# CHAPTER 3

# CLASSIFICATION OF LANDUSE

## Introduction

Remote sensing is an efficient technique to obtain information about the characteristic of landscape with high accuracy and an ability to quantify the data. This chapter describes the study area in detail and devotes discussion to the principle and methodology of remote sensing used in classifying landuse patterns.

## Study Area

Welu estuary was selected as the study site based on the following reasons:

- This site used to be a large pristine mangrove area but has been converted into shrimp ponds which some ponds had already been abandoned. This area is therefore good to provide data to study the impact of shrimp farm expansion.
- Past and current satellite data covering the study area are available. Both Landsat-MSS and Landsat-TM images of the study area which are available had also been taken during the period of shrimp farm boom.

### Description of the Area

*Location.* Welu river starts from Khao Saming district of Trat province and enters to the rather large estuary which covers most of the areas of Khlung district, Chantaburi province. The study area is located on the eastern coast of the Gulf of Thailand between latitude 12° 15′ to 12° 30′ N. and longitude 102° 8′ to 102° 25′ E.(Fig.3.1) which comprises approximately 290 square kilometers.

The area covered in this study is the coastal line of the lower part of Welu estuary and extends up to the road to the surrounding the area ( Fig. 3.1).

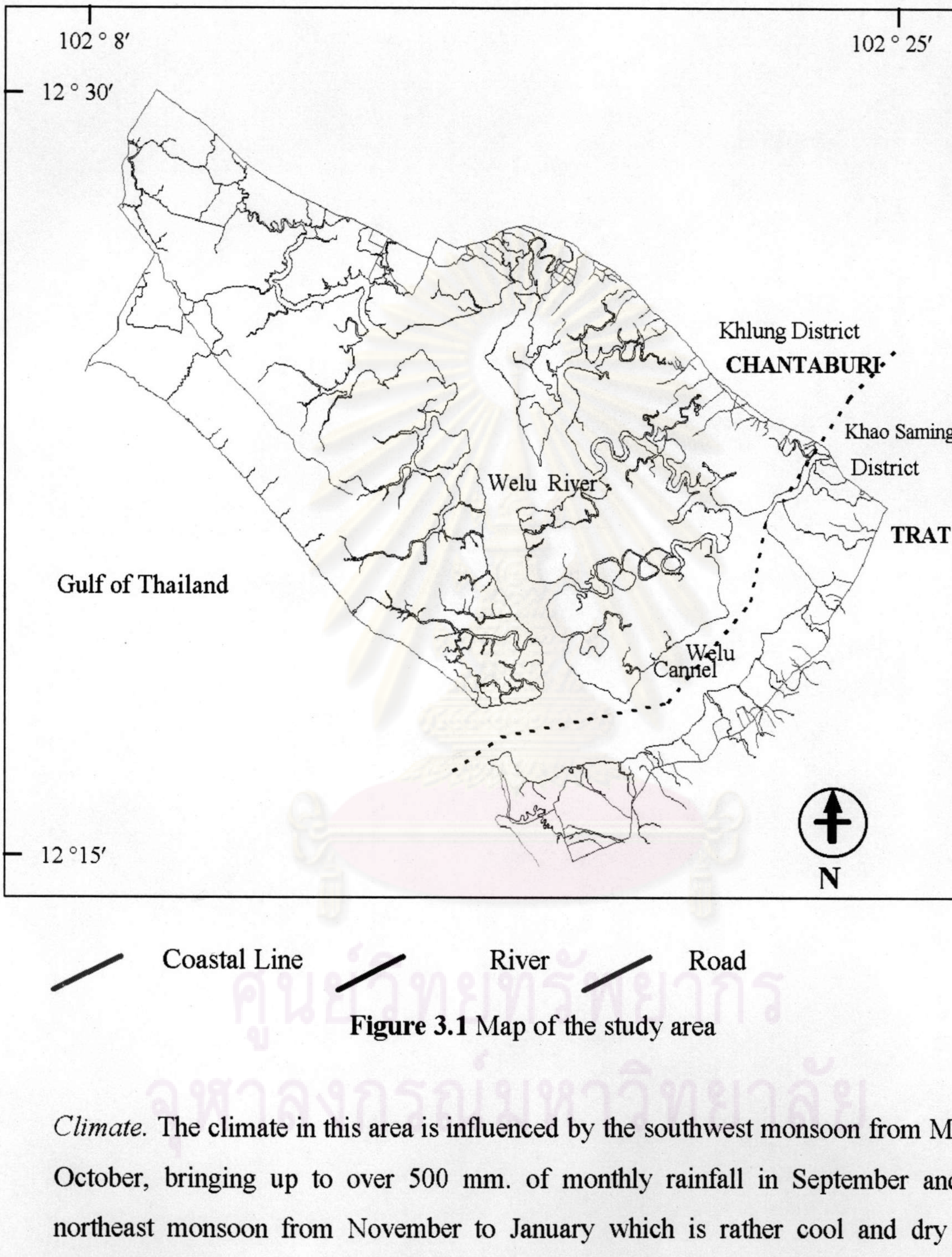


**Figure 3.1** Map of the study area

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*Climate.* The climate in this area is influenced by the southwest monsoon from May to October, bringing up to over 500 mm. of monthly rainfall in September and the northeast monsoon from November to January which is rather cool and dry with minimum mean monthly temperature in December of 24.8° C as compare to 27.7 ° C during summer.

*Land Cover and Landuse*. Up until 1986, most parts of the study were pristine mangrove with *Rhizophora sp*., *Bruguiaera sp.* and *Ceriops sp*. as dominant species (Thailand Remote Sensing Division, 1991).

The majority of landuse in the past was rice plantation which were situated on the north-west of the area. Along the road on the northern side of the study site were orchards and paddy fields, while shrimp ponds were limited along the seashore.

**Remote Sensing Techniques for Landuse Classification**

Remote sensing means the process of information acquisition about an object with the use of a sensor that is not in physical contact with the object. Sensor systems detect and measure electromagnetic energy emitted or reflected by observing objects. Remote sensing systems can be classified into 2 types: 1)active and 2)passive systems (Harrison and Jupp, 1989). Active remote sensing devices, such as radar, emit energy toward an object and then detect the amount of radiation which is reflected backward. The passive system relies on the radiation emitted or reflected from the target which originates from some other source, mainly the sun.

**Properties of Remotely Sensed Data**

A reflectance from an object varies in wavelength. The curve of relationship between percentage of reflectance and interval of wavelength is called spectral reflectance curve ( Fig. 3.2). Since each object has its own spectral signature, it is possible to distinguish properties of objects from remotely sensed data.

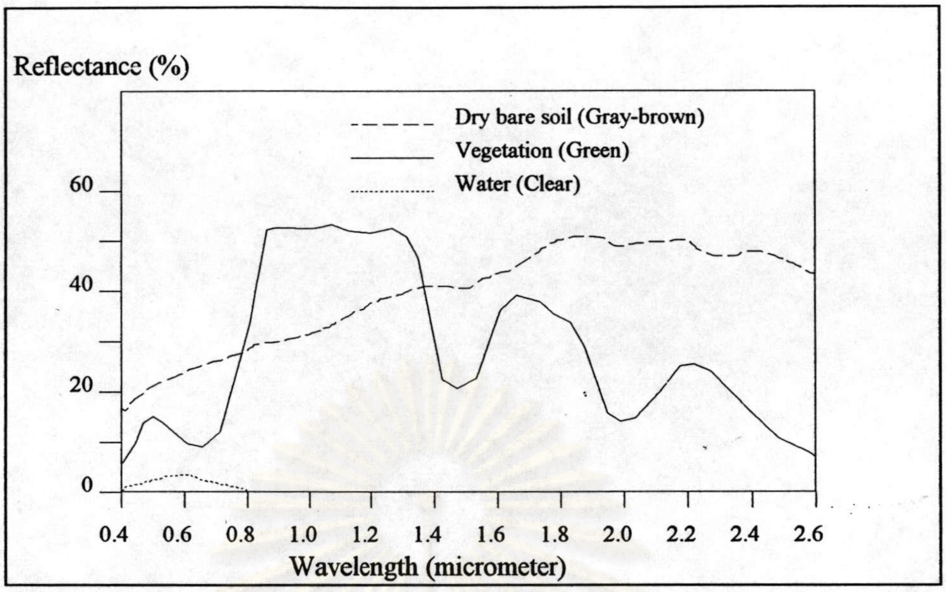


**Figure 3.2** Typical curves of spectral reflectance for vegetation, soil, and water (adapted from Harrison and Jupp ,1989 ).

The detail as described above is one of the reflectance inspection, namely, a fine inspection. Another method is a coarse inspection which uses *albedo* as a measurement. Albedo express different types of land cover reflecting different proportions of incident electromagnetic energy (Table 3.1).

**Table 3.1** Albedo of different surface covers (Bache and MacAskill 1984)

| Surface | Albedo |
|---|---|
| Snow: old | 0.4 |
| fresh | 0.8-0.95 |
| Grass | 0.17-0.30 |
| Agricultural crops | 0.15-0.28 |
| Deciduous forests | 0.10-0.18 |
| Coniferous forest | 0.04-0.15 |
| Water surfaces | 0.03-1.00 |
| Bare soil | 0.06-0.48 |

**Extract Information From Remotely Sensed Data**

This section will describe briefly about the function of the processes to extract information from remotely sensed data. Details of the processes can be found in most image processing text books (e.g., Harrison and Jupp, 1990) and remote sensing text books (e.g., Cracknell and Hayes, 1989); thus, they will not be repeatedly described here.

The processes to extract information from remotely sensed data are widely divide into two basic steps: 1)data processing, and 2)data classification.

Data processing serves 3 purposes; to correct data distortion, to enhance data separability, and to reconfigure data into a desired form. *Data distortion* result from several causes: deflection of detector, atmospheric effect, or natural noise of system. There are several techniques to correct data distortion depending on difference in nature of deformity, namely, interpolation, difference, and despiking. *Data enhancement* is the modification of data values to highlight information within the image, in order to identify particular objects in an image which have low contrast. Several techniques for data enhancement are: 1)band ratio transformation 2)high pass filtering 3)linear and non-linear rescaling, and 4)principal component analysis. *Data reconfiguration* is the process to make image orientation coincide with geographic coordinates by spatial resampling. Additionally, this technique transforms data structure to make their format suitable for electronic calculation.

Data classification refers to a systematic method of identifying a setting class (e.g., paddy field, grassland) to each pixel in the image. From a statistical point of view, classification is a process to partition data into categories with the condition that the degree of heterogeneous (or variance) of each class is equal to or less than accepting level as defined by the user who controls the process. The first step of the classification is determining nucleus or seed (representing a value of required class) of each class, and the next step is assigning a class to each data element. Nucleus determination can be either supervised or unsupervised or semi-supervised (mixed). Supervised classification works from training sites or areas of known ground cover designated by the user, and classifying the image by assigning each data element in the image to one of the land cover classes described by the training sites. Unsupervised classification uses cluster analysis to distinguish difference in reflectance value across a set of bands and create a classification from typical reflectance patterns.

As reviewed by Harrison and Jupp (1990), there are several techniques for classification. For single channel data, the process can be done through the density slicing method which involves grouping ranges of values in single image channel to represent different categories. For multi-channel data, the process can be done through a nearest neighbor classifier, a maximum likelihood classifier or a parallelepiped classifier.

In the nearest neighbor classification, n-channel data of pixels are viewed as vector pointing in an n-dimensional space. Distance between pixel's vectors and vectors pointing to class nuclei are calculated. A pixel is mapped into the class which the euclidean distance, the distance between pixel's vector and the class's nucleus-vector, is shortest. In the maximum likelihood classification, a probability density function for each class is formulated (described by the mean vector and the covariance matrix of the trained data). Probability of the pixel value of each class is calculated by substituting pixel values into each probability density function. The pixel is mapped into class that the calculated probability is maximum. In parallelepiped classification, classification categories are formed as n-dimensional boxes (for n-channel data) having the nucleus of class places at the center of each box and also with specified data range. Pixels are mapped into the first class that they satisfied.

## Landuse Classification From Remotely Sensed Data

### Data Used

Remotely sensed data recorded in the from of Computer Compatible Tapes (CCTs) which received by Thailand Remote Sensing Receiving Station, National Research Council of Thailand were used in the study. Data covered the study area (MSS: path 137, row 51; TM path 128, row 51) were acquired on 21-Jan.-1982 and 02-Mar.-1986 for Landsat-MSS, 20-Feb.-1988, 24-Jan.-1990 and 15-Dec.-1992 for Landsat-TM.

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**Software Used**

In remotely sensed data preprocessing and classification, the data were processed with the version 3.2 of microBRIAN program. This software was jointly developed by the Water Resources Division of CSIRO and the MPA Ltd. in Australia. The software consists of more than a hundred modules covering the whole range of image processing techniques and image statistical analysis.

**Image Rectification**

Since remotely sensed imagery contain a variety of geometric distortions, it is necessary to be accounted for before registering with different image source. The precise geometric correction could be applied by rectifying and resampling the image to standard cartographic projection, such as the Universal Transverse Mercator Projection (UTM), at a 30-m resolution using the microBRIAN's rectification programs (Fig. 3.3). The base maps used in rectification process were 1:50,000 topographic maps of the study area.

In the first step of rectification, a set of ground control points (GCPs) on both the map and the image was setting. Ideally, the selected GCPs should distribute all over the image to be rectified. Because majority of the study area is covered with mangrove and only the artificial structures which is the road around the boundary of the site, setting up of well-distributed GCPs was rather difficult. This study mainly selected a number of GCPs from artificial structures, road intersections, and others from consistent natural landmarks such as cape, island.

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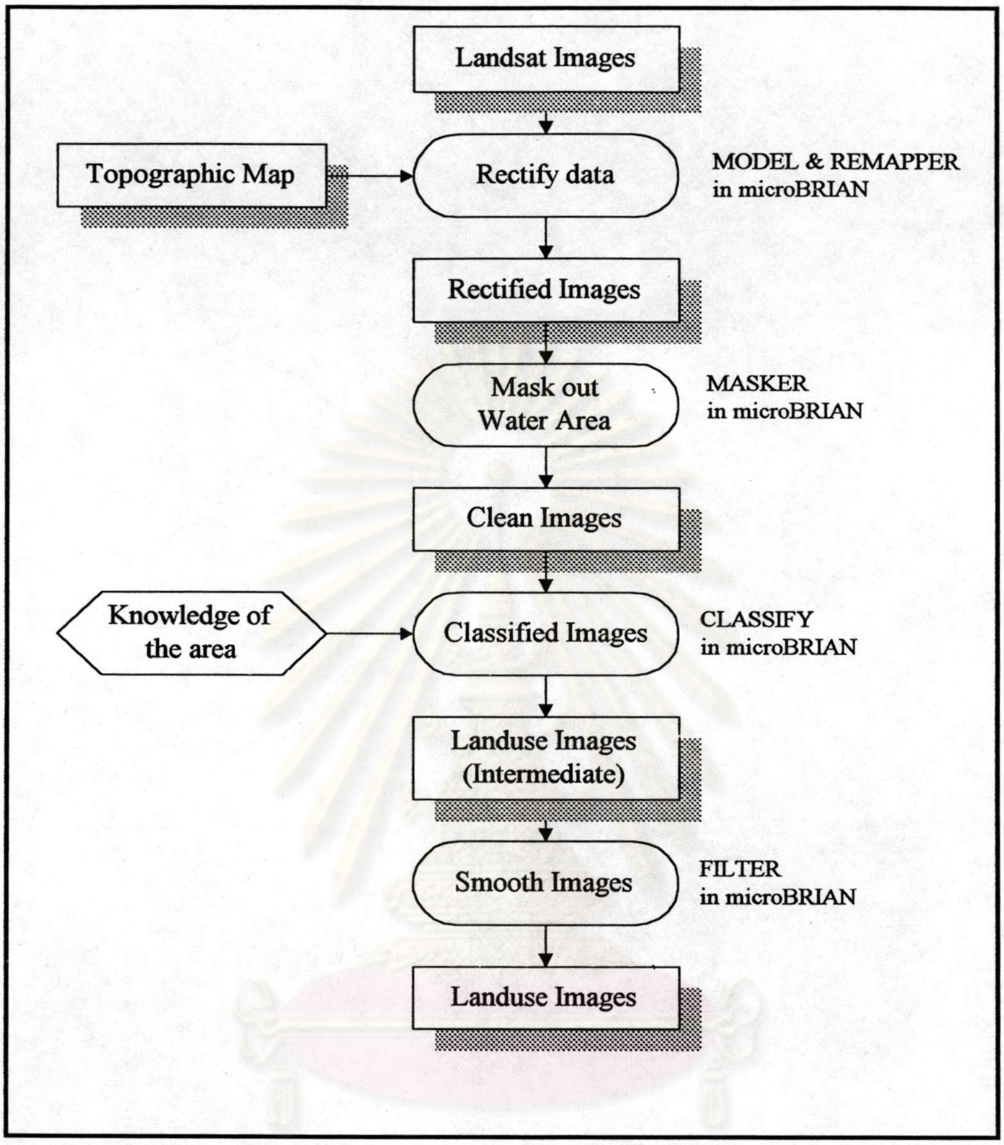


**Figure 3.3** Data flow diagram of the landuse classify process

The second step was to find the best fitting transformation model to map coordinates between the raster (or image) reference and the UTM (or map) reference. According to the results calculated by the rectification programs, the best fitting model from the two set of coordinates (raster and UTM) in this study is a bilinear model.

The received model were used to rectified the remotely sensed images of each year so that their geographical references were the same as other maps.

In the results of rectification, the average of RMS.(root-mean-square) error of X and Y coordinate for all images were found to be 45 and 41.3 m. respectively.

**Image Classification**

This study classified landuse into seven categories (Table 3.2) related to specific problem referred in the objectives and resolution of remotely sensed data.

**Table 3.2** Definition of landuse classes used in the study

| Class | Symbol | Definition |
|---|---|---|
| Mangrove | MG | area covered with mangrove |
| Mangrove cleared | MC | mangrove cleared area in preparation for shrimp farming |
| Swamp and/or Mangrove clearing | SW/MC | Natural swamp and/or mangrove clearing stored with water (too similar to classify separately) |
| Shrimp farm | SF | Shrimp farming area including rearing ponds, water system and other constructions in farm area |
| Standing tree | ST | Areas covered by forest of all types and/or orchard plantation area |
| Paddy field | PF | Area for rice cultivation |
| Grassland | GL | Area covered with grass |

In classification stage, the water areas (river, cannel and sea) were discarded by assigning those cells with null value (equal to 255 in microBRIAN 8-bit images). After excluding the water areas, the images were classified by using the nearest neighbor classifier technique with semi-supervised classification procedure. Firstly, the image were stratified into classes having homogeneous spectral values using rules of specific spectral range derived from areas of known ground cover. Then, these classes were aggregated to form superclasses by considering the similarity of their spectral values. After that, landuse classes were assigned to each final superclasses using background and ancillary data of the study area (Plates 3.1-3.5).

Finally, to interpolate missing values due to scanner or reception malfunctions in some years of classified image(1982,1984), these images were run through a smoothing process. The process used a 3x3 matrix as the filter to replace the center cell of matrix by mode of cell values of the entire matrix.

**Classification Accuracy and Discussion**

Accuracy of the classification was evaluated by comparing the classified image with aerial color infrared photograph and field surveys. Since aerial photograph mapping in Thailand has not been regularly taken, accuracy analysis using aerial photograph was limited to the 1986 classified image only ( aerial photograph was taken on 12-Oct.-1985). Ground truthing by field surveys were carried out in August and November, 1992. A Global Positioning System (GPS) was used to help position the accurate coordinate (latitude and longitude) of ground control points; then recorded the landuse of each position. This study determined altogether 97 ground control points over the study area.

Contingency matrices of the classified results are shown in table 3.3 and 3.4. Classification accuracy are defined as:

$$\text{Overall accuracy} = \sum_{i=1}^{m} a_{ii} / N \tag{3.3}$$

$$\text{Producer's accuracy for class } i = a_{ii} / \sum_{j=1}^{m} a_{ji} \tag{3.4}$$

$$\text{User's accuracy for class } i = a_{ii} / \sum_{j=1}^{m} a_{ij} \tag{3.5}$$

where $a_{ij}$ is a value of the contingency matrix for an element in row $i$ column j

$m$ is the number of classes

$N$ is the total number of sampling cells

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**Table 3.3** Contingency matrix of the 1986 classified image.

*Aerial color infrared photograph ( Verified)*

| | | MG | ST | PF | SW/MC | SF | GL | Total | % User's Accuracy |
|---|---|---|---|---|---|---|---|---|---|
| | MG | 43 | 1 | 2 | 1 | 2 | 0 | 49 | 87.76 |
| | ST | 2 | 12 | 3 | 0 | 0 | 3 | 17 | 70.59 |
| *Classified* | PF | 4 | 3 | 19 | 1 | 3 | 3 | 30 | 63.33 |
| *Image* | SW/MC | 2 | 0 | 3 | 15 | 2 | 1 | 22 | 68.18 |
| *(Observed)* | SF | 3 | 0 | 1 | 2 | 23 | 1 | 29 | 79.31 |
| | GL | 0 | 2 | 5 | 1 | 1 | 17 | 26 | 65.38 |
| | Total | 54 | 16 | 28 | 19 | 30 | 25 | 173 | |
| | %Producer's Accuracy | 79.63 | 75.00 | 67.86 | 78.95 | 76.67 | 68.00 | | |

Overall accuracy = 74.57 %

**Table 3.4** Contingency matrix of the 1992 classified image

*Ground truth (Verified)*

| | | MG | ST | PF | SW/MC | SF | GL | MC | Total | % User's Accuracy |
|---|---|---|---|---|---|---|---|---|---|---|
| | MG | 12 | 0 | 0 | 0 | 0 | 0 | 1 | 13 | 92.31 |
| | ST | 1 | 7 | 1 | 0 | 0 | 0 | 0 | 9 | 77.78 |
| *Classified* | PF | 1 | 1 | 25 | 0 | 1 | 1 | 0 | 29 | 86.21 |
| *Image* | SW/MC | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 7 | 85.71 |
| *(Observed)* | SF | 0 | 0 | 0 | 1 | 20 | 0 | 2 | 23 | 86.96 |
| | GL | 0 | 0 | 1 | 0 | 0 | 6 | 0 | 7 | 85.71 |
| | MC | 0 | 0 | 1 | 0 | 1 | 0 | 7 | 9 | 77.78 |
| | Total | 14 | 8 | 28 | 7 | 23 | 7 | 10 | 97 | |
| | %Producer's Accuracy | 85.71 | 87.50 | 89.29 | 85.71 | 89.96 | 85.71 | 70.00 | | |

Overall accuracy = 85.57 %

From the two tables, the classification procedure used in this study could discriminate between various type of landuse with a satisfied accuracy. A low accuracy of paddy field class in 1986 classified image might be resulted from status of paddy field in that period (satellite image acquired on 2-Mar.-1986) which stored water had evaporated. Hence, paddy fields could be classified as grassland class.

Actually, the study intended to classify residential areas, but the resolution of MSS and TM data did not allow. Therefore, additional ancillary data would be needed if residential areas are to be mapped.

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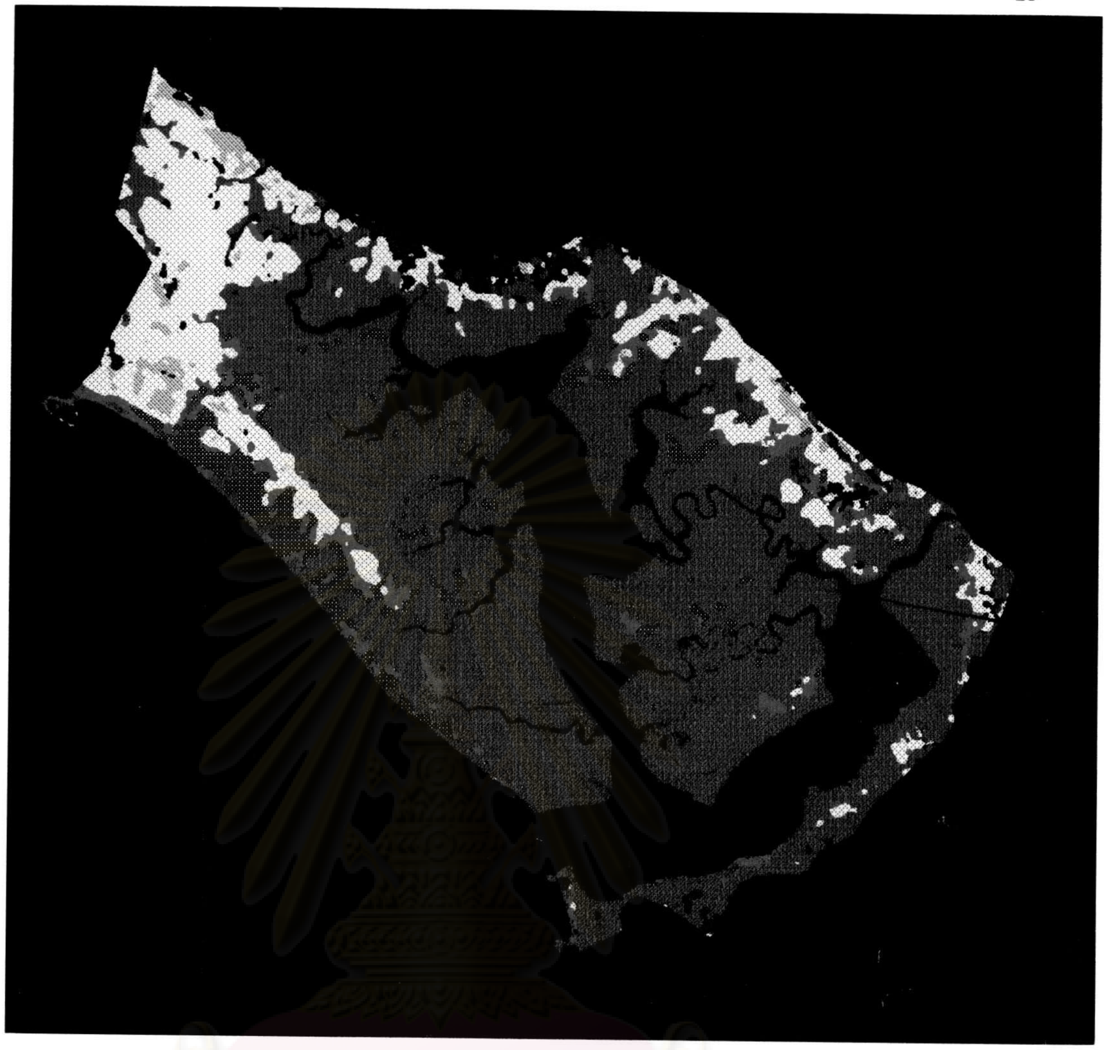

Mangrove Standing Tree Paddy Field Shrimp Farm

Swamp and/or Mangrove Cleared Grass Land

**Plate 3.1** 1982 Classified image of the study area.

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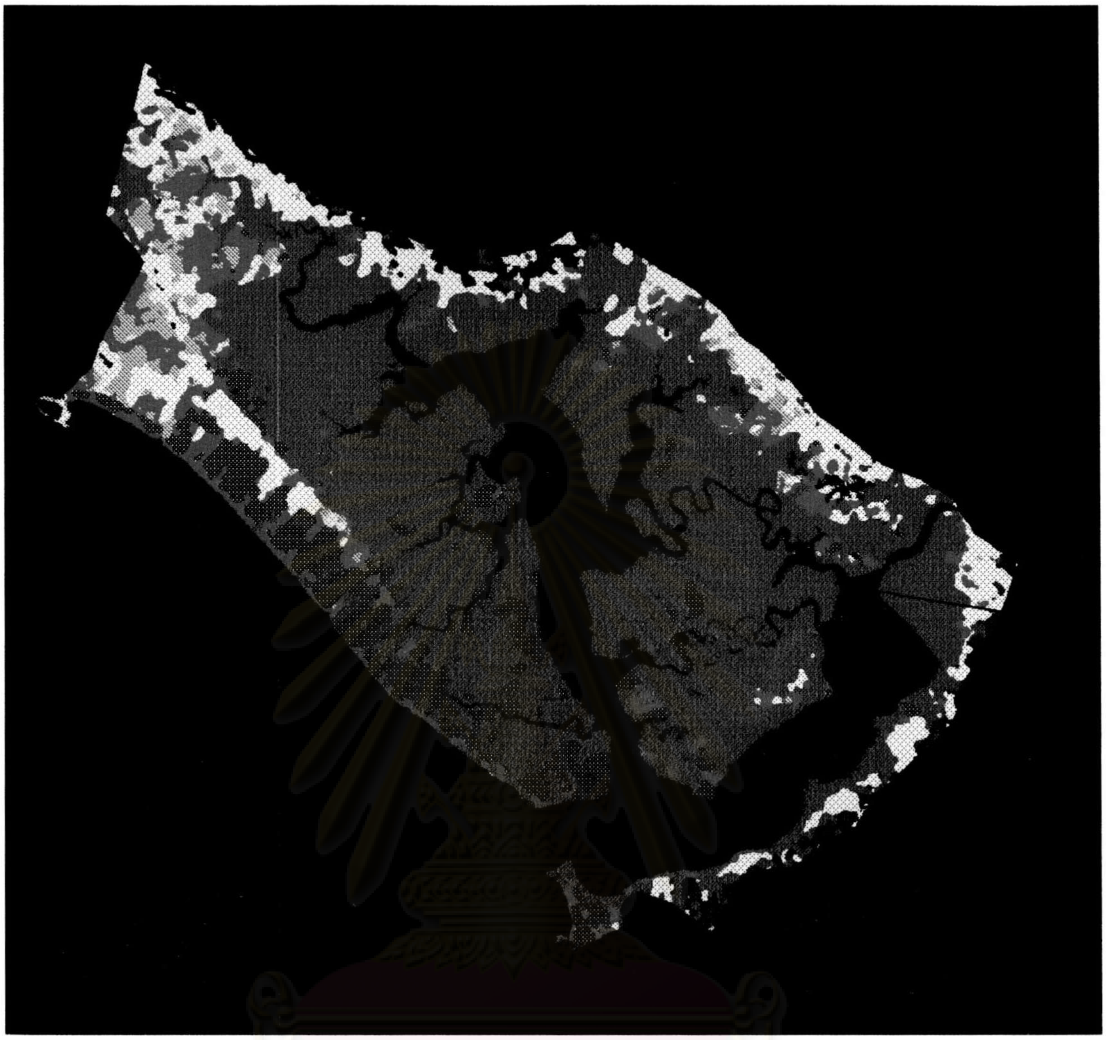



**Plate 3.2** 1986 Classified image of the study area.

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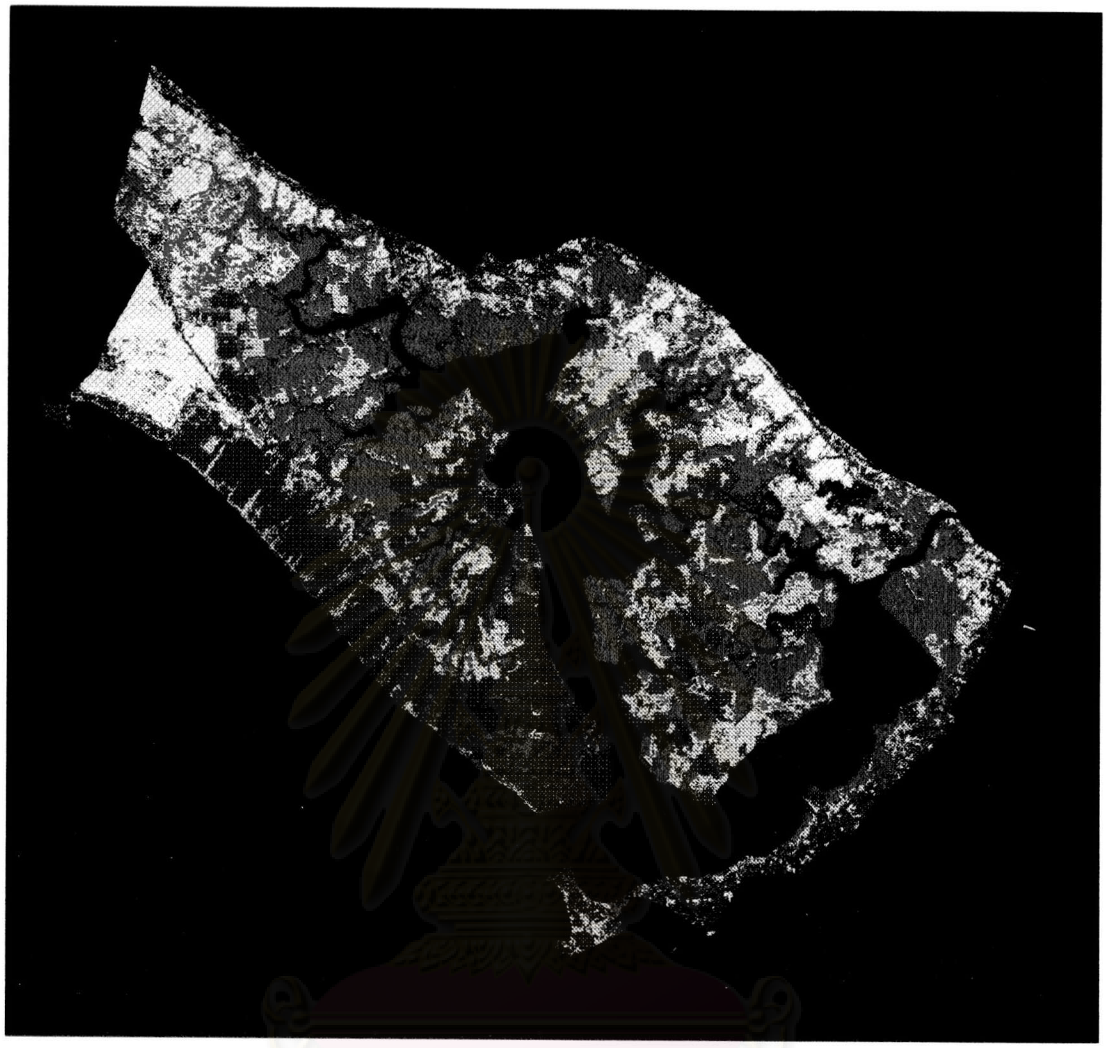

Mangrove | Standing Tree | Paddy Field | Shrimp Farm

Swamp and/or Mangrove Cleared | Grass Land | Mangrove Cleared

**Plate 3.3** 1988 Classified image of the study area.

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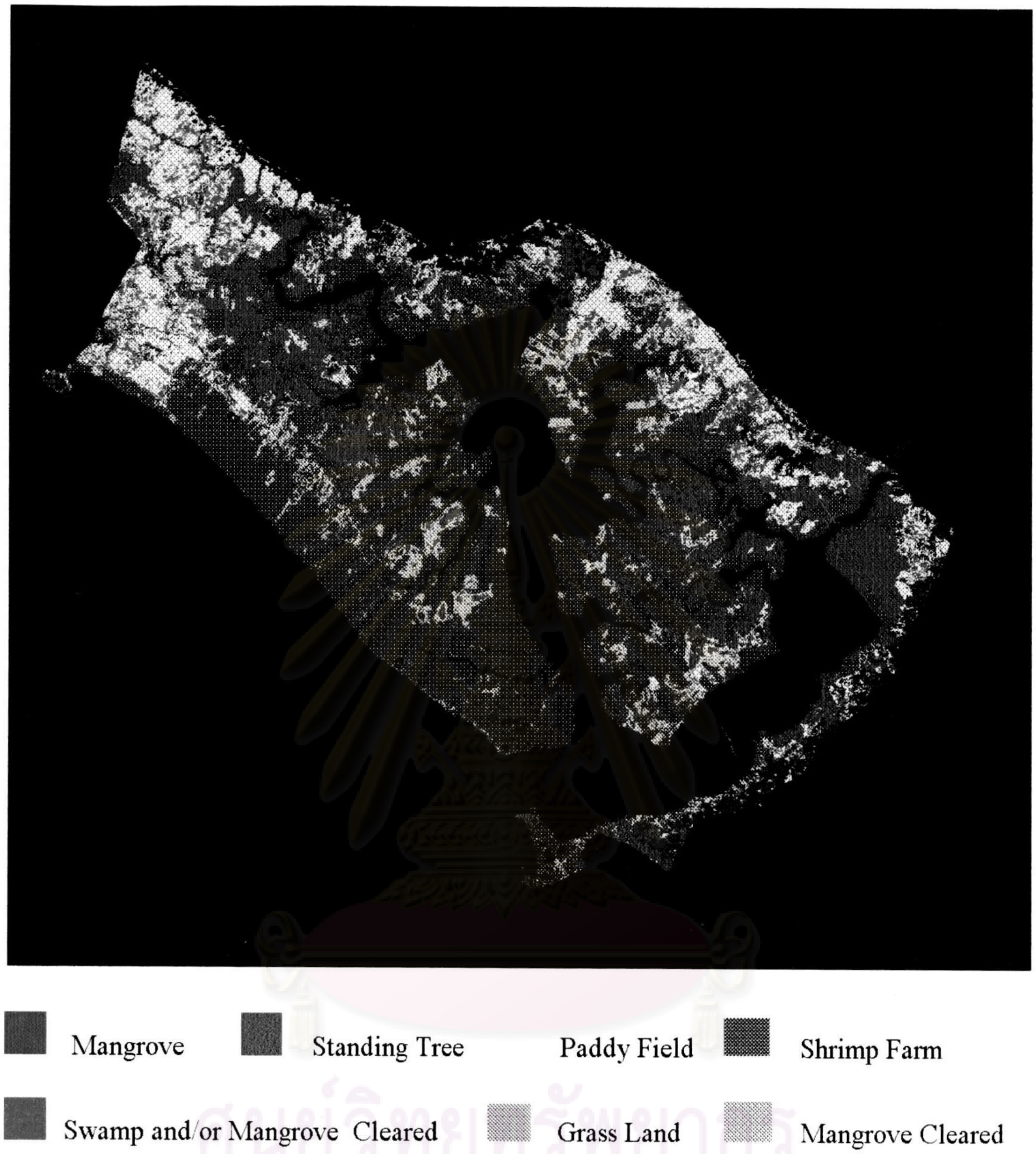


**Plate 3.4** 1990 Classified image of the study area.

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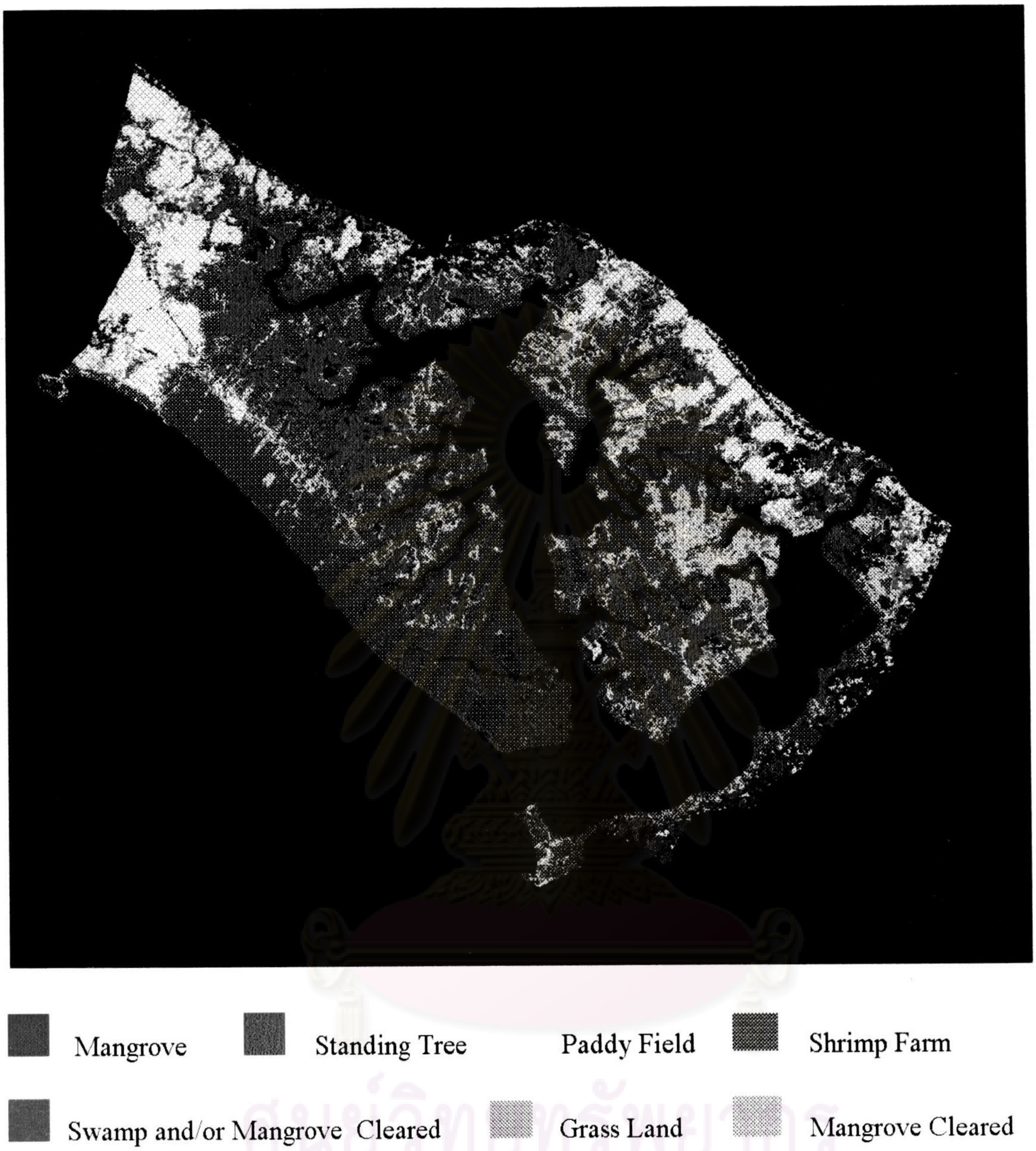


**Plate 3.5** 1992 Classified image of the study area.

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