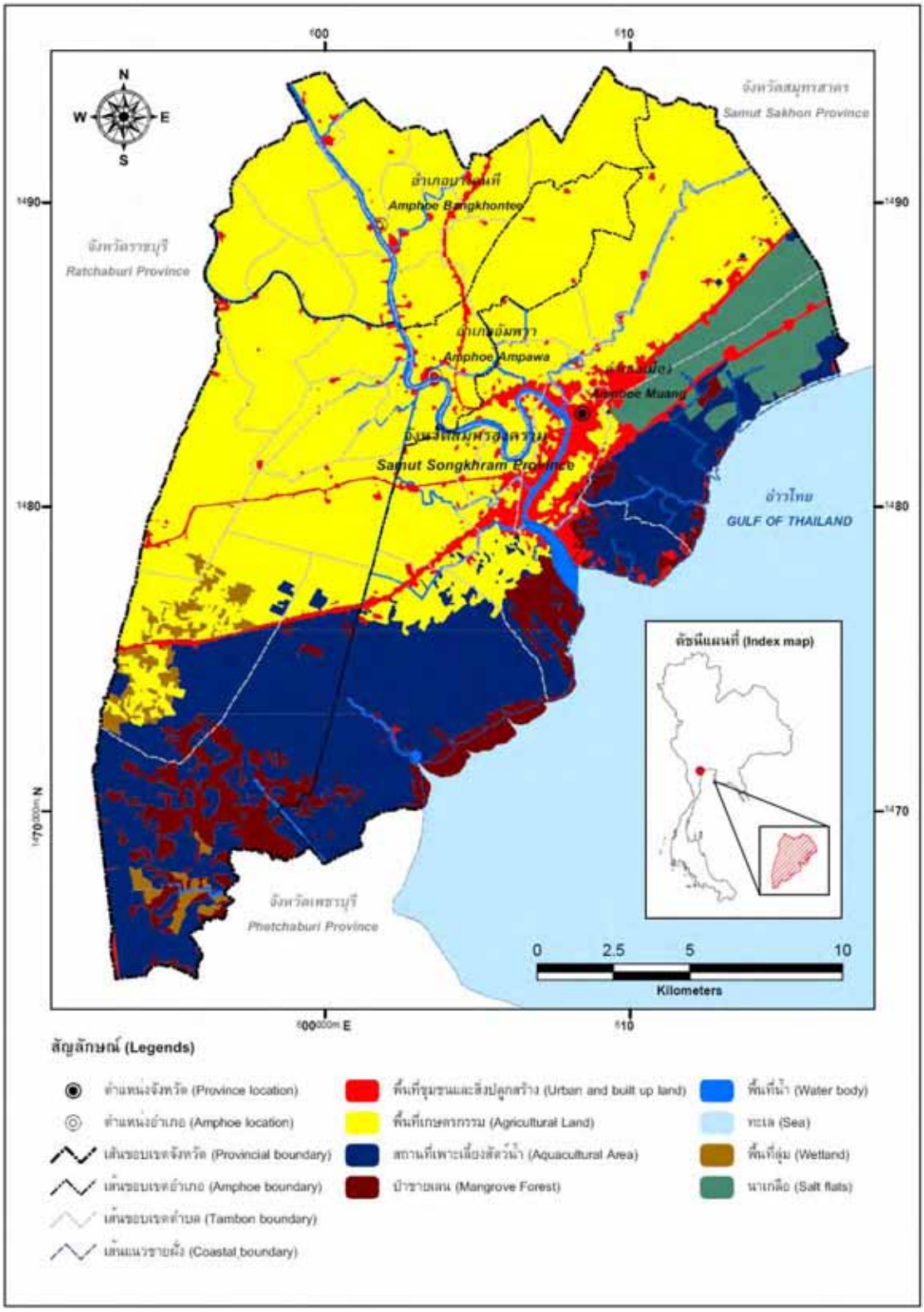


Figure 3-22: Land use map by LANDSAT-5 satellite imagery interpretation, recorded on February 15, 2007 of Samut Songkhram province

d. Findings

The trend of land use change in Samut Songkhram province from 1988 to 2007 is shown in Table 3-13.

Table 3-13: Trend of Land Use Change in Samut Songkhram since 1988 to 2007

Land use	Area (km2.)			Percent		
	1988	1997	2007	1988	1997	2007
Urban and built up land	12.09	21.85	22.14	2.9%	5.3%	5.4%
Agricultural Land	235.08	220.48	223.98	57.0%	53.4%	54.3%
Aquaculture Area	95.38	104.32	100.6	23.1%	25.3%	24.4%
Mangrove Forest	34.2	23.15	26.97	8.3%	5.6%	6.5%
Water body	9.84	9.87	12.64	2.4%	2.4%	3.1%
Wetland	8.77	14.93	6.2	2.1%	3.6%	1.5%
Salt flats	17.3	15.61	19.45	4.2%	3.8%	4.7%
Total	412.64	410.22	411.98	100%	99.4%	99.8%

1) Urban and Built up land

There was a significant increase from 1988 to 1997 and nearly 10 km^2 of land was converted to urban and built up land. Since then, the area did not change significantly. Urban and built up land are mainly located along the Maeklong river and main road.

2) Agricultural Land

More than half of the land is used for agricultural purposes. The percent decreased between 1988 and 1997, but increased slightly from 1997 to 2007. Most of the land is used for planting coconut trees and some fruit trees.

3) Aquaculture Area

The land along the coast from the coast line to around 3 km inland is used mainly as aquaculture area. The area slightly increased from 1988 to 1997 but it has been slightly decreasing from 1997 to 2007.

4) Mangrove Forest

Mangrove forest decreased from 1988 to 1997 mainly due to conversion into aquaculture areas. After 1997, however, the area has been increasing due to various campaigns and planting activities to protect Mangrove forest.

5) Water body and wetland

Water bodies increased from 1997 to 2007. Hence, wetland areas decreased significantly from 1997 to 2007. According to the land use map, the wetlands in the south-west located in Amphoe Ampawa has obviously decreased.

6) Salt Flats

The area of salt flats decreased between 1988 and 1997, but since then the area is increasing and expanding towards the coast.

7) Coastal Erosion

According to the total area of the province, costal erosion decreased between 1988 and 1997, but has increased from 1997 to 2007. Therefore, it can be read from land use map, coastal erosion is being mitigated in this province.

3.3 Improvement of GIS database

3.3.1 Terms of Reference for Improvement of GIS database

Improvement of GIS database was carried out by the local consultant with the guidance provided by the JICA Study Team. The following are the TOR for improvement of the GIS database.

a. Work Objective

In this operation we will facilitate the joint ownership of environmental data for Ayutthaya and Samut Songkhram Provinces in order to increase its utility value as a tool when deciding upon a provincial environmental quality management plan. The current GIS Database (DEQP GIS D/B) will be used as a basis to acquire and enter the latest data for existing layers, and also recreate layers to construct an improved Environmental GIS D/B.

b. Target Areas for Work

Ayutthaya (AYP) : approx. 50km x 50km
Samut Songkhram (SKP) : approx. 20km x 20km

c. Content and Scope of Work

c.1 Division of Roles for Related Organizations

When the environmental GIS database is constructed, the following roles have been assigned for those concerned with the project work:

ONEP: Communication coordination with relevant organizations, as well as acquisition and provision of the latest data,

Study Team: Review required materials and provide data that has already been obtained,

Subcontractor: Gather/enter specified data, acquire location data using GPS, and construct environmental GIS database.

c.2 Method of Execution for Work

The Ministry of Natural Resources and Environment, Department of Environmental Quality Promotion DEQP GIS D/B constructed in 2002 will be used as the basis to construct an Environmental GIS D/B (PEQMP GIS D/B). Currently, the data entered in the DEQP D/B for Ayutthaya Province is from 2004, and that for Samut Songkhram is from 2001, so it is necessary to provide updates with new data from the required items in order to formulate a provincial environmental quality management plan.

The Study Team has reviewed the content of the DEQP GIS D/B and analyzed the layers considered necessary for formulating a provincial environmental quality management plan and those layers that will be necessary for reconstruction. The following table has been arranged to show whether the data in each layer will require updating.

Table 3-14: Improvement Work for GIS data base

Existing /New	DEQP Code	Layer	Update/ New Layer	Work
Existing	D-01	Air Quality	Yes	New Layer + New Data

.

	D-02	Amphoe	No	Coordinate Conversion
	D-03	Aquifers	No	ditto
	D-04	Aspect	No	ditto
	D-05	Drainage Basins	No	ditto
	D-06	Contours	No	ditto
	D-07	EIA Project Area	Yes	New Layer + New Data
	D-08	Elevation Zones	No	Coordinate Conversion
	D-09	Factories	Yes	Update
	D-10	Forest	Yes	Coordinate Conversion
	D-11	Forest Conservation	No	ditto
	D-12	Forest Use	No	ditto
	D-13	Geologic Structure	No	ditto
	D-14	Geology	No	ditto
	D-15	Hospital	Yes	Update
	D-16	Irrigation Project Areas	No	Coordinate Conversion
	D-17-1	Land Use	Yes	Update
	D-17-2	Land Use (Optional Design Using Regions)	No	Coordinate Conversion
	D-18	Mining Permits	No	Coordinate Conversion
	D-19	Municipalities and Sanitary Districts	No	ditto
	D-20	NGO Project Areas	Yes	New Layer + New Data
	D-21	Noise Monitoring Sites	Yes	New Layer + New Data
	D-22	Places/Public Facilities	No	Coordinate Conversion
	D-23-1	Province, District and Tambon Boundaries	No	ditto
	D-23-2	Province, District and Tambon Boundaries (Optional Design Using Regions)	No	ditto
	D-24	School	No	ditto
	D-25	Slope	No	ditto
	D-26	Soil	No	ditto
	D-27	Streams and Rivers	Yes	Update
	D-28	Tourist and Natural and Cultural Heritage Sites	Yes	Update
	D-29-1	Transportation	No	Coordinate Conversion
	D-29-2	Transportation (Optional Design using Routes)	No	ditto
	D-30	Transportation - Accident Location	No	ditto
	D-31	Villages	No	ditto
	D-32	Water Bodies	No	ditto
	D-33	Water Quality Monitoring Stations	Yes	Update
	D-34	Watershed Classification	No	Coordinate Conversion
	D-35	Weather	Yes	Update
	D-36	Wells	No	Coordinate Conversion
	D-37	Cross Section	No	ditto
New	N-01	Conservation area (Ramsar area)	Yes	New Layer + New Data
	N-02	Waste water treatment Project (Sewage Treatment facilities)	Yes	New Layer + New Data
	N-03	Community Solid Waste Project	Yes	New Layer + New Data

	Solid Waste Management	MSW intermediate treatment facilities	Yes	New Layer + New Data
		Sanitary landfill	Yes	New Layer + New Data
		Illegal Dump Site	Yes	New Layer + New Data
	N-04	Water Supply facilities	Yes	New Layer + New Data
	N-05	Hydrological data	Yes	New Layer + New Data
	N-06	Population	Yes	New Layer + New Data
	N-07	Economic index	Yes	New Layer + New Data
	N-08	Provincial Development Plan	Yes	New Layer + New Data
	N-09	Slaughter house	Yes	New Layer + New Data
	N-10	Gravel and sand pits	Yes	New Layer + New Data

Note; Coordinate Conversion: DEQP GIS D/B, which is constructed on the map, scale 1/250,000 with Indian/Thailand Coordination prepared by Royal Thai Survey Department, was changed into the map with WGS 84（World Geodetic System 1984）popular worldwide.

Furthermore, the following table clarifies whether the client will provide the data to be entered in each layer or if the subcontractor will need to obtain the information through their own efforts.

.

Table 3-15: Source of Information for each layer

DB	DEQP Code	Layer	AYP data collection by : ONEP REO/PEO	AYP Study Team	AYP OSS*1 Consultant	AYP GIS Consultant	AYP Remarks	SKP data collection by : ONEP REO/PEO	SKP Study Team	SKP OSS*1 Consultant	SKP GIS Consultant	SKP Remarks
Existing layer	D-01	Air Quality				○	Data will be obtained from PCD WEB site		○		△	Coordinate of two sampling point will be obtained and link with PM10 data.
	D-07	EIA Project Area	○			△	Dta will be obtained from ONEP.	○			△	Data will be obtained from ONEP.
	D-09	Factories	○	○			Three factory lists (Excel file from JICA, GIS DB from PEO and GIS DB from DEQP) will be examined and make one latest DB.		○			Two factory list will be examined (Excel file from JICA and GIS DB form DEQP) and make one latest DB.
	D-15	Hospital (Health)	○	○		△	Two hospital list (Excel file from ONEP and GIS DB from DEQP) will be examined and make one latest DB with location.	○	○		○	Two hospital list (Excel file from ONEP and GIS DB from DEQP) will be examined and make one latest DB with location.
	D-17-1	Land Use		○			Land use map development from satellite image of Landsat 3 date, SPOT1 date		○			Land use map development from satellite image of Landsat 3 date, SPOT1 date
	D-20	NGO Project Areas		○	△		Based on the opinion survey result		○	△		Based on the opinion survey result
	D-21	Noise Monitoring Sites		○		△	**2 points**		○		△	2 point
	D-27	Streams and Rivers		○		△	169 goods transport port and 6 tourism port	○			○	Three fuel tank and port, Fire fly point.
	D-28	Tourist and Natural and Cultural Heritage Sites	○	○		△	Two list (Excel file from ONEP and GIS DB from DEQP) will be examined and make one latest DB with location information	○	○		○	Two list (Excel file from ONEP and GIS DB from DEQP) will be examined and make one latest DB with location information
	D-33	Water Quality Monitoring Stations		○			water quality analysis data under the study will be input		○			water quality analysis data under the study will be input
	D-35	Weather				○	rainfall, humid, evaporation, sunlight hours, temperature, wind direction and velocity for 10 years in a monthly basis and 3 years in daily basis				○	rainfall, humid, evaporation, sunlight hours, temperature, wind direction and velocity for 10 years in a monthly basis and 3 years in daily basis
New layer	N-01	Conservation area	○			○	Area will be examined in *Master plan for urban area of Ayutthaya for World Heritage Data* including bird sanctuary in Wat Tan En （Bang Pahun District）and input necessary data.	○			○	Confirmation of Ramsar Area
	N-02	Waste water treatment Project (Sewage Treatment facilities)		○	△		Data will be obtained from Questionnaire survey to the Local Government which are Tessaban and Orbortor.		○	△		Data will be obtained from Questionnaire survey to the Local Government which are Tessaban and Orbortor.
	N-03 Solid Waste Management	Community Solid Waste Project		○	△		Ditto		○	△		Ditto
		MSW intermediate treatment		○	△		Ditto		○	△		Ditto
		Sanitary landfill		○	△		Ditto		○	△		Ditto
		Illegal Dump Site		○	△		Ditto		○	△		Ditto
	N-04	Water Supply facilities		○	△		Ditto		○	△		Ditto
	N-05	Hydrological data				○	Inflow, outflow of the river, evapotranspiration, ground water replenishment, river discharge at sampling point				○	Inflow, outflow of the river, evapotranspiration, ground water replenishment, river discharge at sampling point
	N-06	Population		○			population data for 5 years per Amphur level		○			population data for 5 years per Amphur level
	N-07	Economic index		○			Economic data for 5 years 1. Gross Provincial Products 2. Number of Employee		○			Economic data for 5 years 1. Gross Provincial Products 2. Number of Employee
	N-08	Provincial Development Plan		○			4 city plan will be input with polygon data linked with 3 PDF files and 1 MapInfo file.		○			2 city plan will be input with polygon data with 2 PDF file.
	N-09	Slaughter house		○		△	REO6 Environmental Quality Report in 2006 with PDF format. 20 slaughter house					no slaughter house in this province.
	N-10	Gravel and sand pits		○		△	Extract from factory list and create a new layer. Location will be obtained if there is no coordinate information.					no gravel and san pits in this province.

△:Coodinate information will be obtained by field checking　　○:Data and coordinate shall be obtained.

***1: Consultant doing questionnaire survey for Local Government , NGO and Resident**

In addition, the following table shows how the location information and link to each database in the layers will be displayed on screen.

The subcontractor will construct the PEQMP GIS D/B according to these indicators.

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
Existing layer	D-01	Air Quality	Point	AYP: There is one air quality monitoring station in AYP, and the data can be acquired from the PCD Website. Subcontractor will investigate data from the past 10 years and enter all data acquired. SKP: PM10 data has been measured at 2 stations. The Study Team has this data but does not know the coordinates. For this, the subcontractor will take measurements for the GPS location of these stations.	Use “air quality” in the DEQP D/B structure.	• Base layer: shows sampling points and ID. • Click on ”data icon” and then any sampling point to display a table showing the name of the sampling point and measurement data. • Click on ”graph icon” and then any of the sampling points, or otherwise click on “graph icon located on the data screen, to display figures for secular change of measurement data. The measurement item displayed through this action shall be SO_2.
	D-07	EIA Project Area	Point/Polygon	Enter data in the Study Team's possession. Subcontractor will use GPS to measure coordinates of the project area. PDF file showing the environmental monitoring data will be input	Use "EIA project area" in the DEQP D/B structure.	• Base layer: shows points and ID. • Click on ”data icon” and then any point to display a table with name and other principal data.
	D-09	Factories	Point/Polygon	Factory list in REO6 GIS database will be used as the basis. In case new factory list from DIW GIS database will be supplied from client, this database shall be used. The sub contractor should check the differences between two databases.	Use “Factories” in the DEQP D/B structure.	• Base layer: shows points and ID. • Click on ”data icon” and any sampling point to display a table with name and other principal data. • Click on ”data icon” and then any of the Amphoe to display the total number of factories, number of employees, etc. in each Amphoe.
	D-15	Hospital	Point, Arc	Check data for the classification of hospitals and number of beds that has been input. If the classification or number of beds is unclear, the subcontractor will investigate this information. For the subcontractor to calculate the amount of medical waste generated they will obtain the required unit load of medical waste generated from relevant organizations (e.g. PCD).	Use “hospital” (AYP) or “Health” (SKP) in the DEQP D/B structure. For volume of medical waste generated, each Amphoe calculates this data. This data will also be added to the database structure.	• Base layer: shows points and ID. • Easy-to-understand display of hospital classifications (using symbols or colors) • Click on ”data icon” and then any Amphoe to display amount of medical waste generated and basic information, such as the total number of hospitals, number of

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
						beds, etc. in each Amphoe.
	D-17-1	Land Use	Polygon	Separate from this task, land use data acquired from analysis of landsat image data will be entered. There are 3 sets of landsat image data for present (2007), 10 years ago and 20 years ago. See appendix for details of classification, etc.	Use “Land use” in the DEQP D/B structure.	• Base layer: shows points and ID. • Click on ”graph icon” to display a selection screen of landsat image data. By clicking on the icons, the necessary image will be displayed.
	D-20	NGO Project Areas	Point/Polygon	Investigate NGO project areas in AYP and SKP and measure the locations using GPS. The subcontractor may use results from the questionnaire survey of local administrative organizations conducted separately by the Study Team as a reference.	Use “NGO Project Areas” in the DEQP D/B structure.	• Base layer: shows points/polygons and ID. • Click on “data icon” and then any point to display a table showing the name of the NGO Project and principal data.
	D-21	Noise Monitoring Sites	Point	AYP: There is data for noise monitoring at 2 stations from REO 6 report SKP: There is data for noise measured at 2 stations. These stations are in the same position as the measurement position of PM10 shown in air quality. Also, the Study Team has this data.	Use “Noise monitoring sites” in the DEQP D/B structure.	• Base layer: shows sampling points and ID. •Click on “data icon” and then any sampling point to display a table showing the name of the sampling point and the measurement data.
	D-27	Streams and Rivers	Arc/Point	AYP: Enter the location information, etc. for “list of port” that the Study Team has in its possession. The subcontractor will use GPS to measure these coordinates. SKP: Enter Port (Fuel station)	Use “Streams and Rivers sites” in the DEQP D/B structure. If there are missing items for this structure, add the corresponding table and column.	• Base layer: shows points and ID. •Click on the “data icon” and then any point to display a table showing name and other principal data.
	D-28	Tourist and Natural and Cultural Heritage Sites	Point/Arc	Enter the new data of heritage sites acquired and arranged by the Study Team. Make sure this complies with current data, and use GPS to measure the coordinates for these added points. Also, in AYP this layer is divided into 2, “Tourist” and “Heritage”, so enter the data	Use the following layers (for each Province) from the DEQP D/B structure. For AYP, use 2 layers “Tourist” and “Heritage”.	• Base layer: shows points and ID. • Click on “data icon” and then any point to display a table showing name and other principal data.

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
				according to this division. For SKP, enter the firefly route for tourists indicated by the PEO/Team.	For SKP, use the layer "Wat".	
	D-29	Transportation	Arc, Point	Not necessary to acquire any new data.	Use "Transportation" in the DEQP D/B structure.	Make improvements by representing roadway and railway (and waterway where necessary) divisions with respective symbols or colors.
	D-33	Water Quality Monitoring Stations	Point	AYP: There are 2 types of data. Data-1 is data from water quality analysis commissioned out by the Study Team. Measurement of the coordinates for the sampling points will be done by the organization that conducts the water quality analysis. Data-2 is the water quality data listed on the EIA reports. Because these coordinates of the EIA project are unclear, the subcontractor will use GPS to measure the data for each sampling point. SKP: There are 2 types of data. Data-1 is data to be entered from water quality analysis commissioned out by the Study Team. Measurement of the coordinates for the sampling points will be done by the organization that conducts the water quality analysis. Data-2 is existent analysis data. The coordinates for these sampling points have been measured and this data is in the possession of the Study Team. We expect information from another layer will be used for distance data from estuaries or provincial boarders to the sampling points.	Use "water quality monitoring stations" in the DEQP D/B structure. If there are items missing for this structure, add the corresponding table and column.	• Base layer: shows sampling points and ID. •Click on "data icon" and then any sampling point to display a table showing the name of the sampling point and measurement data. • Click on "graph icon" and then any sampling point, or otherwise click "graph icon" located on the data screen, to display figures of secular change of measurement data. This action shall display the measurement item BOD. • Create an "all data icon" for the figure above. Clicking on this icon will display a figure showing all of the sampling point data. The item BOD shall be connected by a line to data of the same measurement year. The horizontal axis shall be distance from estuary or province boarder.
	D-35	Weather	Point/Arc	Enter weather data from the past 10 years (1997-2006) for all weather stations in both provinces. The items shown in the DEQP D/B structure will be used for entry. Measure the	Use "Weather" in the DEQP D/B structure.	• Base layer: shows station points and ID. • Click on the "data icon" and then any station point to display a table showing the

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
				location of the weather stations using GPS. Incase there is no meteorological stations in the province, data from nearest station shall be obtained and input.		name of the station point and measurement data. • Click on the "graph icon" and then any station point, or otherwise the "graph icon" located on the data screen, to display a figure of the secular change of measurement data. This operation shall display the item for monthly data.
New layer	N-01	Conservation area (Ramsar area)	Point/Polygon	AYP: Enter the area shown in Master plan for urban area of Ayutthaya for World Heritage Data. Also, enter Bird Sanctuary Data in Wat Tan En, Bang Pahun District. SKP: Enter the Ramsar Area. The subcontractor will investigate the data listed above and measure the coordinates using GPS when necessary.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows point/polygon and ID. • Click on the "data icon" and then any point/polygon to display a table showing the name of the conservation area and principal data.
	N-02	Waste water treatment Project (Sewage Treatment facilities)	Point data	Investigate sewage treatment facilities in AYP and SKP and measure those locations using GPS. The subcontractor may use results from the questionnaire survey of local administrative organizations conducted separately by the Study Team as a reference. AYP: We know that there are 2 sewage treatment facilities.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the "data icon" and then any point to display a table showing the name of the sewage treatment facility and principal data.
	N-03 Solid Waste Manag ement	Community Solid Waste Project	Point data	Investigate community solid waste projects in AYP and SKP and enter the data. When the location can not be determined, show units for each Amphoe. The subcontractor may use results from the questionnaire survey of local administrative	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the "data icon" and then any point to display the name of the community solid waste project and principal data.

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
				organizations conducted separately by the Study Team as a reference.		
		MSW intermediate treatment facilities	Point data	Investigate MSW (Municipal solid waste) intermediate treatment facilities in AYP and SKP and enter data. When the location can not be determined, show units for each Amphoe. The subcontractor may use results from the questionnaire survey of local administrative organizations conducted separately by the Study Team as a reference. SKP: The Study Team has GPS location information for one waste transfer station.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the “data icon” and then any point to display a table showing the name of MSW intermediate treatment facilities and principal data.
		Sanitary landfill	Point data	Investigate landfill (sanitary and open) in AYP and SKP and enter data. Measure the location information using GPS. The subcontractor may use results from the questionnaire survey of local administrative organizations conducted separately by the Study Team as a reference. AYP: The Study Team has confirmed that there are 2 landfill sites. SKP: The Study Team has confirmed that there are no landfill sites in SKP.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the “data icon” and then any point to display a table showing the name of the landfill site and principal data.
		Illegal Dump Site	Point data	Investigate illegal dump sites in AYP and SKP and enter data. Measure the location information using GPS. The subcontractor may use results from the questionnaire survey of local administrative organizations conducted separately by the Study	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the ”data icon” and then any point to display a table showing the address.

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
				Team as a reference.		
	N-04	Water Supply facilities	Point data	Investigate water supply facilities in AYP and SKP and enter data. Measure the location information using GPS. Also, small-scale water supply facilities that are limited to household feeds will be excluded from the study targets. The subcontractor may use results from the questionnaire survey of local administrative organizations conducted separately by the Study Team as a reference.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID • Click on the ”data icon” and then any point to display a table showing the name of the water supply facilities and principal data.
	N-05	Hydrological data	Point/Polygon/ Arc	Acquire and input hydrological data. If the location information of the data acquired can not be determined, show units for each Amphoe. If data does not exist, inform the client. Required data: Amount of rainfall, inflow, outflow, evaporation, and groundwater replenishment of both provinces, as well as river discharge at water quality monitoring positions of both provinces	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the “data icon” and then any point to display a table showing hydrological data.
	N-06	Population	Polygon	Enter population data from the past 5 years acquired by the Study Team. The data is in Amphoe units.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the “data icon” and then any Amphoe to display population data. • Click on the “graph icon” and then any Amphoe, or otherwise click on the “graph icon” located on the data screen, to display a table showing population data for the past 5 years.
	N-07	Economic index	Polygon	Economic Index data from the past 5 years acquired by the Study Team. The data is in province units.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows points and ID. • Click on the “data icon” and then inside a province to display economic index data.

Database	Code	Layer	Feature Class	Data	Database Structure	Utilization
	N-08	Provincial Development Plan	Point/Polygon	This layer shall be items shown in province development plan and city plan. However, currently the provincial development plan in both AYP and SKP provinces has not been made. Hence, at this point in time, this layer will show city plan. AYP: City plans for 4 places are being made. SKP: City plans for 2 places are being made. The subcontractor will represent the information for those locations using polygons. The Study Team has acquired PDF files of the city plans and a MapInfo file.	A new structure is created using a separate example from the DEQP D/B structure as a reference.	• Base layer: shows polygons and ID. • Click on the "data icon" and then any city plan to display a PDF file of the city plan.
	N-09	Slaughter house	Point	Investigate slaughter houses in both provinces and measure the location information using GPS.	Create a new layer, using "Factories" in the DEQP D/B structure as a reference.	• Base layer: shows points and ID. •Click on the "data icon" and then any point to display a table showing the name of the slaughter house and the principal data.
	N-10	Gravel and sand pits	Point	Make a single layer for gravel and sand pits - code number "29012" – in the DEQP D/B. Not necessary to acquire any new data.	Create a new layer, using "Factories" in the DEQP D/B structure as a reference.	• Base layer: shows points and ID. •Click on the "data icon" and then any point to display a table showing the name of gravel and sand pit and principal data.

c.3 Content and Scope of Work for Subcontractor

- Gather/enter the latest specified data, and enter data provided by the Client
- Acquire GPS location information for data specified in Table 3
- Import the Layer (Land Use) provided by the Client into the PEQMP GIS D/B
- Construct the PEQMP GIS D/B indicated in Table 2

c.4 Reference Materials

In this work, the DEQP GIS D/B will be used as the basis, but other GIS D/B and Excel files (see below) will be provided as reference material.

- ONEP GIS D/B
- Ayutthaya GIS D/B (Factory List)
- Factory List (Excel files, AYP and SKP)

c.5 Method of Fixing Position

Coordinate system to be used for PEQMP GIS DB shall be match to DEQP GIS DB system. . Ellipsoid shall be WGS84.

c.6 Seminar

After completion of the development of PEQMP GIS DB, a seminar will be held to disseminate the environmental GIS data base to the stakeholders. Half day seminars at two provinces will be organized by the counterpart. The sub contractor should send the responsible personnel to explain about the contents of the PEQMP GIS DB.

c.7 Work Schedule

- Contract: Early-September
- Delivery Period: Three months

c.8 Output

PEQMP GIS D/B for AYP and SKP

- Output according to the image in following figure.
- A DVD using Coverage format
- The final output will fundamentally be the Thai language. However, an English language version will be prepared of the tabular DB items and graph items, place names displayed on screen as the base map, legend, etc.

The Final Report will contain the following

- D/B Structure and contents of D/B
- Color printouts (A3 size) of the initial screen for each layer
- List of materials used to create D/B and the materials
- 2 sets each of the Thai and English language versions
- 2 CDs in either MS Word or Excel format

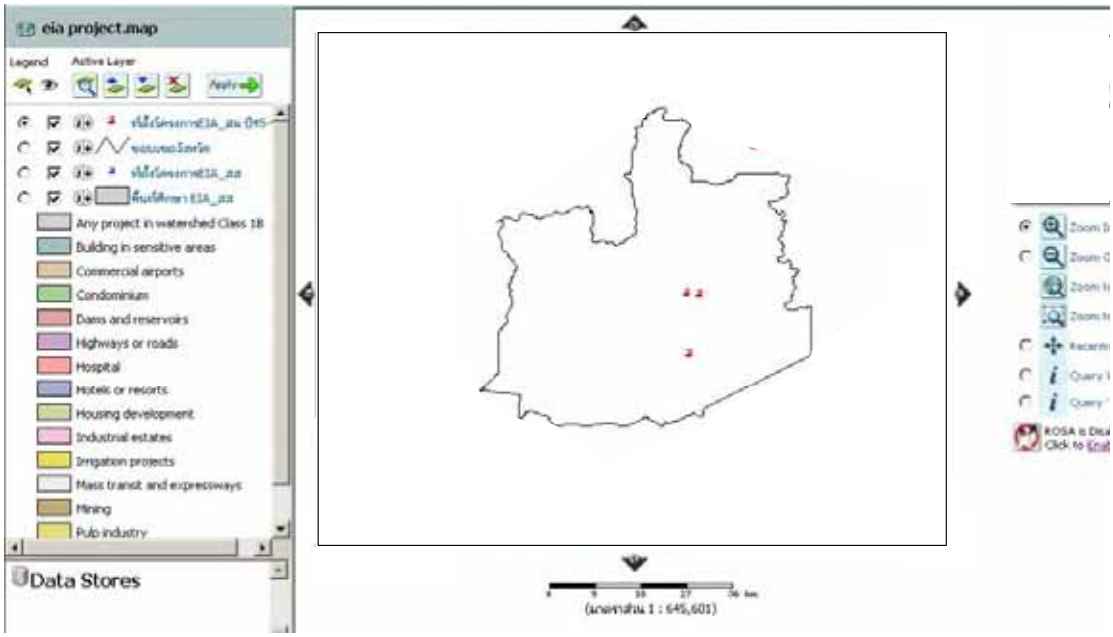


Figure 3-23: Image of Output

3.3.2 Result

a. Basic Information

a.1 Data Format

GIS database was developed according to the coverage form of Arkinfo. Coverage form consists of table data and spatial data.

a.2 Coordinate System

The coordinate system is as follows.

- Projection: UTM (Universal Transverse Mercator)
- Zone Number: 47
- Datum: WGS84 (World Geodetic System 1984)

b. Result

Details of this Environmental GIS database and utilization manual are described in Annex 2: Utilization Plan Manual for Environmental GIS database.

3.3.3 Findings

- MNRE has commenced development of NREM GIS data base since 1992 and completed in 2002. All the REO and most PEO have been provided with NREM GIS data base. In spite of investing a lot of money and allocation of considerable budget for maintenance of NREM GIS data base, NREM GIS data base has not been fully utilized for Provincial NREM.
- Current situation and change of NREM in model provinces has been presented in area bases using NREM GIS data base in JICA Study. But there are certain

conditions when GIS data base will be used for NREM. Especially, as for the collection of data, updating data, utilization for daily activities, promotion of GIS database must be carefully done with full understanding of the conditions and limitations which GIS database has.

a. Advantages and Disadvantages of using GIS data base for NREM

Below are the advantages and disadvantages of using GIS data base for NREM.

Table 3-16: Advantages and Disadvantages of using GIS database

Usage	Advantages	Disadvantages
Formulation of Provincial EQMP	• GIS data base provides basic information to show current and past NRE in entire province • GIS data base provides basic information of NRE such as Environmental Hot Spot for the formulation/modification of a land use plan and control land use.	• Since planning at a PC screen is difficult, print outs are needed of large scale map for planning. Large scale map printing needs a considerable time, experience and cost. • Current GIS data base was constructed based on 1/50,000 topographic map, however, large scale maps like a 1/5,000 are needed for sector planning. In addition, current data base can not provide sufficient information for sector planning which requires a considerable investment to improve the GIS data base.
NRE Information Management	• GIS data base can integrate basic NRE information and provide them to the public easily.	• It requires experts for data input and output of necessary information, and money for data collection and output of information.
Daily NREM Activities	• GIS data base is a very useful tool to provide area based NREM information for public relations and educations.	• It can not be used frequently for daily NREM activities because of difficulty of data input and output.

b. Recommendations

- Because experts are necessary for data input and output on a large plotter and a budget are needed for data collection/output, it might be difficult for a PEO to have such experts and budget allocation for operation and maintenance (O&M). Because REO has GIS experts, it is a suitable office to take responsibility for O&M of regional/provincial GIS databases as a regional information centre. PEO shall be given user access to the GIS databases.
- For use of area based information (output) such as sector planning and land use planning/control, hard copies of area based information as output of GIS database containing information such as Hot Spots. Large scale hardcopies are preferable printed on a plotter.

- Area based information provided by aerial photographs is very useful for NREM because the situation can be easily understand.

3.4 Opinion Survey to the Stakeholders

3.4.1 Outline of the Survey

a. Objective

In order to formulate a PEQMP reflecting stakeholders' opinion as much as possible, opinions should be collected from LAs, NGOs, residents, and business establishments, to identify environmental quality to be preserved and improved and to decide the priority of mitigation measures to be introduced.

b. Target Group of the Survey

b.1 Local Administration (LA)

Model province	Orborjor (PAO)	Tessaban (Municipality)	Orbortor (TAO)	Total
AYP	1	34	19 (124)	54 (159)
SKP	1	5	30	36

Note: Number in parenthesis shows total number of Orbortor and local administration in AYP as of August 2007.

b.2 NGO

Five NGOs, working for natural resources and environment, were surveyed in AYP and in SKP respectively.

b.3 Resident and Business Establishment

Model Province	Resident	Business	Total
AYP	226	97	323
SKP	64	47	111
Total	290	144	434

c. Content and Result

Three kinds of questionnaires were prepared for LAs, NGOs and resident/business establishments, face-to-face interviews were also conducted. The results are compiled in Main Report.

- The current situation of NREM in LAs
- Income and expenditure of residents and business establishments
- Priority of NREM
- Enforcement of environmental laws and regulations
- Role of governmental organization for environment improvement
- Activity against global warming
- Willingness of cooperation for improvement of NREM

- Recommendation to PEQMP

The result of the opinion survey is included as much as possible in the formulation of a PEQMP.

3.4.2 Ayutthaya

a. Target Group of the Survey

The following stakeholders were surveyed.

a.1 Local Administration (LA)

The opinion survey of Local Administration (LA) in Ayutthaya (OP-LA-AYP) was conducted by using its own questionnaire sheet from September 18 to October 26, 2007. All of Orborjor and Tessaban were interviewed in this Survey, but not Orbortor. Since some Orbortors were raised to Tessaban, the number of LA surveyed was changed as shown in the following table.

Table 3-17: Number of LA interviewed in Ayutthaya Province (AYP)

Result	PAO (Orborjor)	Municipality (Tessaban)	TAO (Orbortor)	Total
Planned	1	29	21	51
Actual	1	34	19	54

(Note) Total number of Orbortor in AYP is 124 in October 2007.

a.2 NGO

The opinion survey of NGOs in Ayutthaya (OP-NGO-AYP) was carried out using its own questionnaire sheet from September 25 to 27, 2007. NGOs interviewed are listed in the table below.

Table 3-18: NGO interviewed in AYP

Name	Number of Members (Person)
1. The Corporation Office of Public Organization	100
2. Natural Resources and Environmental Conservation Club	35
3. Lower Chao Phraya River Basin Committee (Phra Nakhon Sri Ayutthaya)	16
4. Phra Nakhon Sri Ayutthaya Community Organization	240
5. Eco Town Club	28

a.3 Resident and Business Establishment

The opinion survey of residents (local people) and business establishment in Ayutthaya (OP-RE-AYP and OP-BE-AYP respectively) were conducted by using the same questionnaire sheet in September and October 2007. The resident and business establishment interviewed are listed in the table below. Since many residential houses are used for business purposes in AYP, the number of business establishments is more than planned after the

segregation of residents and business establishments at the time of the compilation of the survey results.

Table 3-19: Number of Resident and Business Establishment interviewed in AYP

District	Population In 2005	% of Population	Number of Sample		
			Resident	Business Establishment	Total
1. Phra Nakhon Si Ayutthaya	135,850	18	48	13	61
2. Tha Ruea	47,565	6	13	3	16
3. Nakhon Luang	33,638	5	10	7	17
4. Bang Sai	45,384	6	10	5	15
5. Bang Ban	33,980	5	10	6	16
6. Bang Pa-in	76,646	10	23	7	30
7. Bang Pahan	42,239	6	10	6	16
8. Phak Hai	42,956	6	12	5	17
9. Phachi	30,189	4	12	9	21
10. Lat Bua Luang	35,800	5	11	5	16
11. Wang Noi	58,976	8	22	8	30
12. Sena	65,056	9	22	13	35
13. Bang Saai	19,529	3	4	3	7
14. Uthai	41,783	6	11	4	15
15. Maharat	23,528	3	5	2	7
16. Bang Phraek	9,278	1	3	1	4
Actual Total	742,397	100	226	97	323
Planned Total	-	-	225	75	300

(Data Source) "Administrator Record 2006", Department of Provincial Administration

b. Main Findings

b.1 Current Natural Resources and Environmental Management in LA by OP-LA-AYP

b.1.1. Area, Population, Household and Staffs of LA

The sizes of Tessaban or Orbortor in AYP appear to be very small in every aspect as shown in the table below; as reference, their average area and population in Japan are 207.6 km^2 and 70,202, respectively. (In 2006, area in Japan 377,835km^2, 127,767,944 of population and 1,820 of cities (779), towns (844) and villages (197) which correspond to the Tessaban and Orbortor in Thailand.)

Table 3-20: Area, Population, Household and Employee of LA

LA	Nos	Administration Area (km^2)	Average Population	Average Nos. of Household	Average Nos of LA Staffs
Orborjor	1	2,556.6	760,645	242,123	322
Tessaban	34	16.3	8,799	2,967	105
Orbortor	19	18.9	4,480	1,125	23

b.1.2. Financial and Organizational Issues on Natural Resources and Environmental Management of LA

The portion of the budget for Natural Resources and Environmental Management (NREM) in LA differs from Orborjor, Tessaban and Orbortor. Orborjor spends almost nothing, only 0.2%, while those of Tessaban and Orbortor share a certain portion (see below).

Regarding organizational issues for NREM, most LAs (53 out of 54) have 1 or 2 organizations responsible for the NREM. Although responsible department in Orborjor, Civil Works Department, has 159 personnel of which belongs to the staff, their main work is not concerned with NREM but civil works.

In conclusion, Orborjor seems to handle few NREM projects in AYP.

Table 3-21: Financial Issues on NREM of LA

LA	Nos	A. Average Budget of LA in 2007 (1,000 Baht)	B. Average Budget for NREM in 2007 (1,000 Baht)	Share of Budget for NREM (B/A x 100)
Orborjor	1	840,024	1,668	0.2 %
Tessaban	34	51,872	2,242	4.3 %
Orbortor	19	15,124	724	4.8 %

(Note) NREM: Natural resources and environmental management

b.1.3. Development Control

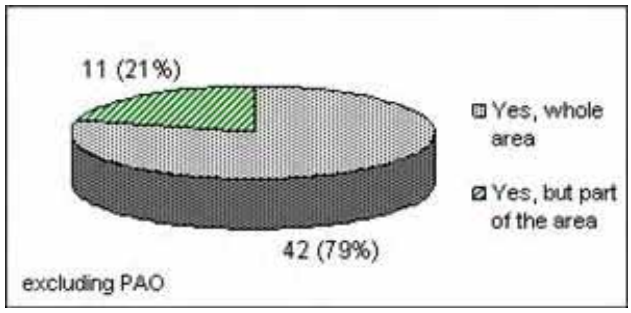
Most LA (93% including Orborjor) have an organization responsible for development control (building and construction permits and enforcement). The average number of staff engaging in development control in an Orborjor is 159 while those inTessaban and Orbortor total 16 and 4 respectively.

b.1.4. Zoning Map

The number of LA that have zoning maps (area development plan, land use plan, etc.) to control development of their administrative area are 26% (11 LAs in total), excluding Orborjor.

b.1.5. Water Supply System

As shown in the figure to the right, 79% of LA excluding Orborjor have water supply in their whole administrative area and 21% have partial supply in their area. According to the OP-RE-AYP and by OP-BE-AYP, 59% of business establishments and 58% of residents have tap water supply. The details of these water supply systems are mentioned in Section 4.3.2a Water Quality.

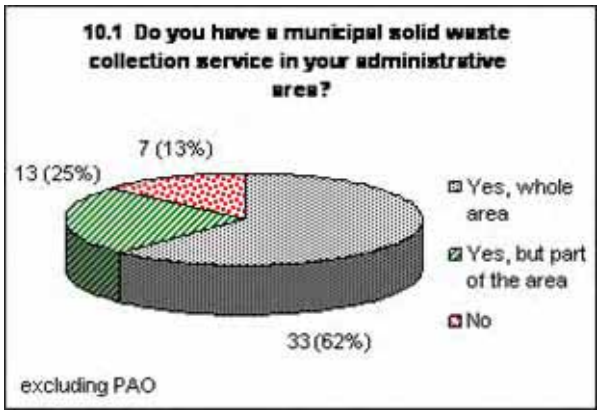


b.1.6. Sewerage System

Only two LAs (4%) have sewerage systems covering part of their administrative area. According to the OP-RE-AYP and OP-BE-AYP, only 1% of residents and 3% of business establishments are connected to a sewerage service. However, more than 75% of residents

and business establishments have flush toilets with septic tank. The details of the sewerage system are mentioned in the Section 4.3.2a Water Quality.

b.1.7. Solid Waste Management (SWM)



As shown in the figure to the right, 87% of LAs have SWM collection service in their administrative area; 62% in whole area and 25% in part of area. 18 LAs out of 53 have a final disposal site in their administrative area and 10 disposal sites applies to semi-sanitary landfill operation according to the answer of them though eight are open dumping. The details of SWM system are mentioned in the Section 4.3.2 b SWM System.

b.1.8. Natural Assets

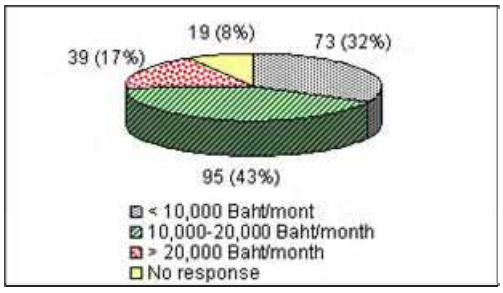
57% of LA replied they have special natural assets in their administrative area. Natural assets include the Pasak River, Noi River, Lopburi River, canals.

b.1.9. Cultural Assets

70% of LA replied they have special cultural assets in their administrative area. Most of cultural assets are temples as well as world heritage sites, stupas, a holy pond, and so forth.

b.2 Income and Expenditure of Households and Business Establishments

b.2.1. Income of Households by OP-RE-AYP



As shown in the figure to the right, the majority (43%) of total income of a household is 10,000 – 20,000 Baht/month.

b.2.2. Water Fee Paid by OP-RE-AYP and by OP-BE-AYP

Average water fees paid by residents and business establishments are 207 Baht/month and 486 Baht/month respectively.

b.2.3. Electricity Paid in Baht/month by OP-RE-AYP and by OP-BE-AYP

Average electricity fees paid by residents and business establishments are 881 Baht/month and 2,109 Baht/month, respectively.

b.2.4. Sewerage Service Fee Paid by OP-RE-AYP and by OP-BE-AYP

No sewerage service fee is charged at present.

b.2.5. Solid Waste Collection Fee by OP-RE-AYP and by OP-BE-AYP

Average solid waste collection fees paid by residents and business establishments are 25 and 40 Baht/month, respectively.

b.3 Prioritized Issues on NREM

b.3.1. Problems in LA

The first and second most serious problems in LA differ according to the target group as shown in the table below.

Table 3-22: The First and Second Most Serious Problems in LA

Target Group	The Most Serious Problems	The Second Most Serious Problems
LA	Natural Resources and Environment Degradation	Insufficient capability of LA
Resident	Natural Resources and Environment Degradation	Economic Stagnation
Business Establishment	Economic Stagnation	Natural Resources and Environment Degradation
NGO	Natural Resources and Environment Degradation	Insufficient capability of LA

As shown in the table, the majority of target groups consider natural resources and environment degradation is the most serious problem in LA. The opinion survey also asks the target groups about measures to solve the problems above. There are a large numbers of measures suggested. Those are presented in the sheets of detailed answers.

b.3.2. Requests for Improvement of Administrative Area from Residents by OP-LA-AYP

The largest number of requests is for improvement of infrastructure like roads and bridges, followed by electricity in public areas and potable water supply.

b.3.3. Complains from Residents by OP-LA-AYP

About 33% of LA does not have any complaints from residents. The most frequent complaints voiced are on “Smoke/dust from industries”, followed by “Flood and erosion”.

b.3.4. Interest in Environmental Issues and Information Source

Interest in environmental issues differs according to the target group as shown in the table below.

Table 3-23: Interest in Environmental Issues

Target Group	Yes (%)	Yes, but only a little (%)	No or No Response (%)
Resident	20	77	3
Business Establishment	28	71	1
NGO	100	0	0

Information source of environmental issues differs slightly according to the target group as shown in the table below.

Table 3-24: Information Source of Environmental Issues

Target Group	Biggest Source	Second Biggest Source

Resident	TV News	Newspaper
Business Establishment	TV News	Newspaper
NGO	TV News	Internet

As shown in the table, the main information source for environmental issues is TV news.

b.3.5. Natural Resources and Environment Problems

The most serious and second most serious problems on natural resources and environment differ according to the target group as shown in the table below.

Table 3-25: Natural Resources and Environment Problems

Target Group	The Most Serious Problems	The Second Most Serious Problems
LA	Water resources	Solid waste
Resident	Water resources	Global warming/climate change
Business Establishment	Water resources	Global warming/climate change
NGO	Solid waste	Water resources

LA, residents and business establishments replied that the most serious problem in natural resources and environment (NRE) is the “Water resources”. The reasons for the answer are “Losts of agriculture area and property” and "Obstacle for transportation and agriculture” due to “Flood”. On the contrary, NGOs replied that “Solid waste” is the most serious problem because open dumping operation of solid waste causes environmental and health problems.

b.3.6. Affects of Environmental Degradation

Affects of environmental degradation differs according to the target group as shown in the table below.

Table 3-26: Affects of Environmental Degradation

Unit: %

Target Group	Serious	Some Extent	No Affect	I do not know
LA	6	77	17	0
Resident	12	64	19	5
Business Establishment	10	75	12	3
NGO	20	60	20	0

b.3.7. Comparison of Economic Development and Environmental Conservation

Regarding the question of which of the two of economic development or environmental conservation is more important, the answer of each target group is summarized in the table below.

Table 3-27: Comparison of Economic Development and Environmental Conservation

Unit: %

Target Group	Economic Development	Environment Conservation	Both	Others
LA	33	11	43	13

Resident	39	23	38	0
Business Establishment	35	25	40	0
NGO	0	40	60	0

The table indicates that "Economic Development" is more important than "Environmental Conservation" except for NGOs.

b.3.8. Environmental Quality Management Projects in LA by OP-LA-AYP

All LAs have environmental quality management projects as a part of their annual budget plan. Basically, the types of projects are similar every year. As for the budget of 2007, the largest amount of budget is spent to "Improve the surrounding of tourist attractions and public places". In terms of the number of projects, however, "Promote separation of solid waste" and "advocate environmental consciousness amongst people" are the first and second most frequent.

b.3.9. Main Pollutant Source

The answer of each target group on the main source of pollution is summarized in the table below.

Table 3-28: Main Pollutant Source

Target Group	Air Pollution	Water Pollution	Solid Waste	Noise Pollution
LA	Factories (53%)	Household (35%)	Household (90%)	No Problem (36%)
Resident	Factories (35%)	No Problem (27%)	Household (50%)	Road Transportation (46%)
Business Establishment	Automobile (35%)	No Problem (42%)	Household (42%)	Road Transportation (53%)
NGO	Factories (60%)	Household (40%)	Household (80%)	Road Transportation & No Problem (40%)

b.4 Observation of Environmental Regulations

b.4.1. Degree of Observation of Environmental Regulations in AYP

As for the degree of observation of environmental regulations in AYP, the answers differ according to target groups as shown in the table below.

Table 3-29: Observation of Environmental Regulations in AYP

Unit: %

Target Group	Yes, observed	Somewhat observed	Seldom observed	Do not know
LA	9	33	52	6
Resident	2	17	63	18
Business Establishment	3	20	51	26
NGO	0	0	100	0

b.4.2. Measures for Observation of Regulation

As for the measures for observation of environmental regulations, the answers of each target group are shown in the table below.

Table 3-30: Measures for Observation of Regulation

Target Group	Most Frequent Answer	Second Frequent Answer
LA	• Awareness should be raised among industries to take pollution control measures more seriously	• The central government tightens controls and increases penalties
Resident	• The local administration (Orborjor, Tessaban and Orbortor) tightens controls and increases penalties	• Awareness should be raised among people to pay more attention to environmental issues
Business Establishment	• The local administration tightens controls and increases penalties	• Awareness should be raised among people to pay more attention to environmental issues
NGO	• The local administration tightens controls and increases penalties	• The central government tightens controls and increases penalties • Awareness should be raised among industries to take pollution control measures more seriously • Awareness should be raised among people to pay more attention to environmental issues

As shown in the table above, "The local administration tightens controls and increases penalties" is the most popular answer from target groups, except for LA.

b.5 Role of the Government for Improvement of Environment

b.5.1. Central Government and Provincial Administrations by OP-LA-AYP and OP-NGO-AYP

For the improvement of environment, LAs and NGOs replied that the central government and provincial administrations should take the following measures as shown in the tables below.

Table 3-31: Prioritized Measures to be taken by the Central Government

Target Group	Most Prioritized Measure	Second Most Prioritized Measure
LA	• To strengthen local administrations	• To tighten its control and increase penalties
NGO	• To promote environmental education • To promote participation of local people	• To establish new laws and regulations • To disclose more information and data

Table 3-32: Prioritized Measures to be taken by the Provincial Administrations

Target	Most Prioritized Measure	Second Most Prioritized Measure

Group		
LA	• To construct more waste water treatment facilities and solid waste treatment & disposal facilities	• To tighten its control and increase penalties
NGO	• To promote environment education • To promote participation of local people	• To tighten its control and increase penalties • To construct a reuse/recycle center • To strengthen capability of Local Administration • To disclose more information and data

As indicated by the tables, LA expected the central government "To strengthen local administrations" and provincial administrations "To construct more waste water treatment facilities and solid waste treatment & disposal facilities". On the other hand, NGO expected the central government and provincial administrations "To promote environment education and participation of local people".

b.5.2. Local Administrations by OP-NGO-AYP

For the improvement of environment, NGOs replied that the local administrations (Orborjor, Tessaban and Orbortor) should take the following measures as shown in the tables below.

Table 3-33: Prioritized Measures to be taken by the Local Administrations

Target Group	Most Prioritized Measure	Second Most Prioritized Measure
NGO	• To construct proper waste water treatment facilities and solid waste treatment & disposal facilities	• To establish new regulations • To tighten its control and increase penalties • To disclose more information and data

b.5.3. Government by OP-RE-AYP and OP-BE-AYP

For the improvement of environment, residents and business establishments replied that the government should take following measures as shown in the tables below.

Table 3-34: Prioritized Measures to be taken by the Central Government

Target Group	Most Prioritized Measure	Second Most Prioritized Measure
Resident	• To promote environmental education	• Law enforcement
Business Establishment	• To promote environmental education	• Law enforcement

As indicated by the table, residents and business establishments expected the government "To promote environment education" as their first priority.

b.6 Efforts for Confronting Global Warming

b.6.1. Efforts for Confronting Global Warming in LA by OP-LA-AYP and OP-NGO-AYP

At present, 63% of LA and 60% of NGO make efforts to confront global warming issues. The largest number of activities made by LA is "Afforestation" (by 29 LAs in total), followed by "Save energy such as raising temperature of air conditioners" (28 in total) and "Education of residents about environmental conservation, water and energy conservation, 3Rs, etc" (28 in total). As for NGOs, the largest number of activities is "Education of residents about environmental conservation, water and energy conservation, 3Rs, etc" followed by "Save energy such as raising temperature of air conditioners".

b.6.2. Cooperation of Residents for Preservation of Environment by OP-LA-AYP and OP-NGO-AYP

LA and NGO evaluate cooperation of residents for preservation of environment as shown in the table below.

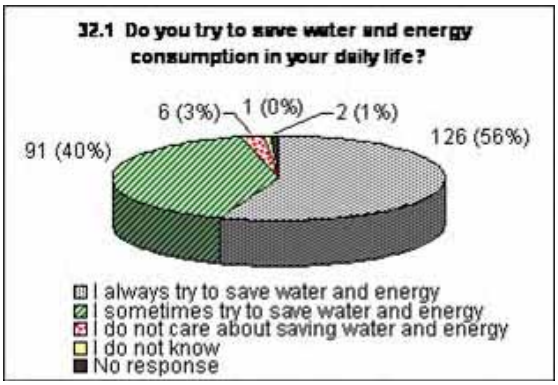
Table 3-35: Cooperation of Residents for Preservation of Environment

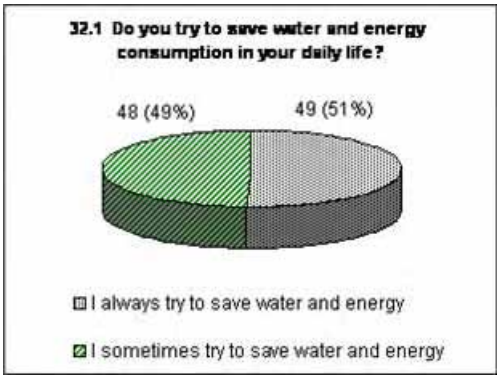
Target Group	Yes, very much (%)	Yes, some extent (%)	No or No Response (%)
LA	31	56	13
NGO	20	80	0

According to LA the most popular activity done by residents is "Cleaning public areas such as roads, parks, drains, etc." (41 of 54 LAs replied), followed by "Afforestation" (39 of 54 LAs), and "Cleaning their surrounding area" (26 of 54 LAs). According to NGOs the most popular activity done by residents is "Cleaning public areas such as roads, parks, drains, etc." (All 5 NGOs replied), followed by "Cleaning their surrounding area" (4 of 5 NGOs replied), and "Afforestation" (3 of 5 NGOs replied).

b.6.3. Conservation of Water and Energy by OP-RE-AYP and OP-BE-AYP

As for the conservation of water and reducing energy consumption, 56% of residents replied they "always try to save them" (see left figure below) while 51% of business establishment replied so (see right figure below).





As for their reason to conserve water and reduce energy consumption, most residents(51%) and business establishments(54%) replied that they did so because of "Both economic and environmental concern".

b.7 Willingness to Cooperate for the Improvement of Natural Resources and Environmental Management

b.7.1. Water Supply Fee by OP-RE-AYP and OP-BE-AYP

As for the current water supply fee and increase of the fee for improved service, the opinions of residents and business establishments are summarized in the tables below.

Table 3-36: Current Water Supply Fee

Target Group	Expensive (%)	Appropriate (%)	No service (%)	Do not know (%)
Resident	18	73	1	8
Business Establishment	16	77	1	6

Table 3-37: Increase of Water Supply Fee for Improved Service

Target Group	Accept (%)	Not Accept (%)	Do not know (%)
Resident	48	31	21
Business Establishment	24	13	63

More than 70% of residents and business establishments replied the current water fee is appropriate. Although about half (48%) of the residents would accept an increase in the fee in exchange for improved service, the intention of the majority (63%) of business establishments remains undecided.

b.7.2. Sewerage Fee by OP-RE-AYP and OP-BE-AYP

At present no one pays a sewerage fee. As for payment of the fee for improved service, the opinions of residents and business establishments are summarized in the table below.

Table 3-38: Payment of Sewerage Fee

Target Group	Accept (%)	Not Accept (%)	Do not know (%)
Resident	23	11	66
Business Establishment	24	13	63

Since more than 63% of residents and business establishments replied "Do not know", it is difficult to make a conclusion on payment of sewerage fee.

b.7.3. Solid Waste Collection Fee by OP-RE-AYP and OP-BE-AYP

As for the solid waste collection service fee and increase of the fee for improved service, the opinions of residents and business establishments are summarized in the tables below.

Table 3-39: Current Solid Waste Collection Fee

Target Group	Expensive (%)	Appropriate (%)	Cheap (%)	No service (%)	Do not know (%)

Resident	7	68	3	18	4
Business Establishment	10	78	4	4	4

Table 3-40: Increase of Solid Waste Collection Supply Fee for Improved Service

Target Group	Accept (%)	Not Accept (%)	Do not know (%)
Resident	54	27	19
Business Establishment	54	28	18

More than 80% of resident and business establishment who receive solid waste collection service replied that the collection service fee is appropriate. More than half (54%) of residents and business establishments would accept an increase in the fee for improved service.

b.7.4. Increase of Tax and/or Fee for Environmental Conservation by OP-NGO-AYP

As for the increase of tax and/or a fee for environmental conservation, 40% of NGOs replied that they "Strongly disagree" and 20% said they "Somewhat disagree".

b.7.5. Knowledge about "Environmentally Friendly Products" by OP-RE-AYP and OP-BE-AYP

65% of residents and business establishments acknowledge "Environmentally Friendly Products".

b.7.6. Attitude for the Purchase of "Environmentally Friendly Products" by OP-RE-AYP and OP-BE-AYP

The table below shows the attitude of residents and business establishments for the purchase of "Environmentally Friendly Products".

Table 3-41: Attitude for the Purchase of "Environmentally Friendly Products"

Target Group	Buy them even if more expensive (%)	Buy them if the same price (%)	Others (%)
Resident	68	30	2
Business Establishment	68	27	5

68% of residents and business establishments replied they will buy "Environmentally Friendly Products" even if they are more expensive.

b.7.7. Cooperation to Reduce Environmental Problems in Their Community by OP-RE-AYP and OP-BE-AYP

94% of residents and 97% of business establishments expressed their willingness to cooperate to reduce environmental problems in their community.

b.7.8. Cooperation to Separate Waste Collection by OP-RE-AYP and OP-BE-AYP

92% of residents and 94% of business establishments expressed their willingness to cooperate with a separate waste collection system introduced by the local administration.

b.7.9. Participation in the Process or Meetings for Formulation of PEQMP by OP-RE-AYP and OP-BE-AYP

The table below shows the intentions of residents and business establishments to participate in the process or meetings for the formulation of PEQMP.

Table 3-42: Intentions of Resident and Business Establishment for Participation in the Process or Meeting for Formulation of PEQMP

Target Group	Participate without Conditions (%)	Participate with Conditions (%)	Others (%)
Resident	27	46	27
Business Establishment	24	48	28

b.7.10. Participation in a Committee to Monitor Implementation of the PEQMP by OP-NGO-AYP

80% of NGOs are willing to participate in the process without any conditions. The condition that one NGO replied was, "Yes, if the PEQMP can lead to action and sustainable development".

b.8 Suggestions for Formulation of PEQMP

In order to establish sustainable natural resources and environmental management in the province, each target group gave suggestions for the formulation of PEQMP as shown in the table below.

Table 3-43: Suggestions for Formulation of PEQMP

Target Group	Largest Nos. of Suggestion	Second Largest Nos. of Suggestion
LA	• The province should construct solid waste treatment and disposal facilities.	• The PEQMP should be implemented seriously by related organizations.
Resident	• Open more information to the public and public participation is important for environmental management.	• Law enforcement is important to control emission of pollution from factories and small enterprises in the province.
Business Establishment	• Increase the penalty of laws and regulations and tighten their control, especially on factories.	• Promoting environmental education among people is important.
NGO	• Many organizations do not pay attention to solve environmental problems seriously.	• The government should build up understanding and knowledge of agriculture to people. • The government should continue and make use of previous projects. • Set up measures against people that are out of the scope of the provincial census registration in order to increase the amount of budget

		allocation from the government. • Raise awareness of people and take action to reach sustainable achievements. • Give priority to the problems pointed out by people without bias or inducement.

3.4.3 Samut Songkhram

a. Target Group of the Survey

The following stakeholders were surveyed:

a.1 Local Administration (LA)

The opinion survey to the Local Administration (LA) in Samut Songkhram (OP-LA-SKP) was conducted by using a unique questionnaire sheet from September 6 to October 4, 2007. All LAs were interviewed in this Survey. Since three Orbortors were combined with others, the number of LAs surveyed was changed as shown in the following table.

Table 3-44: Number of LA interviewed in Samut Songkhram Province (SKP)

Result	PAO (Orborjor)	Municipality (Tessaban)	TAO (Orbortor)	Total
Planned	1	5	33	39
Actual	1	5	30	36

a.2 NGO

The opinion survey to the NGOs in Samut Songkhram (OP-NGO-SKP) was conducted by using its own questionnaire sheet from September 10 to October 4, 2007. NGOs interviewed are listed in the table below.

Table 3-45: NGO interviewed in SKP

Name	Number of Members (Person)
1. Samut Songkhram Chamber of Commerce	188
2. We love Mae Klong Group	33
3. Samut Songkhram Marine Fisheries Center	298
4. Mae Klong Marine Fisheries Co-operatives	199
5. Samut Songkhram Industrial Council	40

a.3 Resident and Business Establishment

The opinion survey of the residents (local people) and business establishments in Samut Songkhram (OP-RE-SKP and OP-BE-SKP respectively) were conducted by using the same questionnaire sheet in September and October 2007. The residents and business establishments interviewed are listed in the table below. Since many residential houses are used for business purposes in SKP, the number of business establishments is higher than

planned after returns from residents and business establishments at the time of the compilation of the survey results.

Table 3-46: Number of Resident and Business Establishment interviewed in SKP

District	Population In 2005	% of Population	Number of Sample		
			Resident	Business Establishment	Total
Mueang Samut Songkhram	103,268	52.9	28	31	59
Bang Khonthi	33,741	17.3	14	6	20
Amphawa	58,059	29.8	22	10	32
Actual Total	195,068	100	64	47	111
Planned Total	-	-	75	25	100

b. Main Findings

b.1 Current Natural Resources and Environmental Management in LA by OP-LA-SKP

b.1.1. Area, Population, Household and Staffs of LA

The sizes of Tessaban and Orbortor in SKP appear to be very small in every aspect as shown in the table below. For reference, the average area and population in Japan are 207.6 km^2 (377,835km^2 of area of Japan divided by number of LA, 1,820) and 70,202 (127,767,944 of population of Japan divided by number of LA, 1,820) respectively. (There are 779 cities, 844 towns and 197 villages in Japan which correspond to the Tessaban and Orbortor in Thailand.)

Table 3-47: Area, Population, Household and Employee of LA

LA	Nos	Administration Area (km2)	Average Population	Average Nos. of Household	Average Nos of LA Staffs
Orborjor	1	416.7	195,068	51,964	132
Tessaban	5	12.0	8,610	2,608	84
Orbortor	30	13.2	5,082	1,310	17

b.1.2. Financial and Organizational Issues on Natural Resources and Environmental Management of LA

The amount of budget allocated for Natural Resources and Environmental Management (NREM) in LA differs from Orborjor, Tessaban and Orbortor. NREM budget of Orborjor is nearly zero at only 0.08%, while the portion dedicated by Tessaban and Orbortor is of a certain portion (see below).

This phenomenon also appears in organizational issues for NREM. The portion of staff for NREM in Orborjor is only 4.5% while those of Tessaban and Orbortor are 22.6% and 52.4% respectively. Most LAs (34 out of 36) have 1 or 2 organizations responsible for NREM. On the other hand, two Orbortors do not have any particular organizations responsible for this work since the work has only been done by temporary staff.

In conclusion, Orborjor seems to carry out few NREM projects in SKP.

Table 3-48: Financial and Organizational Issues on NREM of LA

LA	Nos	A. Average Budget of LA in 2007 (1,000 Baht)	B. Average Budget for NREM in 2007 (1,000 Baht)	Share of Budget for NREM (B/A x 100)	Average Nos of Staff in LA for NREM (person)	Share of Staffs for NREM in LA (%)
Orborjor	1	191,703	160	0.08 %	6	4.5
Tessaban	5	64,578	2,899	4.49 %	19	22.6
Orbortor	30	12,450	1,180	9.48 %	8.9	52.4

(Note) NREM: Natural resources and environmental management

b.1.3. Development Control

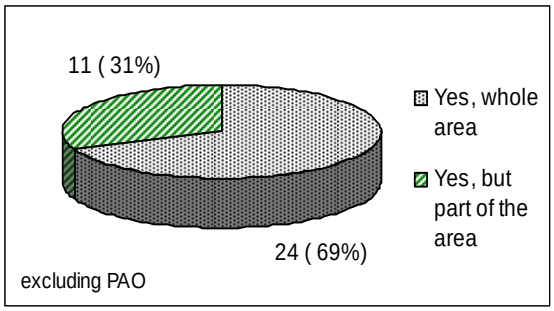
Most LA (86% including Orborjor) have an organization responsible for development control (building and construction permits and enforcement). The average number of staff engaging in development control in a Tessaban is 14 while those in Orborjor and Orbortor are 6 and 3 respectively.

b.1.4. Zoning Map

31% of LA (11 LAs in total) excluding Orborjor have zoning maps (area development plan, land use plan, etc.) to control development in their administrative area.

b.1.5. Water Supply System

As shown in the figure to the right, 69% or 24 LA, excluding Orborjor, have water supply in their whole administrative area and 31% have partial coverage of their area. According to the OP-RE-SKP and by OP-BE-SKP, 74% of business establishments have tap water supply while only 54% of residents do. The details of the water supply system are mentioned in the Section 5.3.2a Water Quality.

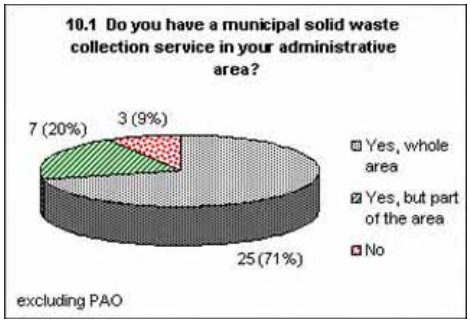


b.1.6. Sewerage System

Only two LAs (6%) have sewerage systems covering part of their administrative area. According to the OP-RE-SKP and OP-BE-SKP, only 6% of residents and business establishments are connected to the sewerage service. However, more than 75% of residents and business establishments have a flush toilet with septic tank. The details of the sewerage system are mentioned in Section 5.3.2a Water Quality.

b.1.7. Solid Waste Management (SWM)

As shown in the figure to the right, 91% or 35 LA have SWM collection service in their administrative area; 71% covering the whole area and 20% in part of the area. There is no final disposal site in SKP and most of wastes are disposed of at dump sites in Ratchaburi Province. The details of



the SWM system are mentioned in Section 5.3.2 b SWM System.

b.1.8. Natural Assets

The number of LA that replied that they have special natural assets in their administrative area was 80% or 28 LA. Natural assets include Don Hoi Lot, Mae Khlong River, canals, and so forth.

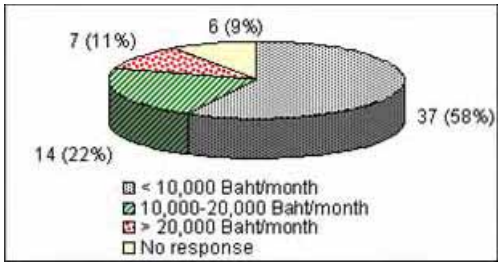
b.1.9. Cultural Assets

The number of LA that replied that they have special cultural assets in their administrative area was 74% or 26 LA. Most of the cultural assets are temples but this also includes some parks, shrine, monuments, and so forth.

b.2 Income and Expenditure of a Household and Business Establishment

b.2.1. Income of a Household by OP-RE-SKP

As shown in the figure to the right, the majority (58%) of total household income is less than 10,000 Baht/month.



b.2.2. Water Fee Paid by OP-RE-SKP and by OP-BE-SKP

Average water fees paid by residents and business establishments are 188 Baht/month and 296 Baht/month respectively.

b.2.3. Electricity Paid Baht/month by OP-RE-SKP and by OP-BE-SKP

The average electricity fee paid by residents is 659 Baht/month and for business establishments it is 1,653 Baht/month.

b.2.4. Sewerage Service Fee by OP-RE-SKP and by OP-BE-SKP

At present, there is no sewerage service fee is charged.

b.3 Solid Waste Collection Fee by OP-RE-SKP and by OP-BE-SKP

Average solid waste collection fees paid by residents and business establishments are 15 Baht/month.

b.4 Prioritized Issues on Natural Resources and Environmental Management

b.4.1. Problems in LA

The most serious and second most serious problems in LA differ according to the target group as shown in the table below.

Table 3-49: The First and Second Most Serious Problems in LA

Target Group	The Most Serious Problem	The Second Most Serious Problem
LA	Natural Resources and Environment Degradation	Economic Stagnation
Resident	Natural Resources and Environment Degradation	Economic Stagnation
Business Establishment	Natural Resources and Environment Degradation	Economic Stagnation

NGO	• Natural Resources and Environment Degradation • Local people were not informed nor did they understand the development projects in SKP	Economic Stagnation

As shown in the table, all target groups consider natural resources and environment degradation is the most serious problem in LA. The opinion survey also asked the target groups about measures to solve the problems above, and there were many measures included in the answers which are presented in the detailed answer sheets.

b.4.2. Requests from Residents for Improvement of Administrative Area by OP-LA-SKP

The largest number of requests is for improvement of infrastructure like roads and bridges, followed by electricity in public areas.

b.4.3. Complaints from Residents by OP-LA-SKP

About half of LAs (47%) did not receive any complaints from residents. The most common complaints are concerned with "the smell from marine by-products and coconut factories", followed by "wastewater from marine by-product factories, coconut juice factories and shrimp farms".

b.4.4. Interest in Environmental Issues and Information Source

Interest in environmental issues differs according to the target group, as shown in the table below.

Table 3-50: Interest in Environmental Issues

Target Group	Yes (%)	Yes, but only a little (%)	No or No Response (%)
Resident	44	53	3
Business Establishment	34	55	11
NGO	100	0	0

The target groups indicated a variety of information sources concerning environmental issues as shown in the table below.

Table 3-51: Information Source of Environmental Issues

Target Group	Primary Source	Secondary Source
Resident	TV News	Public Announcement
Business Establishment	TV News	Residents' Association
NGO	TV News	People

As shown in the table, the primary information source for environmental issues is television news.

b.4.5. Natural Resources and Environment Problems

The first and second most serious problem concerning natural resources and environment differ according to the target group as shown in the table below.

Table 3-52: Natural Resources and Environment Problems

Target Group	Most Serious Problem	Second Most Serious Problem
LA	Fishery/Marine and coastal resources	Solid waste
Resident	Fishery/Marine and coastal resources	Global warming/climate change
Business Establishment	Fishery/Marine and coastal resources	Global warming/climate change
NGO	Fishery/Marine and coastal resources	• Water quality • Solid waste

Every group replied that the most serious problem in natural resources and environment (NRE) is “Fishery/Marine and coastal resources”. The stated reasons include “Marine resources decrease drastically and fishermen gain less profit than in the past” and “Loss of Razor clam”. Residents and business establishments replied the second most serious problem in NRE is “Global Warming/Climate Change”. The reasons given for their concern are "health problems ", "adverse impacts on agriculture" and "a decrease of marine species" due to the rise of temperature. Meanwhile, LA and NGO indicated that “solid waste” is the second most serious problem because improper solid waste management causes serious environmental problems.

b.4.6. Effects of Environmental Degradation

Effects of environmental degradation differ according to the target group as shown in the table below.

Table 3-53: Effects of Environmental Degradation

Unit: %

Target Group	Serious	Some Extent	No Effect	Don't know
LA	8	67	25	0
Resident	20	64	14	2
Business Establishment	9	61	17	13
NGO	20	80	0	0

b.4.7. Comparison of Economic Development and Environmental Conservation

Regarding question of which of the two of economic development and environmental conservation is more important, the answer of each target group is summarized in the table below.

Table 3-54: Comparison of Economic Development and Environmental Conservation

Unit: %

Target Group	Economic Development	Environment Conservation	Both	Others
LA	14	28	52	6
Resident	11	47	42	0
Business Establishment	19	34	47	0

NGO	0	20	80	0

The table indicates that "Environmental Conservation" is slightly more important than "Economic Development".

b.4.8. Environmental Quality Management Projects in LA by OP-LA-SKP

All LAs have environmental quality management projects as a part of their annual budget plan. Basically, the types of projects are similar from year to year. As for the budget of 2007, the largest portion of the budget is spent for "Canal Dredging". In terms of the number of projects, however, "Improvement of Public Places" and "Campaign to raise Environmental Conscience" are most frequent.

b.4.9. Main Pollutant Source

The answer of each target group on the main source of pollution problems is summarized in the table below.

Table 3-55: Main Pollutant Source

Target Group	Air Pollution	Water Pollution	Solid Waste	Noise Pollution
LA	No Problem (56%)	Factories (28%)	Household (88%)	No Problem (47%)
Resident	Automobile (32%)	No Problem (35%)	Household (40%)	Road Transportation (41%)
Business Establishment	Automobile (43%)	Factories (37%)	Household (49%)	Road Transportation (43%)
NGO	No Problem (80%)	Factories & Household (80%)	Household (100%)	Water Transportation (20%)

b.5 Observation of Environmental Regulations

b.5.1. Degree of Observation of Environmental Regulations in SKP

The responses concerning the degree to which environmental regulations are observed in SKP differed according to target groups, as shown in the table below.

Table 3-56: Observation of Environmental Regulations in SKP

Unit: %

Target Group	Yes, observed	Somewhat observed	Seldom observed	Don't know
LA	34	33	33	0
Resident	6	39	40	15
Business Establishment	6	23	44	27
NGO	0	40	60	0

b.5.2. Measures for Observation of Regulation

Answers from each target group concerning measures for a higher degree in observation of environmental regulations are shown in the table below.

Table 3-57: Measures for Observation of Regulation

Target Group	Most Common Answer	Second Most Common Answer
LA	• The provincial administration tightens control and increases penalty • Industry awareness should be raised to take pollution control measures more seriously • People's awareness should be raised to pay more attention to environmental issues	
Resident	• The local administration (Orborjor, Tessaban and Orbortor) tightens controls and increases penalties	• People's awareness should be raised to pay more attention to environmental issues
Business Establishment	• People's awareness should be raised to pay more attention to environmental issues	• The central government tightens controls and increases penalties
NGO	• People's awareness should be raised to pay more attention to environmental issues • Government should learn the people's way-of-life before creating development projects	

As shown in the table above, “Raising people's awareness” is a common opinion among all four target groups.

b.6 Role of the Government for Improvement of Environment

b.6.1. Central Government and Provincial Administrations by OP-LA-SKP and OP-NGO-SKP

LA and NGO suggested the following measures to be taken by the central government and provincial administrations for improvement of the environment.

Table 3-58: Prioritized Measures to be taken by the Central Government

Target Group	First Priority Measure	Second Priority Measure
LA	• To construct more waste water treatment facilities and solid waste treatment & disposal facilities	• To promote participation of local people
NGO	• To promote environmental education	• To promote participation of local people • To disclose more information and data

Table 3-59: Prioritized Measures to be taken by the Provincial Administrations

Target Group	First Priority Measure	Second Priority Measure
LA	• To construct more waste water treatment facilities and solid waste treatment & disposal facilities	• To promote participation of local people
NGO	• To promote participation of local	• To promote environmental

	people	education • To help industries improve pollution control capabilities

As indicated in their answers, LA expected the central government and provincial administrations "to construct more waste water treatment facilities and solid waste treatment and disposal facilities". On the other hand, NGO expected the central government and provincial administrations "to promote environmental education and participation of local people".

b.6.2. Local Administrations by OP-NGO-SKP

For the improvement of environment, NGO replied that the local administrations (Orborjor, Tessaban and Orbortor) should perform the measures as shown in the table below.

Table 3-60: Prioritized Measures to be taken by the Local Administrations

Target Group	First Priority Measure	Second Priority Measure
NGO	• To promote environmental education	• To promote participation of local people • To disclose more information and data

b.6.3. Government by OP-RE-SKP and OP-BE-SKP

For the improvement of environment, residents and business establishments replied that the government should take the following measures, as shown in the tables below.

Table 3-61: Prioritized Measures to be taken by the Central Government

Target Group	First Priority Measure	Second Priority Measure
Resident	• To promote environmental education	• To promote participation of local people
Business Establishment	• To promote environmental education • To promote participation of local people	• To disclose more information and data

As the table shows, residents and business establishments expected the government "to promote environmental education and participation of local people".

b.7 Efforts to Confront Global Warming

b.7.1. Efforts to Confront Global Warming in LA by OP-LA-SKP and OP-NGO-SKP

About 58% or 21 LA are taking efforts to confront global warming issues at present while only one NGO (20%) does. The most common action taken by 17 LA is "educating residents about environmental conservation, water and energy conservation, 3Rs, etc.", followed by "saving energy such as raising air conditioning temperatures, using bicycles instead of cars"

in 12 LA, and "promoting the 3Rs (waste reduction, reuse and recycling)" in 10 LA. One NGO indicated they "save energy by raising air conditioning temperature" and perform "reforestation" projects.

b.7.2. Cooperation of Residents for Preservation of Environment by OP-LA-SKP and OP-NGO-SKP

LA and NGO evaluate the amount of cooperation by residents for the preservation of the environment, as shown in the table below.

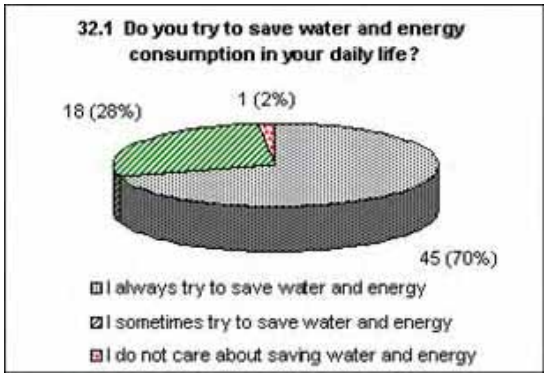
Table 3-62: Cooperation of Residents for Preservation of Environment

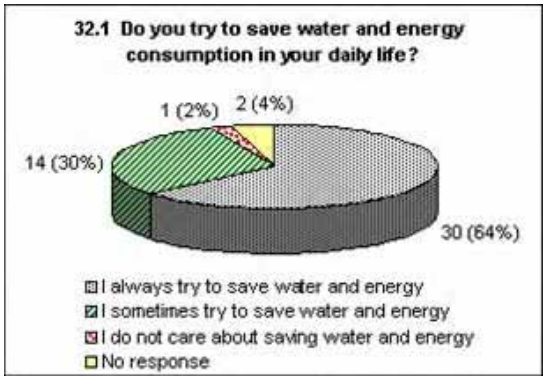
Target Group	Yes, very much (%)	Yes, some extent (%)	No or No Response (%)
LA	36	58	6
NGO	40	60	0

According to (26 out of 36) LA, the most common activity done by residents is "cleaning public areas such as roads, parks, drains, etc.," followed by "reforestation" (16 of 36 LA) and "cleaning their surrounding area" (15 of 36 LA). According to NGO, the most common activity done by residents is "cleaning their surrounding area", "reforestation" and "organizing local meetings to share experiences and information" (2 of 5 NGOs replied).

b.7.3. Water and Energy Conservation by OP-RE-SKP and OP-BE-SKP

The percentage of residents who replied they always try to conserve water and energy was 70% (see below, figure on the left), while 64% of business establishments replied that they do so (see below, figure on the right).





The most common reason given by (50% of) residents for water and energy conservation was "both economic and environmental concerns" while (45% of) business establishments indicated "economic reasons".

b.8 Willingness to Cooperate for the Improvement of Natural Resources and Environmental Management

b.8.1. Water Supply Fee by OP-RE-SKP and OP-BE-SKP

As for the current water supply fee and increase in the fee for improved service, the opinions of residents and business establishments are summarized in the tables below.

Table 3-63: Current Water Supply Fee

Target Group	Expensive (%)	Appropriate (%)	No service (%)	Don't know (%)
Resident	25	69	3	3
Business Establishment	26	64	4	6

Table 3-64: Increase of Water Supply Fee for Improved Service

Target Group	Acceptable (%)	Not Acceptable (%)	Don't know (%)
Resident	45	35	20
Business Establishment	31	52	17

More than 60% of residents and business establishments replied that the water fee is appropriate. Although the majority (45%) of resident indicated that they would accept a fee increase for improved service, the majority (52%) of business establishments would not.

b.8.2. Sewerage Fee by OP-RE-SKP and OP-BE-SKP

At present no one pays sewerage fee. The opinion of residents and business establishments on the payment of a fee for improved service is summarized in the table below.

Table 3-65: Payment of Sewerage Fee

Target Group	Acceptable (%)	Not Acceptable (%)	Don't know (%)
Resident	38	18	44
Business Establishment	26	30	44

The majority of residents and business establishments (44%) replied “Don't know”, and thus making a conclusion on the payment of a sewerage fee would be difficult.

b.8.3. Solid Waste Collection Fee by OP-RE-SKP and OP-BE-SKP

As for the solid waste collection service fee and increase of the fee for improved service, the opinions of residents and business establishments are summarized in the tables below.

Table 3-66: Current Solid Waste Collection Fee

Target Group	Expensive (%)	Appropriate (%)	Inexpensive (%)	No service (%)	Don't know (%)
Resident	2	44	5	47	2
Business Establishment	9	57	0	34	0

Table 3-67: Increase of Solid Waste Collection Supply Fee for Improved Service

Target Group	Acceptable (%)	Not Acceptable (%)	Don't know (%)
Resident	43	19	38
Business Establishment	45	39	16

More than 85% of residents and business establishments who receive solid waste collection service replied that the collection service fee is appropriate. A majority of residents and

business establishments (43% and 45% respectively) would accept an increase in the fee for improved service.

b.8.4. Increase of Tax and/or Fee for Environmental Conservation by OP-NGO-SKP

As for the increase of tax and/or fee for environmental conservation, 80% of NGO replied "strongly agree".

b.8.5. Knowledge about "Environmentally Friendly Products" by OP-RE-SKP and OP-BE-SKP

78% of residents and 81% of business establishments acknowledge "environmentally friendly products".

b.8.6. Attitude for the Purchase of "Environmentally Friendly Products" by OP-RE-SKP and OP-BE-SKP

The table below shows the attitude of residents and business establishments for the purchase of "environmentally friendly products".

Table 3-68: Attitude for the Purchase of "Environmentally Friendly Products"

Target Group	Buy them even if more expensive (%)	Buy them if the same price (%)	Others (%)
Resident	48	42	10
Business Establishment	55	32	13

About half of residents and business establishments replied they will buy "environmentally friendly products" even if they are more expensive.

b.8.7. Cooperation to Reduce Environmental Problems in Their Community by OP-RE-SKP and OP-BE-SKP

100% of residents and 98% of business establishments expressed their willingness to cooperate to reduce environmental problems in their community.

b.8.8. Cooperation to Separate Waste Collection by OP-RE-SKP and OP-BE-SKP

98% of residents and 91% of business establishments expressed their willingness to cooperate with a separate waste collection system introduced by the local administration.

b.8.9. Participation in the Process or Meetings for Formulation of PEQMP by OP-RE-SKP and OP-BE-SKP

The table below shows the intentions of residents and business establishments to participate in the process or meetings to formulate PEQMP.

Table 3-69: Intentions of Residents and Business Establishments to Participate in the Process or Meetings to Formulate PEQMP

Target Group	Participate without Conditions (%)	Participate with Conditions (%)	Others (%)
Resident	37	42	21
Business Establishment	40	32	28

b.8.10. Participation in a Committee to Monitor Implementation of the PEQMP by OP-NGO-SKP

All NGOs are willing to participate in the process without any conditions.

b.9 Suggestions for Formulation of PEQMP

In order to establish sustainable natural resources and environmental management in the province, each target group gave suggestions to formulate PEQMP as shown in the table below.

Table 3-70: Suggestions to Formulate PEQMP

Target Group	Primary Suggestion	Secondary Suggestion
LA	• The province should construct high technology incinerator for municipal solid waste and infectious solid waste disposal or establish an integrated solid waste management system in the province.	• Public participation should be considered more. • PAO should play an important role for solid waste management in the province. • Promotion of natural products and environmental friendly products should be considered.
Resident	• All related organizations should work together to improve the environment. • Implementation of the PEQMP should be concrete. All information gathered from questionnaire survey should be used to support the project.	• Support of environmental education to people is important
Business Establishment	• The government should tighten its control on wastewater pollution and solve wastewater problems caused by neighboring provinces. • Implementation of the PEQMP should be concrete. All information gathered from questionnaire survey should be used to support the project.	• Related organization responsible for the PEQMP should educate people about the plan. Monitoring and evaluation process should be done properly. • Support of environmental education to people is important • Public participation is important for environmental management.
NGO	• Creation of the plan should start with the concept of public participation and design of proper indicators to evaluate the achievement of the plan. • The implementation indicators should be designed for each area due to the differences of problems. • The province should promote tourism that creates revenue for the community and conforms to people's way of life	• There are seven more suggestions in the Appendix.