LAND USE CHANGE MAPPING USING REMOTE SENSING AND GIS: A CASE STUDY IN BEN TRE PROVINCE, VIETNAM

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Abstract - Land-cover and land-use (LCLU) changes have significant climate impacts in tropical coastal regions with the added complexity of occurring within the context of a warming climate. The individual and combined effects of these two factors in tropical area are investigated by use of an integrated mesoscale atmospheric modeling approach, taking the eastern region of Ben Tre Province as the test case. To achieve this goal, scenario is supported with high-resolution remote sensing LCLU data. Here, the authors show that LCLU changes produced the large near-surface (30m), using satellite images Landsat 5, 7 and 8 to analyse the changes in LCLU from 1989 to 2015. Impacts of climate change, including CO_2, rainfall, temperature, storm; particularly sea level rise, will make conditions even more precarious for mangroves and others land uses, heighten the urgent need to improve their management and protection. Ben Tre Province, Vietnam is one of the coastal areas of the world that are predicted to be most affected by sea level rise and climate change. The land use change has changed over large areas for years by climate change. Thus, satellite data was the best option for identification of its pattern. Remote sensing has been used as a tool for natural resources management. This study aims at understanding the changes in area and migration of land use during 26 years from 1989 to 2015 in Thanh Phong and Thanh Hai Communes, Ben Tre Province, Vietnam. In this study, satellite and GIS analysis are the major research methods. They provide information for identifying relationship in spatio-temporal on land use pattern.

Keywords - Coastal ecosystem, GIS, Mekong River Delta, Remote sensing.

I. INTRODUCTION

A. Climate change impacts on land use change

The ongoing global climate change is recognized as a great threat to natural habitats and species survival [1] – [2]. Scientists worldwide are looking at the ecological and hydrological impacts resulting from climate change. The issue of climate change is a great challenge to wetland conservation and restoration. Especially climate change will significantly alter many of the world's coastal wetland habitats [1] – [3]. Global climate change, specifically changes in temperature, CO_2, precipitation, hurricanes and typhoons, and sea level, combined with anthropogenic threats will threaten the resilience of mangroves and other land use types.

The Intergovernmental Panel on Climate Change [4] has released its third assessment report on potential regional impacts of climate change in the U.S. This report indicates that the effects of changes in regional weather will not be consistent from place to place. Some regions will receive more moisture than historic averages, others less. Temperature is projected to shift significantly, resulting in permanent alteration of ecosystems. There is no consistent answer to these questions. However, we do surmise that the projected changes in the global climate, which in turn will mean changes in national and regional weather patterns, may have substantial effects on our transportation system. How might these effects demonstrate themselves? The effects on transportation depend to a great extent on how we use the land for various purposes.

B. Study area

Ben Tre Province is situated in the downstream of the Mekong River, divided by a great number of big rivers in the form of a hand-shaped fan, with 4 main estuaries in Ben Tre Province: Dai, Ba Lai, Ham Luong and Co Chien, with Ba Lai dam and culvert built in 2001. It has a tropical monsoon climate with the wet season and the dry season.

Thanh Hai and Thanh Phong are adjacent communes located on the coast, 70 km to the southeast of Ben Tre City (Figure 1). The area of Thanh Phong Commune is 39.61 km^2 and 55.11 km^2 is Thanh Hai Commune's area in 1999. The shoreline length of two communes is 25 km. They have a total of 1600 ha of mangrove forest and their coastline includes large areas of mudflats interlaced with rivers, which are an important source of seafood. In particular, the Ben Tre white clam, a local specialty, is famous throughout Viet Nam. Clam culture and collection play a crucial role in the livelihoods of thousands of coastal dwellers. Other livelihood activities include non-rice farming, such as watermelon, yam bean, peanuts and sweet potato crops are grown on the sand dunes, as well as aquaculture, in particular shrimp-crab farming under mangrove forests, intensive shrimp farming and blood cockle culture along the river banks, and near-shore fishing. Due to their location at the coastal estuaries, Thanh Hai and Thanh Phong are highly exposed to storms, high tides, saltwater intrusion and flooding.

This study focuses on Hamlet 8 of Thanh Hai Commune and Hamlets of 6 and 7 of Thanh Phong Commune. Hamlet 8 has an area of 115 ha and a

population of 7978 (2183 households). The total land area of two hamlets (Hamlets of 6 and 7) around 2000 ha and total households around 746 households [5].

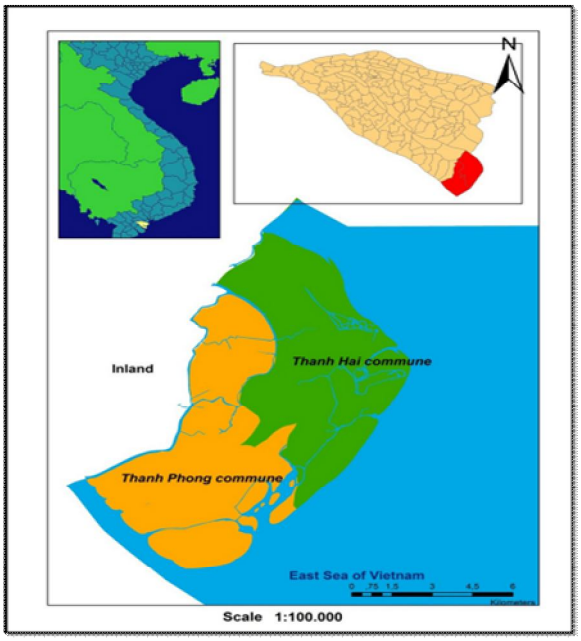


Fig.1 Study area

II. METHODOLOGY

A. Data Sources

This study uses historical Landsat Thematic Mapper (TM), Enhance Thematic Mapper (ETM+) and the Operational Land Imager and/or Thermal Infrared Sensor (OLI/TIRs sensors) images captured in 1989, 2001, 2009 and 2015. This study uses low resolution images because of budget. Besides, collected free Landsat images do not coincide exactly with events such as weather, flood or storms in the study area. So, it is not easy to pinpoint the causes of change in mangrove growth. However, the year of the images follow the climate change event and campaigns of government are chosen. Such as there are two extreme storms in 1997 and 1998, it belongs to period of time from 1989 to 2001. The period from 2001 to 2009, there is a campaign for forest replantation in this area from 1998 to 2010. There is an extreme storm in 2006. From 2010, the government encourages expansion of the shrimp farm area. The new tourist zone opens in 2013, and the 2015 satellite image is used to analyze the changes in land use for period time from 2009 to 2015.

B. Field trip research (field data collection)

We gather ground truth data to guide the classification scheme, train the classification of the imagery and analyse the accuracy of the final map. The field observations extended to all study sites. In this study, a total of 12 sampling plots are conducted to collect mangrove characteristics and land-use information of which 6 sampling plots are completed in April 2014 and 6 sampling in Feb 2015. In general, the sampling plots are conducted along the forest, the shoreline, the river and residential areas randomly.

C. Image analysis

The Landsat images are already geo-referenced. In order to obtain a pixel-to-pixel match between two images, the higher resolution Landsat 8 is used to register Landsat 5 and 7 images to improve geometric accuracy. This geometric correction is required to improve the geo-location to an angle mean square error of less than a pixel and accuracy of subsequent change analysis. All images are geo-referenced to UTMWGS-1984 Zone 48N projection and datum.

The land uses are exclusively distributed along shorelines and in front of agriculture zones and aquaculture areas. A mask showing only land use areas is then created by manually digitization a background map in order to reduce data volume and increase the overall classification accuracy. The mask is then used to define the land use area in the pre-processed Landsat images (1989, 2001, 2009 and 2015).

III. RESULTS

A. Definition of NDVI

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum [6].

$$NDVI = \frac{\rho(NIR) - \rho(\mathrm{Re}\,d)}{\rho(NIR) + \rho(\mathrm{Re}\,d)} \quad (1)$$

This formulation allows us to cope with the fact that two identical patches of vegetation could have different values if one were, for example in bright sunshine, and another under a cloudy sky. The bright pixels would all have larger values, and therefore a larger absolute difference between the bands. This avoided by dividing by the sum of the reflectance.

Theoretically, NDVI values are represented as a ratio ranging in value from -1 to 1 but in practice, extreme negative values represent water, values around zero represent bare soil and values over 6 represent dense green vegetation.

There are two methods to calculate NDVI by ENVI software:

1. Band Math: 'Band Math' Tools are used for band calculations. Bands b1, b2, b3, etc. are variables

used to identify the bands in the equation. Once an equation is set, the variables are matched to bands. For example: NDVI is (TM band 4-TM band 3)/(TM band 4+TM band 3). In ENVI this would be (b4-b3)/(b4+b3)

2. Transform: This menu has tools for band ratios and NDVI that are faster to use than "Band Math". Transform ➔ NDVI

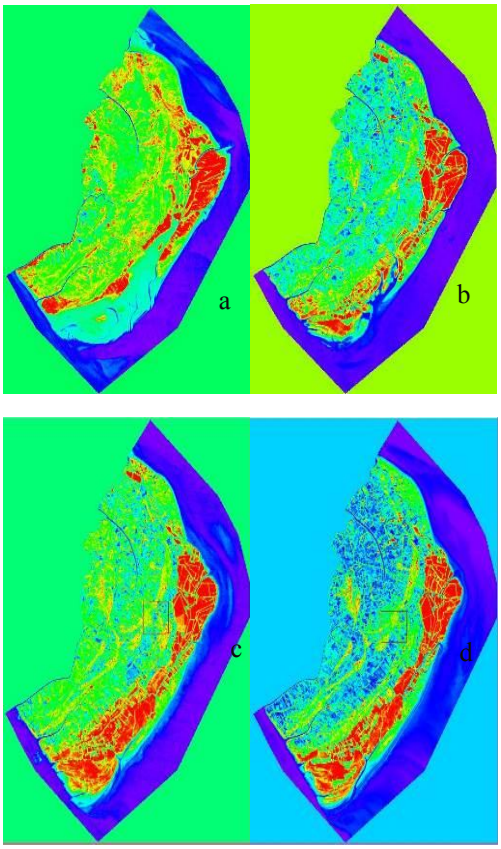


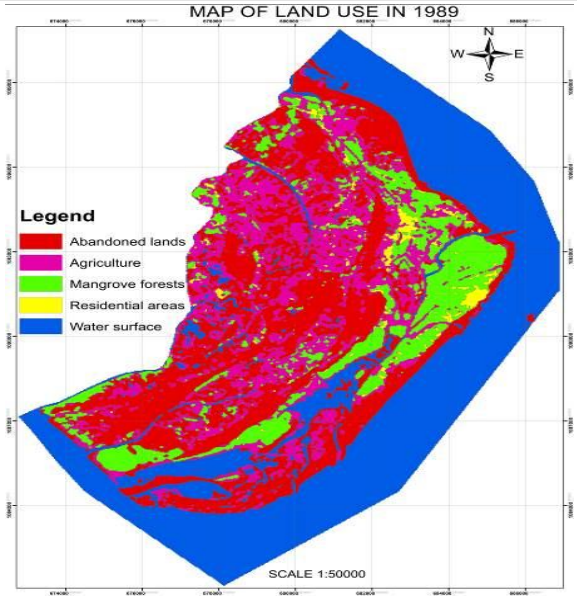
Fig.2 NDVI images in (a) 1989, (b) 2001, (c) 2009, and (d) 2015 with rainbow color table applied to data values from -1 to 1

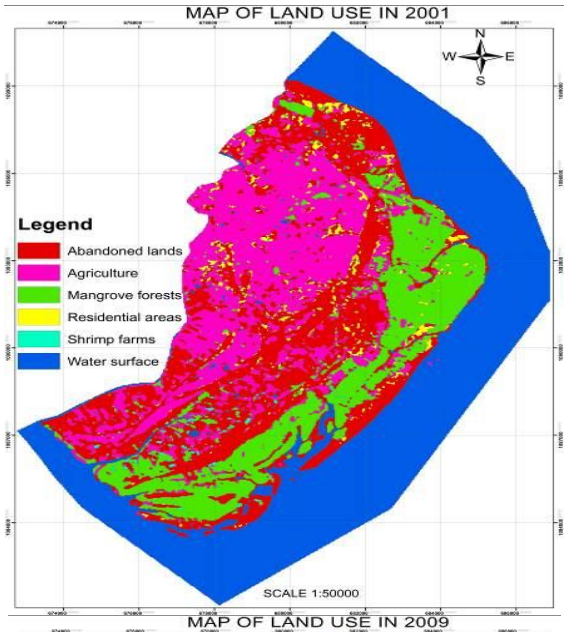
B. Land use map in 1989, 2001, 2009 and 2015

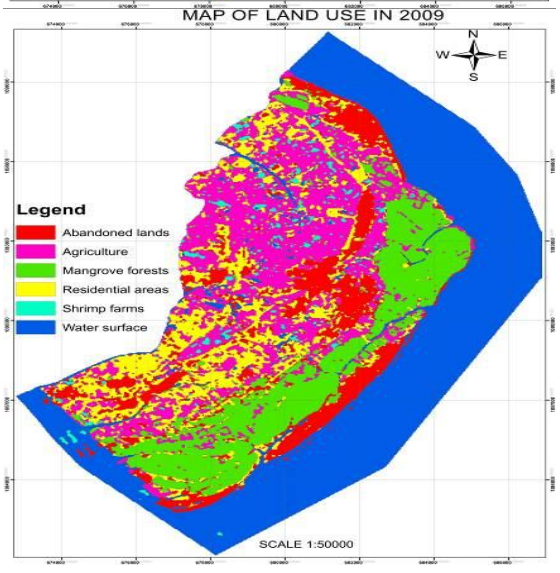
Steps of Classification: The common methods used to classify Landsat images by ENVI software is to used tools: Classification → Supervised → Maximum Likelihood. It called Maximum Likelihood Classifier (MLC) methods. The result is shown in Figure 4.6.

Steps of post-classification: This step is to assess and increase accuracy after classification step. Majority Analysis method is used for this stage.

From menu in ENVI (Version 4.8), click Classification → Post Classification → Majority/Minority Analysis. The results of post-classification accuracy assessment are high. All of them are more than 0.8 (Kappa coefficient equal to 1 is absolute accuracy). After previous steps, ArcGis (Version 10.1) is used for mapping land use and land use change mapper. The land use maps in 1989, 2001, 2009 and 2015 are presented in Figure 3.







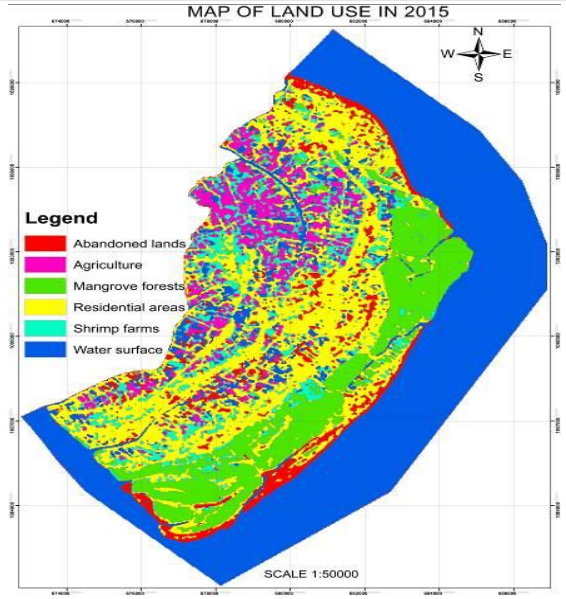


Fig.3 Land use map in 1989, 2001, 2009 and 2015

C. Land use change between 1989 and 2001

As shown in Figure 4, the area of abandoned lands occupied the largest area in 1989 with 4365 ha (38.94%). It reduced strongly from this period to 3400 ha in 2001, a declines of 965 ha over 12 years. During the Vietnam-USA war period, this area is one of points receive weapon of Ha Noi government. The war finished in 1975, that why in 1989 there are a lot of abandoned plot. The extent of mangroves increased significantly in the first period of 1989 and 2001 (from 14.78% to 18.09%) approximate 450 ha. The shrimp farms start appearing only until 2001 with 50 ha (0.43%).

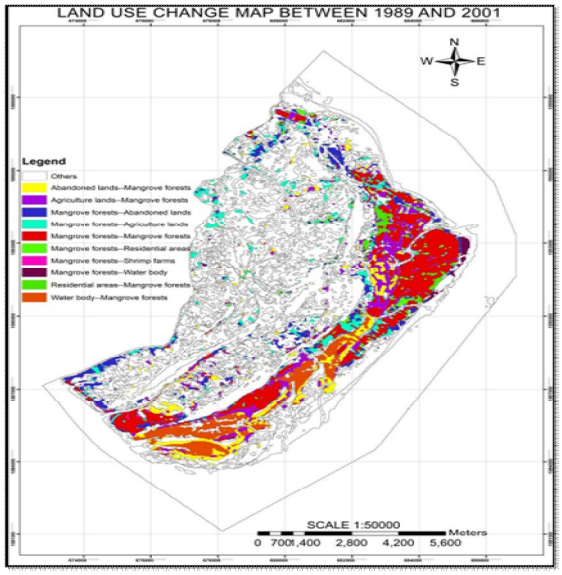


Fig. 4 Land use change map between 1989 and 2001

In this period, the mangrove area convert to different land use is about 725 ha, including residential area (65 ha), abandoned land (361 ha), agriculture (299 ha). There are four substantial land uses convert forward mangrove area such as abandoned land (327 ha), agriculture land (427 ha), water body (372 ha) and residential area (99 ha), total about 1225 ha variation land use area convert to mangrove area.

D. Land use change between 2001 and 2009

Figure 5. presents the extent of mangroves still increases slightly in the second period of 2001 and 2009 (from 18.09% to 24.36%) approximately about 95 ha. Shrimp farm increase 200 ha (from 49 ha in 2001 to 239 ha in 2009). The agriculture area is stable with 3000 ha from 2001 to 2009. The mangrove reforestation and plantation campaigns were implemented in this area from 1998 to 2010. But the effect of the campaign is not very efficient.

In this period, the mangrove area convert to different land use including residential area (121 ha), water body (69 ha), abandoned land (371 ha), agriculture (274 ha). There are four variation land use area convert to mangrove area convert forward mangrove area such as abandoned land (371 ha), water body (138 ha) agriculture land (75 ha), and residential area (38 ha).

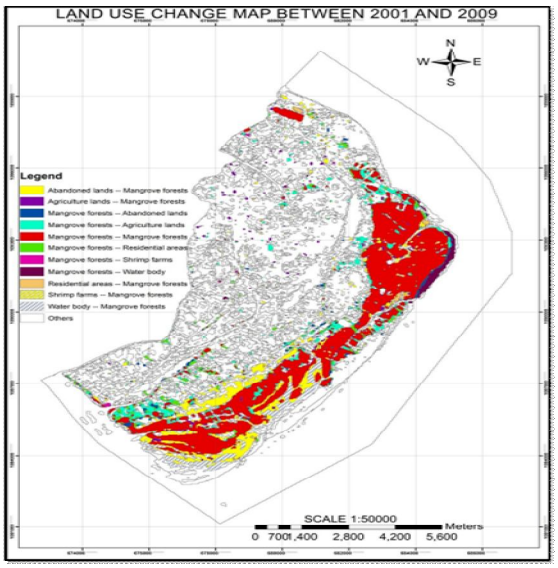


Fig. 5 Land use change map between 2001 and 2009

E. Land use change between 2009 and 2015

During the period between 2009 and 2015, average rates of mangrove loss is significant in all study areas and range from 24.4% (2200 ha) to 21.3% (1800 ha). A large part of the mangrove area (400 ha) is converted into shrimp farms and residential lands (Figure 6), mainly in Thanh Hai because this commune developed tourist zone at the shoreline from early 2013.

Figure 6. also presents the significantly increased in two land use types, those are residential area and shrimp farm area. The shrimp farm area is 239 ha in 2009, but in 2015 it is 1192 ha, increased of 953 ha over 6 years. The residential area increases from 1943 (21.49%) ha to 3644 ha (42.96%). Meanwhile the agriculture land is decreased substantially from 3040

to 1000 ha (including 122 ha agriculture land convert to abandoned land and 1173 ha to residential land, 740 ha to shrimp farm and 72 ha to mangrove forest). Since 1999, the Agriculture -Extension Center intensifies shrimp farming investment and proves to be successful. Shrimp farming starts developing, expanding and thriving. Until 2010, with the appearance of the white-leg shrimp (shrimp species resistant to salinity), shrimp farming strongly thrives. Farming area rapidly increases during this period. There are four land uses convert to shrimp farming including abandoned land (90 ha), residential land (192 ha), mangrove forest (126 ha), agriculture land (740 ha). Meanwhile the conversion of shrimp farm to variation land uses is small with 80 ha convert to agriculture land, 47 ha convert to residential area.

The mangrove reforestation and plantation campaigns from the previous periods are not effective, resulting in steady reduction of the mangrove area.

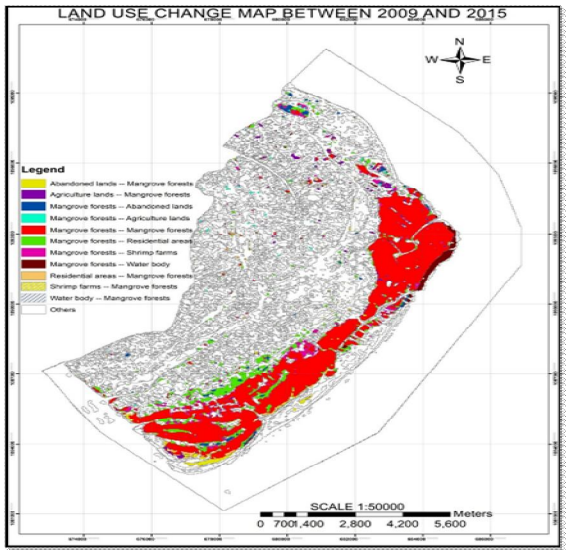


Fig. 6 Land use change map between 2009 and 2015

F. Land use change between 1989 and 2015

In general, the mangrove area increases during 26 years from 1989 to 2015. But it is not stable. The overall loss of mangrove is mainly caused by the replacement of mangrove by shrimp farms and residential area. It proves the unsustainable development in this area. A larger increase of shrimp farms and the human settlement area is observed in 2015. The shrimp farms area increases from 0 to 1192 ha. The residential area increases from 2502 to 3645 ha. The large increase of these two land use types may influent ecosystem especially the shoreline ecosystem. In particular, there is an estimated 4365 ha of abandoned land cover in 1989. But by 2015, this has reduced by 3500 ha, with 840 ha remain. This kind of steady land use decrease over 26 years, it proves that the inhabitants used barren land effectively. The agriculture lands are steady up until 2009 and converting to other land uses afterwards.

The mangrove forest convert to different land use, 171 ha to shrimp farm, 274 to water body, 516 ha to residential area, 83 ha to agriculture and 70 ha to abandoned lands. In contrast, at the same time, the variation land uses convert to mangrove area is not balance, including 56 ha residential land, 347 ha abandoned land, 368 ha agriculture land and 493 ha water body lands convert forward mangrove forest area. The total of mangrove area is increased but it is unsustainable over the last 26 years.

The total area of study zone is decreased from 11208 to 8484 ha. This is due mainly to erosion phenomena and sea level rise occurred in the study area over 26 years. The loss is about 2800 ha lands, with more declined since 2001. In 1989, there are few islands located offshore of the study area (at 9°51'45"N, 106°41'50"E), but it no longer appears in 2015. It proves evidence for the total area change (Figure 7).

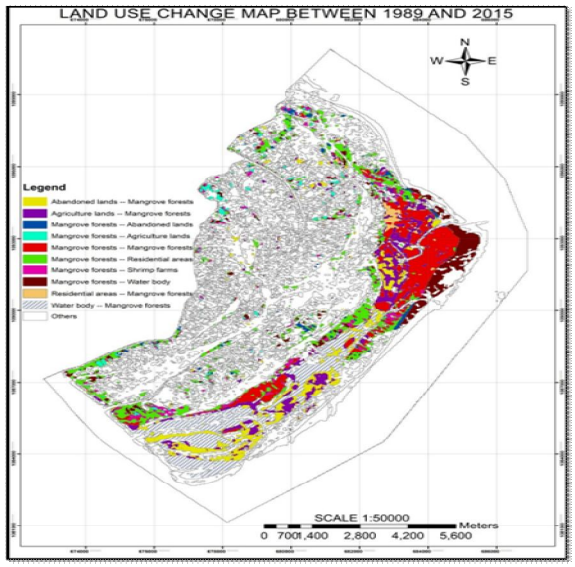


Fig.7 Land use change map between 1989 and 2015

DISCUSSION & CONCLUSION

The overall accuracy assessment of the classification using Landsat 5 and 7 images were 90%, 83%, 86% in 1989, 2001 and 2009, respectively. The overall accuracy analysis of the 2015 Landsat 8 images was 88%. This accuracy in classification of mangroves and non-mangroves showed that use of Landsat images is adequate for assessing spatio-temporal mangrove changes when higher spatial resolution satellite images are limited. The results are useful in monitoring the dynamic nature of fringe mangrove community and adjacent land use in Thanh Hai and Thanh Phong Communes, and provide useful data for shoreline mangrove management, conservation efforts and national monitoring programs for estimating mangrove values in Vietnam.

As shown in above sections, the extent of mangroves significantly increased in the first period of 1989 and 2001 and then increased until 2009. However, it significantly decreased in the period of 2009 and 2015. In 1989, there was an estimated only 1656 ha of

mangrove cover, but by 2001, this had increased by 451 ha. The total mangrove area in 2009 was 2203 ha, representing a positive recovery of fringe mangroves, an increase of 9.58% over the period of 1989 and 2009. In 2015, the mangrove extent was calculated at 1806 ha, an overall decrease of 6.51% (150 ha) as compared to 1989. From 2001 to 2009, the mangrove area increases 12 ha/yr. In contrast, the mangrove area decreases 25 ha/yr from 2009 to 2015. Meanwhile, the areas of shrimp farms and residence increased steadily during the 26 years, with shrimp farm area increased from 0 ha to 1192 ha and residential lands increased from 2502 ha to 3645 ha. The area of abandoned lands declined from 4365 ha to 840 ha and most of it was replaced by mangrove areas and shrimp farms. The total area of study zone decreased from 11208 to 8484 ha. This is due mainly to erosion phenomena and sea level rise occurred in the study area over 26 years.

Year / Land use	1989	2001	2009	2015
Agriculture lands (ha)	2684.97	3035.34	3040.74	1000.44
Abandoned lands (ha)	4365.18	3400.65	1617.03	840.33
Residential areas (ha)	2502.00	3055.50	1943.73	3644.91
Water body (ha)	5424.21	5488.11	5339.70	5910.48
Shrimp farms (ha)	0	49.68	239.58	1192.32
Mangrove forests (ha)	1656.810	2107.71	2203.65	1806.30

Table 1. Summary of land use areas in 1989, 2001, 2009 and 2015

Human and natural threats affect coastal life and shoreline biological diversity, as well as the adjacent ecosystems. One of the consequences of the loss of mangroves may alter or totally disturb the natural tidal system. Tidal creeks may be blocked, fisheries decline, sedimentation rates decrease, and toxic waste pollution, such as antibiotic impact of aquaculture and agriculture. Additional problems include salinity intrusion of coastal soils, increased erosion, land subsidence, land degradation, and extensive exposure of coastlines to wave surges. Reforestation and rehabilitation programs towards the sustainable use of mangroves have to be implemented.

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