
DETECTING CHANGES IN THE MANGROVE FORESTS OF SOUTHERN THAILAND USING REMOTELY SENSED DATA AND GIS

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ABSTRACT

Remote sensing and GIS were used to analyze the changes in the mangrove forest. Mangrove forests have been used by different user groups. Changing of government policies on mangrove forest utilization and management caused the occurrence of three major activities; mangrove forest concession, tin-mining activities and intensive shrimp farming. These activities were considered as the major reasons for changes of mangrove forest areas and led to the degradation of mangrove forest, the loss of mangrove forest and ecological disturbance. Furthermore, it affected the mangrove forest dependence-dwellers.

1. INTRODUCTION

Mangrove forests are one of the primary features of coastal ecosystems throughout the tropical and subtropical region of the world. Various kinds of fauna including shrimp, fishes, crabs, mollusks, mammals, reptiles, birds, insects and micro-organisms are found in mangroves ecosystem. People in mangrove communities have utilized mangrove ecosystems for their food resources, firewood, charcoal, timber and other minor products. In Thailand mangrove forests are found in 23 provinces of the coastline. It was estimated that 168,682 hectares of mangrove forest area existed in 1993. More than 50% of mangrove forests which cover an area of 199,217 ha. were lost during 1961-1993. Various activities carrying out in mangrove forest area such as shrimp farming, tin-mining activities, mangrove over-exploitation, industrial area and settlements leading to the reduction of mangrove forests. Among these activities, shrimp farming, tin-mining and overexploitation are major causes of the loss of mangrove forest area.

Having recognized the importance of mangrove ecosystem, the government has established some policies on mangrove forest conservation. The establishment of new mangrove areas through afforestation and rehabilitation of degraded mangrove forest are conducted throughout the country. However, remotely sensed data is one of the best source of information that can show the location of all areas that have been deforested or degraded or still healthy. More over Landsat Thematic Mapper data can be used to define the degree of degradation of the mangrove forest. GIS land use change detection analysis can be used to identify the changes that took place.

The main objectives of this research was to detect, identify and delineate the areas of mangrove forest in Phang-Nga Bay area, define all changes happened to the mangrove forest during the last 20 years using the multi-temporal analysis and identify the degree of degradation in the mangrove forest.

2. MATERIALS AND METHODS

2.1 Area of Study

Bang-Toey sub-district is one of 9 sub-districts of Muang district in Phang-Nga Province, southern Thailand. It covers an area of 108.30 square kilometers. Figure 1 shows the location of the study area. The southern part of the sub-district is bordered by Phang-Nga Bay which is known as one of the best developed natural mangrove forests

remaining and the area of mangrove forest in this province. Eight villages are under the administration area of Bang-Toey sub-district. They are Bang-Toey Nue Village, Bang-Toey Klang Village, Khao Thao Village, Bang Seid Village, Gor Khiem Village, Ban Klang Village, Bang-Toey Tai Village and Bang Pad Village.

Bang-Toey sub-district is generally characterized by a flat landform with a very gentle slope. The northern part of sub-district is surrounded by limestone mountains. The utmost south of Bang-Toey sub-district comprises the other land form types such as flood plains, mudflats and coastal zones which is a part of Phang-Nga Bay.

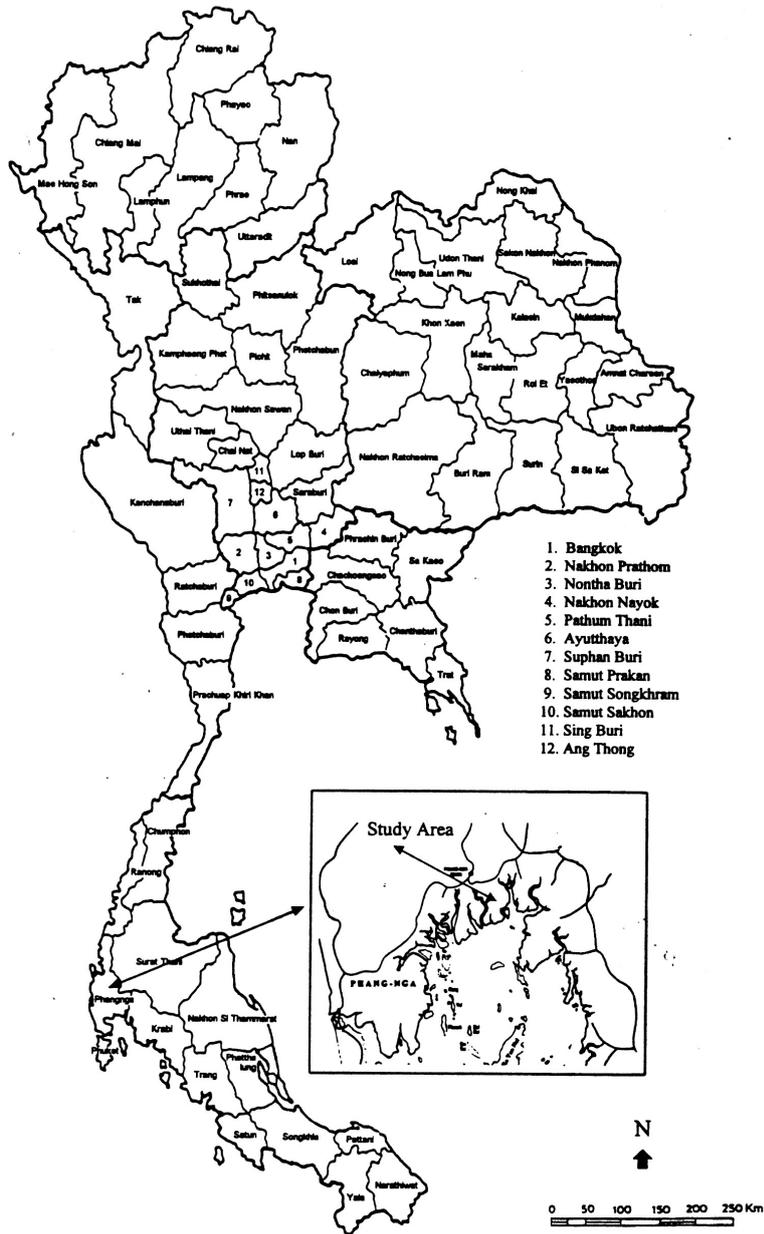


Figure 1. Location map of the study area in Bang-Toey sub-district, Phang-Nga Province, southern Thailand.

2.2 Generation of land use/cover change map of Bang-Toey sub-district from satellite imagery

Seven bands of Landsat satellite imagery 1995 covering Bang-Toey sub-district was georeferenced. A false color composite image was generated by using 3 bands (453/RGB) combination. In the false color composite, the mangrove forest can be differentiated from other features such as terrestrial forest, agriculture area and shrimp ponds. This gave the general idea about different land use/cover type of Bang-Toey sub-district. Supervised classification was selected to classify the image. The available aerial photos covering some part of Bang-Toey sub-

district provided useful information in selecting training samples for each classes. Then the computer aided classification was implemented on the TM image to come up with the cover type map. Ground truth for both classified and unclassified areas were done during fieldwork.

After fieldwork a satellite imagery of 1996 was obtained, it provided more updated information, and some changes in the area could be seen clearer than the image of 1995. Therefore, the image of 1996 was used instead of the one of 1995 to generate land use/cover change map 1988-1996. The image of 1988 and 1996 were georeferenced and generated for false color composite 453/RGB in order to be used for classification. The experiences gained from the interpretation of image 1995 and ground truth were used during the selection of training samples and the evaluation of candidate training classes of the satellite images 1988 and 1996. Maximum likelihood algorithm was selected for running classification using a threshold distance of 40. From the result the two images were classified to 9 classes as follows: 1) mangrove forest, 2) open mangrove forest, 3) rubber and oil palm plantation, 4) abandoned tin-mining area, 5) paddy field, 6) bare soil, 7) terrestrial forest, 8) water and 9) turbid water/shrimp ponds. Even though some mangrove species like *Rhizophora species*. can be found as pure stand in one zone, distinguishing of different species zonation was not possible for this study because it requires intensive survey. However, a zonation of *Rhizophora species* was found in a small part of the study area which appears in the bright red color in the image. But from ground survey it was found that this cannot be applied to other mangrove forest areas which appear in the same color. Moreover, in the study area most of mangrove forest has mixed image. For this reason the mangrove forest area was classified into two separate classes. One is the mangrove forest and the other is the open mangrove forest. The mangrove species which have not much differences of spectral reflectance value were put in one class as mangrove forest. Meanwhile the spectral reflectance value of the open mangrove forest such as community mangrove forest and young mangrove plantation was lower than the normal mangrove forest because of the effect of water under the trees.

As this study focuses on the changes in mangrove forest area, rubber and oil palm plantation was grouped as one class because their spectral reflectance values are not much different. Although turbid water could not be separated from shrimp ponds, one can be distinguished from another by the shape and location. Final classification maps of 1988 and 1996 were overlaid by using three dimensional table to generate a land use/cover change map of Bang-Toey sub-district. A flow chart shows generation of land use/cover change map is shown in Figure 2.

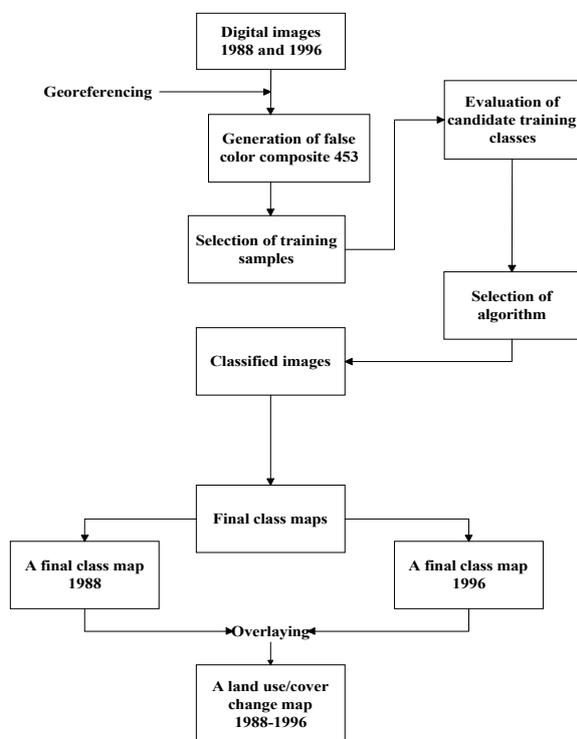


Figure 2. Change detection analysis using satellite images

2.3 Generation of land use/cover change map of Ban Klang village using aerial photographs

Two maps showing land use/cover map changes for the periods 1976-1984 and 1984-1995 were generated from aerial photographs of 1976, 1984 and 1995. A grid of a scale 1:12,500 was created for drawing of a base map. It was found that a lot of changes had occurred over the years in the boundary of study area due to its location on a coastal area. Therefore, three different base maps were made in order that the delineation of photo-interpretation would be fitted. Four ground control points from GPS readings and other auxiliary points were marked on the aerial photographs to be used for radial triangulation. As it is not possible to obtain four ground control points in Ban Klang village, one of four ground control points is selected from Bang Pad village, a neighboring village. Therefore, this village has to be included in the map of Ban Klang village. By using radial triangulation techniques aerial photographs were joined together. The same technique was used for the three different dates of aerial photos (1976, 1984 and 1995). Then photo-interpretation of each year was delineated on its own base map. These three maps from the delineation of photo-interpretation were digitized using ILWIS program. From this step land use/cover maps of 1976, 1984 and 1995 were generated. A two-dimensional table was created for map overlaying to obtain a land use/cover change map. The land use/cover map of 1976 was overlaid on the one of 1984 to generate the land use/cover change map 1976-1984. The same method was used for the generation of land use/cover change map 1984-1995. The steps for generation of land/use cover change maps 1976-1984 and 1984-1996 are shown in Figure 3.

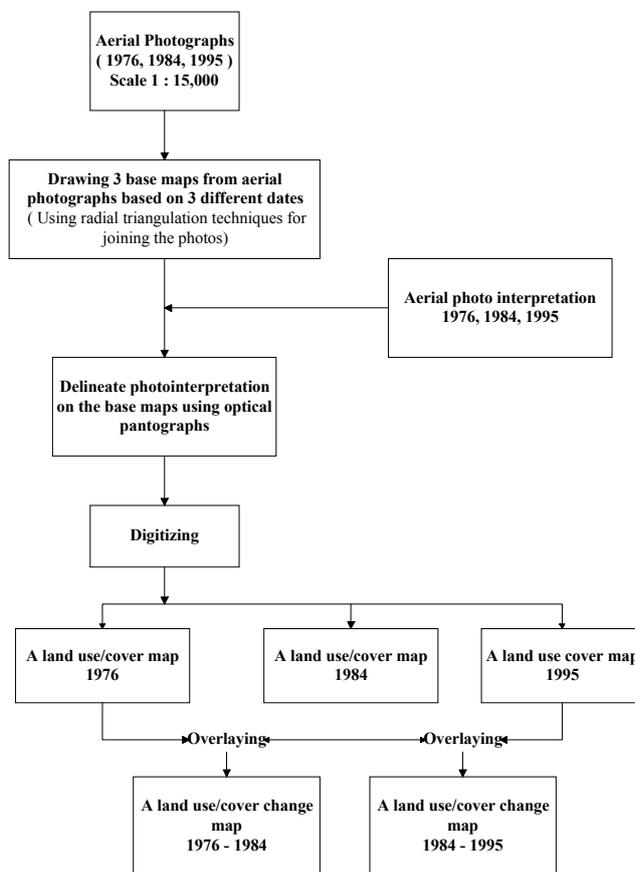


Figure 3. Change detection analysis using aerial photographs.

3. RESULTS AND DISCUSSIONS

3.1 Changes of mangrove forest in Bang-Toey sub-district

The information from the land use/cover map 1996 indicates that open mangrove forests appeared throughout Bang-Toey sub-district. These open mangrove forests are abandoned tin-mining areas which some trees have regenerated, degraded-mangrove forests resulted from over-exploitation, and the young mangrove forest plantation planted by Mangrove Forest Management Unit. The presence of a large open mangrove forest area in the small island on the right of the map is the young mangrove forest plantation. The tin-mining is one of the activities leading to the loss of mangrove forest area. This appears in large areas in the map.

The land use/cover change map 1988/1996 (Figure 4) provides information about the conversion of mangrove forest in Bang-Toey sub-district to other types of land use/cover. Despite the area of change in each class cannot be shown due to lack of accuracy assessment, this map gives the idea of changes and their locations. During 1988-1996 mangrove forests were mainly converted into tin-mining areas and shrimp ponds. At present these tin-mining areas are abandoned due to the expiration of tin-mining concession permit. Some abandoned tin-mining areas are replaced by shrimp ponds and some are changed to be the open mangrove forest because of natural regeneration.

The change of mangrove forest to open mangrove forest has occurred both in the big patch and along the small branch of rivers. Conversely, the change of open mangrove forest to the better condition of mangrove forest in some places and the change of tin-mining area to open mangrove forest are visible.

Finally, it can be seen that the condition of mangrove forest has been changed from 1988 to 1996. Tin-mining areas, shrimp ponds and open mangrove forest are major changes occurring to mangrove forest in Bang-Toey sub-district.

3.2 Changes of mangrove forest in Ban Klang village

In order to know the changes of mangrove forest area and their locations in the village from 1976 to 1995, the information from land use/cover map 1995 and land/use cover change map of 1976/1984 (Figure 5) and 1984/1995 (Figure 6) are presented in this section.

From a land use/cover change map of Ban Klang village 1976/1984, it shows that the presence of tin-mining (Tm) was the major change of mangrove forest area in the village from 1976 to 1984. During this period tin-mining activities covered an area of 71 ha. Both mangrove forest and inland forest (For) became land clearance (Clr). Meanwhile some areas of mangrove forest (Mgrv) and degraded mangrove forest (Dmgrv) were converted to settlements (Stm) as well. The details on area of changes is shown in Table 1.

Comparing the land use/cover change map 1976-1984 with 1984-1995, it is obvious that the change in area of mangrove forest during 1984-1995 is more than during 1976-1984. From 1984 to 1995 mangrove forest has been changed to various land use/cover types such as community mangrove forest (Comgrv), degraded mangrove forest (Dmgrv), shrimp ponds (Sp), settlements (Stm) and agriculture area (Agri). The estimated area of these changes is shown in Table 2.

Table 1. The estimated area of changes of Ban Klang village 1976-1984

Types of land use/cover change	Estimated area (ha.)
Degraded mangrove forest (Dmgrv) to Mangrove forest (Mgrv)	11.56
Degraded mangrove forest (Dmgrv) to Settlement (Stm)	7.81*
Forest (For) to Clearance (Clr)	8.23
Forest (For) to Agriculture (Agri)	12.36
Mangrove forest (Mgrv) to Clearance (Clr)	8.09
Mangrove forest (Mgrv) to Tin-mining area	71.17
Mangrove forest (Mgrv) to Settlement (Stm)	5.00

Table 2. The estimated area of changes of Ban Klang village 1984-1995

Types of land use/cover change	Estimated area (ha.)
Forest (For) to Agriculture area (Agri) / Settlements (Stm)	21.92
Mangrove forest (Mgrv) to community mangrove forest(Comgrv)**	14.45*
Mangrove forest (Mgrv) to degraded mangrove forest (Dmgrv)**	59.24
Mangrove forest (Mgrv) to Agriculture (Agri)	23.79
Mangrove forest (Mgrv) to shrimp ponds (Sp)	14.12
Mangrove forest (Mgrv) to abandoned tin-mining (Atm)**	59.39
Paddy field (Pd) / Settlements (St) to shrimp ponds (Sp)	14.78
Abandoned tin-mining (Atm) to community mangrove forest (Comgrv)	90.01 *
Abandoned tin-mining (Atm) to degraded mangrove forest (Dmgrv)	17.77
Abandoned tin-mining (Atm) to shrimp ponds (Sp)	7.51
Mangrove forest (Mgrv) to settlements (Stm)**	10.32

Conclusion

Mangrove forests have been used by different user groups. Changing of government policies on mangrove forest utilization and management caused the occurrence of three major activities; mangrove forest concession, tin-mining activities and intensive shrimp farming. These activities were considered as the major reasons for changes of mangrove forest areas and led to the degradation of mangrove forest, the loss of mangrove forest and ecological disturbance. Furthermore, it affected the mangrove forest dependence-dwellers.

LAND USE/COVER CHANGE 1988-1996 OF SOUTHERN PART OF BANG-TOEY SUB-DISTRICT

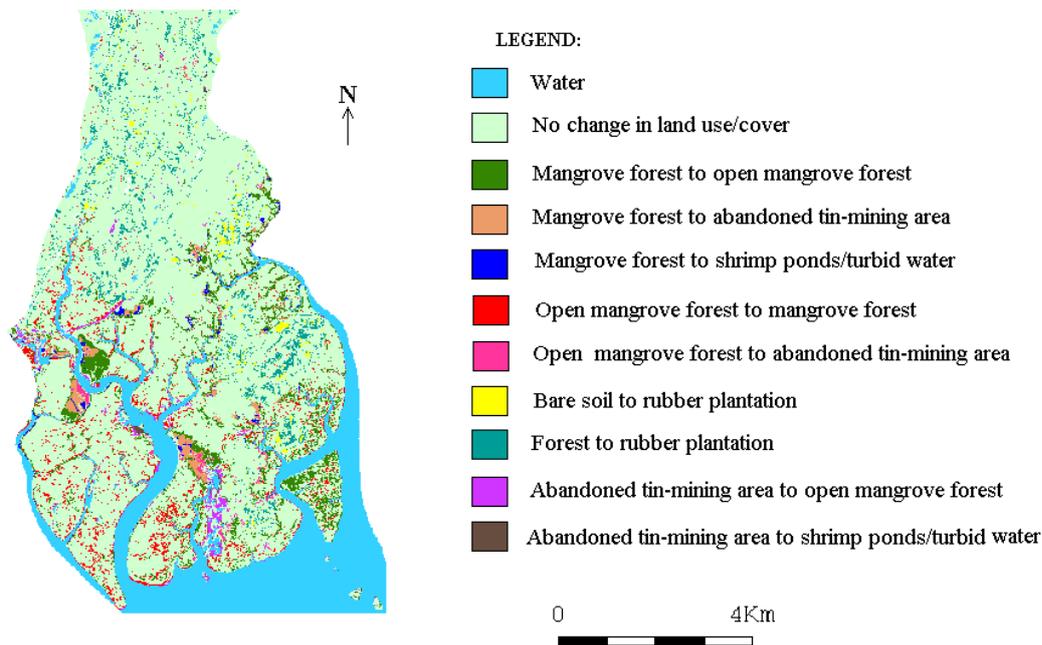


Figure 4. Land use/cover change detection map resulted from satellite images 1988/1996.

LAND USE/COVER CHANGE OF BAN KLANG VILLAGE 1976/1984

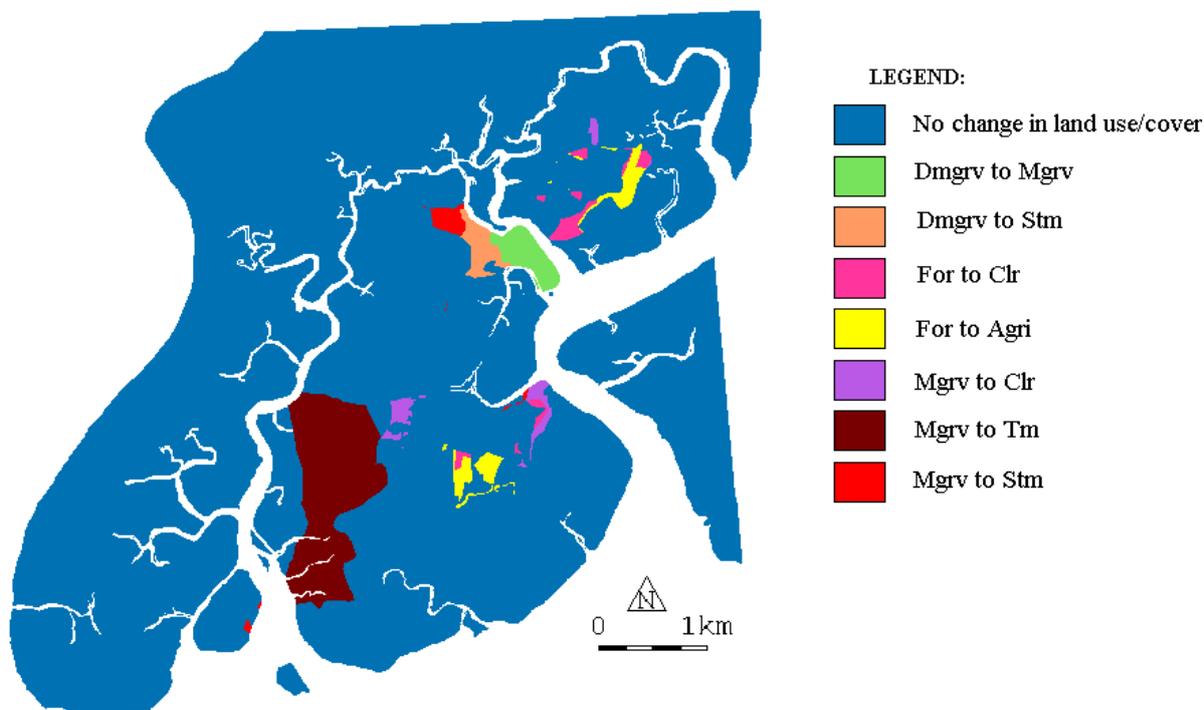


Figure 5. Land use/cover change detection map resulted from aerial photo 1976/1984.

LAND USE/COVER CHANGE OF BAN KLANG VILLAGE 1984/1995

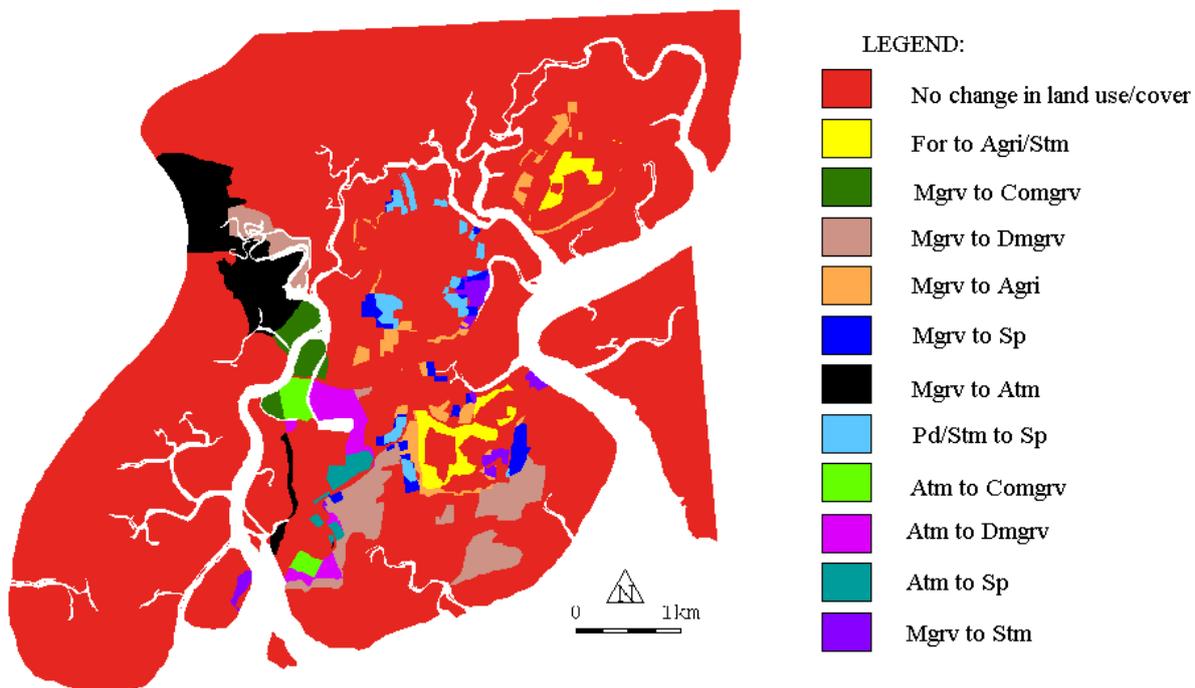


Figure 6. Land use/cover change detection map resulted from aerial photo 1984/1995.