APPLICATION OF GIS AND REMOTE SENSING FOR ASSESSING THE IMPACT OF SEA LEVEL RISE IN BEN TRE PROVINCE

Le Van Trung[1], Pham Thi Mai Thy[2], Chau Nguyen Ngan Ha[1]

[1]Department of Environment, Ho Chi Minh City University of Technology.

[2]Ho Chi Minh City Institute of Resources Geography, Vietnam Academy of Sciences and Technology,

01 Mac Dinh Chi Street, District 1, Ho Chi Minh City, Vietnam.

Email: ptmthy@hcmig.vast.vn

ABSTRACT

Sea level rise has been caused by climate change and strongly influenced on the coastal zone, especially for agricultural areas such as the Mekong Delta in general and Ben Tre Province in particular. "Application of GIS and remote sensing for assessing the impact of sea level rise in Ben Tre Province" has been done in this research to evaluate how agricultural activities will be impacted. This research has proposed a solution which integrates the existing GIS and analysis information of the Landsat images to map land use in 1995, 2005 and 2014. Then, the relationship of the land use changes and the inundated areas of climate change scenarios created by Vietnamese MONRE was defined. Consequently the sensitive areas affected by sea-level rise are determined, and the upcoming land use changes are also predicted. In addition, the solutions were proposed to reduce the impact of sea level rise for sustainable development of Ben Tre Province. The results will help local people as well as local authorities have the appropriate response.

1. INTRODUCTION

Ben Tre is an agricultural province which economy specializes in farming and maritime activities. According to Department of Environment and Natural Resource of Ben Tre province, Ben Tre is critically affected by climate change, especially sea level rise due to its coastal and downriver location. In order to solve this problem, Ben Tre government have made some projects of planting coastal mangrove forests, building dikes and dams to deal with sea level rise in the future. According to climate change scenarios of Ministry of Natural Resources and Environment (MONRE), in the middle of 21st century, sea level is predicted to rise from 28 cm to 33 cm and in the late 21st century, it will increase from 65 to 100 cm in compared with the period 1980-1999. This leads to a strong economic and social impact on Ben Tre province.

2. METHODOLOGY AND RESULTS

2.1 Data

- Landsat 4, 7 and 8 satellite images of the years 1995, 2002 and 2005;

- Land use map in 2005 provided by Department of Natural Resources and Environment (DONRE) of Ben Tre province;

- Climate change scenario maps of Ben Tre in scale 1/350,000 (Figure 1, Figure 2);

- Annual report of 1995, 2005, 2012 of General Statistics Office.

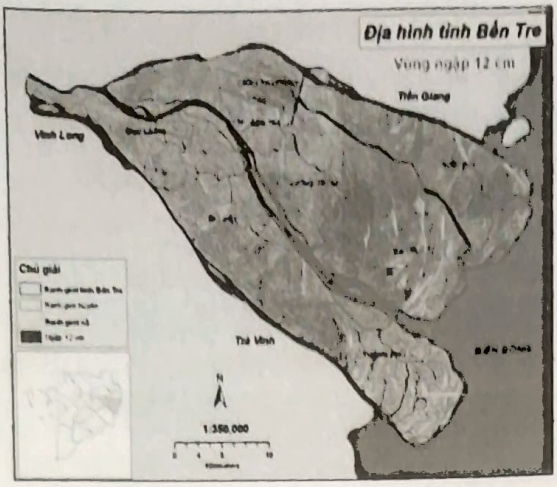

Figure 1. Vulnerability areas as sea level rises 12cm in 2020 according to Climate Change scenarios

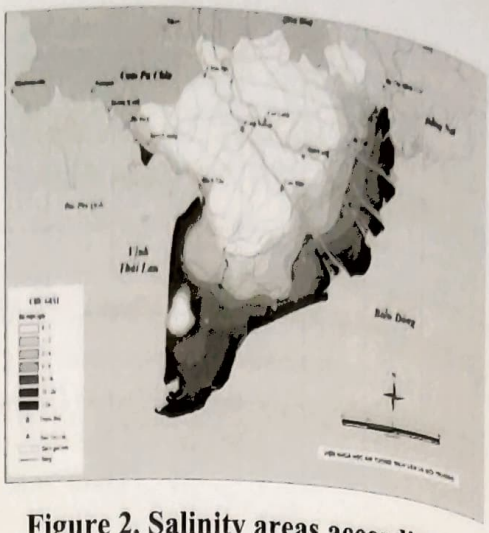

Figure 2. Salinity areas according to Climate Change scenarios A2 as sea level rises 15cm

2.2 Methodology and results

The methodology is summarized in the working process in Figure 3.

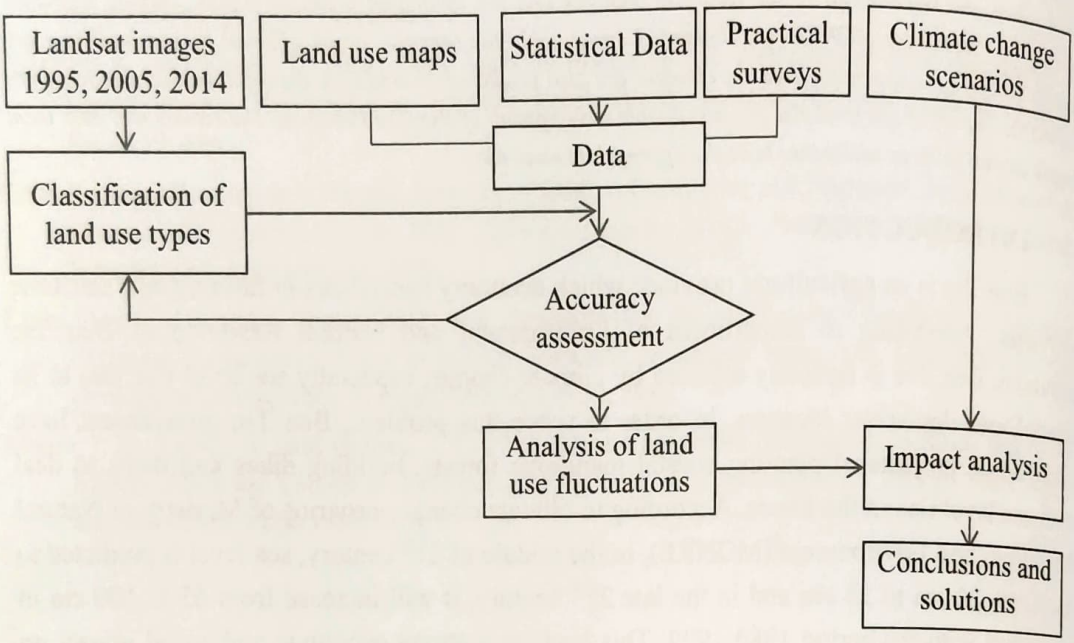

Figure 3. The analyzing process

a) Mapping land use in 1995, 2005 and 2014

Land use maps of 1995, 2005, 2015 (Figure 4, Figure 5 and Figure 6, respectively) were created by analyzing Landsat satellite images in 1995, 2005, and 2014 (enhancing, geometric correction, gap-filling, Maximum Likelihood classification) to extract 10 categories of land uses (rivers, perennial orchard, paddy fields, annual vegetation, mangrove forests, bare, urban, aquaculture and other areas), processing after sorting, accurate evaluation and vector format conversion.

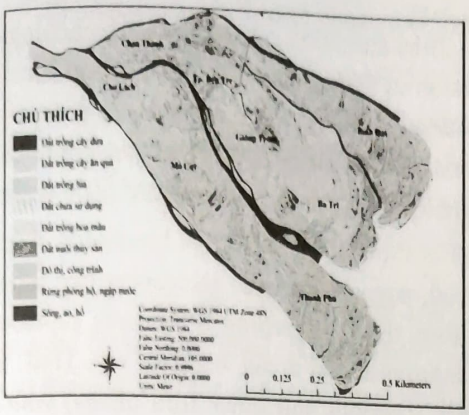

Figure 4. Classification of land use from Landsat 7 satellite images in 1995

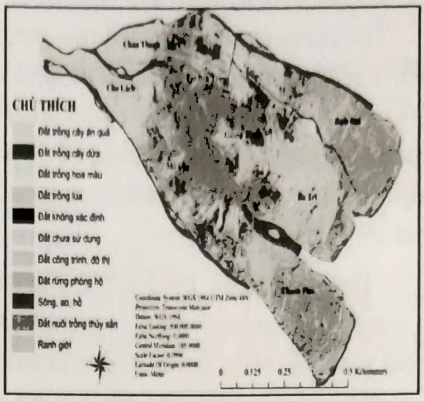

Figure 5. Classification of land use from Landsat 7 satellite images in 2005

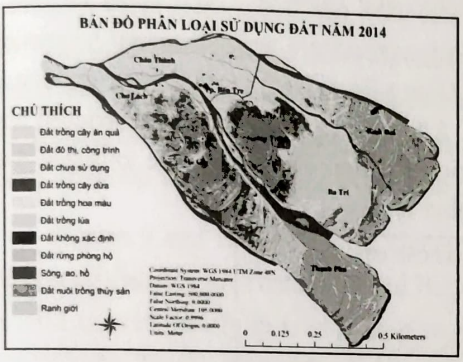

Figure 6. Classification of land use from Landsat 8 satellite image in 2014

Table 1. Comparison of land use types in 1995, 2005, 2014

No.	Classes	Area (ha)			Percentage (%)		
		1995	2005	2014	1995	2005	2014
1	Rivers, streams	30.008	25.868	23.366	13,25	11,23	10
2	Aquaculture areas	16.807	36.918	49.101	7,423	16,03	21
3	Coconut trees areas	36.410	46.206	35.645	16,08	20,06	15
4	Other perennial orchard	29.330	46.544	50.310	12,95	20,20	22
5	Paddy fields	49.156	48.562	22.888	21,71	21,08	10
6	Annual vegetables	18.771	7.006	14.007	8,29	3,04	6
7	Urban areas	435	12.113	17.967	0,19	5,26	8
8	Bare lands	22.198	336	72	9,80	0,15	0
9	Mangrove forest areas	23.288	6.336	14.515	10,29	2,75	6
10	Unknown areas	0	486	2.456	0	0,21	1
	Total	**228.398**	**232.384**	**232.341**	**100**	**100**	**100**

b) Accurate assessment

Kappa Coefficient and overall accuracy were calculated by checking with land use map in 2005 Ben Tre Department of Environment and Natural Resources and ground control points collecting from the survey in 2014. The results of accurate assessment are 0.76 and 0.78 of Kappa Coefficient and 86.9% and 78.94% of overall accuracy.

c) Analysis of land use changes

The changes are analyzed two periods: 1995 - 2014 and 2005 - 2014 by GIS technology. Table 1 represents more details of land use conversion in Giong Tom, Mo Cay, Chau Thanh and Cho Lach Districts where rice areas were decreased rapidly and converted into perennial orchard area (coconuts and other). The forests, rice fields of Thanh Phu, and Binh Dai Districts were also converted into aquaculture areas so that rice area was reduced 50% within about 19 years.

- For the period 1995-2005: For 10-year period, aquaculture area increasing two times and perennial orchard area (coconuts and other fruit trees) enlarging 50% have replaced annual plants (paddy fields and vegetation) and mangrove forest areas, respectively. Thus, in 2005, 40% of the province areas were orchard trees (coconut and other fruit plants) which were planted mostly in the west of Ben Tre such as Chau Thanh, Cho Lach, Giong Tom, Mo Cay Districts, Ben Tre City. Beside that, in some coastal districts (Binh Dai, Ba Tri and Thanh Phu) a majority of land was aquaculture (Figure 7 and Table 1).

- For the period 2005-2014: For 9-year period, aquaculture area continued increasing 50%, especially in coastal districts. However, in Giong Tom District, rice land continued decreasing and converted mainly into orchard area. A large area of coconut land reduced and converted into other orchard in Chau Thanh District and Ben Tre City while enlarged and replaced others in Mo Cay District (Figure 8 and Table 1).

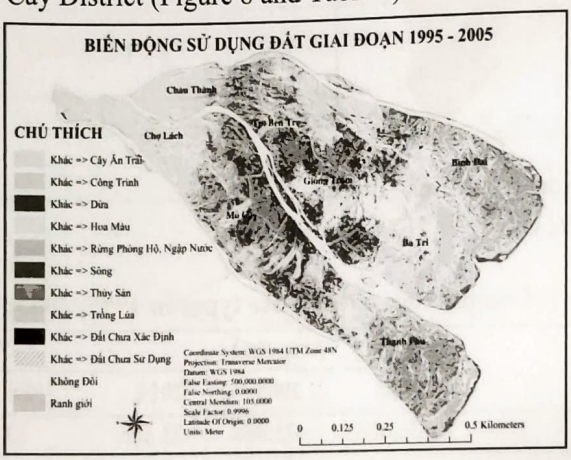

Figure 7. Map of cultivation purposes conversion during period 1995-2005 of Ben Tre

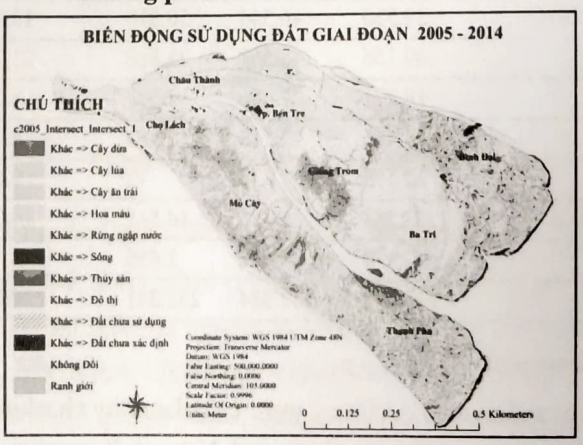

Figure 8. Map of cultivation purposes conversion during period 2005-2014 of Ben Tre

d) Analysis of climate change effects

The land use changes from 1995 to 2014 were compared with climate change scenario maps (saltwater area - Figure 2 and flooded area - Figure 1). According to data at An Thuan station (Thanh Phu), Binh Dai, Ben Trai stations (Thanh Phu) and My Hoa station (Ba Tri) from 1st Jan 1984 to 31st Dec 2009, average sea level rise is from 0,454 to 1,076 cm/year which influenced agricultural activities at Ben Tre Province.

Giong Tom, Ba Tri and Binh Dai Districts are low terrain, thus they can be easily damaged by sea rise level. Hence, cultivation area will be reduced which will affect badly to local farmers' income and Ben Tre economy.

Besides, the center of Giong Tom, and Chau Thanh Districts locate in higher terrain, far from sea and are surrounded by Ham Luong River which loads water from upstream. Therefore, these areas suffer less from lack of water in dry season and less effect on sea level rise. Therefore, these areas are very suitable for growing rice and vegetation, except Tan Thanh and Binh Thanh sub-districts. However, in recent years because of economic, human resources problems and others, the area used to be most of rice area, has been converted from paddy area into orchard land (coconut and cacao).

Figures 9 and 10 showed the change of crop area in Ben Tre province, particularly in the coastal districts. In Thanh Phu and Binh Dai Districts, rice area reduced many in 2005 and in 2014 existed mostly in Giong Tom and Ba Tri which locates 10-40km far away from the coastal zone. That is the result of salinity intrusion and sea level rise. Additionally, according to climate change scenario of MONRE (Figure 2), when sea level rise reaches 15cm, 70% of rivers in Ben Tre Province have salinity greater than 3g/l which will make young and grown-up rice plants dead. This means that 70% of Ben Tre province area can not grow any rice plant in forecast.

3. CONCLUSION AND RECOMMENDATIONS

Using remote sensing to assess impact of sea level rise on land use situation is very effective to a large area. The results are expressed in specific numbers by analyzing satellite images from 1995 to now.

As the coastal area and low terrain, sea level rise should be cared in Ben Tre Province because its economy mostly bases on agriculture. Although according to the scenarios until the year 2020, the situation of sea level rise is still not very clear. However, if the local authorities do not start giving any solution for this problem, 5.81 km^2 annual plants area will be lost in 2050 according to worst scenario. Having a long-term funding will help to solve food security problem which includes restructuring plant areas, making specific policy of specialized plant areas, especially food crop plants area in less sea level effect areas and avoiding local farmers spontaneously change their cultivation. Some approaches are using draining dams to regulate the amount of water according to the season in order to minimize flooding during rainy season and prevent sea water flow into upstream in dry season; continuing planting mangrove trees along the coastal areas like natural levees.

The result shows that rice area became narrow. In 2014, almost rice area still remains at Giong Tom and Ba Tri Districts. In coastal districts such as Binh Dai, Ba Tri and Thanh Phu, rice area almost disappears and is replaced by aquaculture area such as shrimp and fish farms. Besides, orchard area has increased over many years but this area is predicted to be affected by climate change and sea level rise.

The regions locating at the center of Giong Trom and center of Chau Thanh Districts have ground and are far away from sea should be less affected areas in the future, the government should be oriented to the people to increase rice area and support the farmers the technique and others. Besides, Cho Lach and Mo Cay District, also high terrain, still continue maintain the orchard area. However, sea level rises will affected to some isles, thus around these should build strong levees and grow many trees to prevent dangerous landslides.

Ba Tri District has low elevation, locates near sea, is affected less by upstream water and a lot by sea level rise, therefore Channel 9A should be dredged and drained to release upstream water. Besides that, dams which prevent the effect of sea water or the flooding or keep fresh water, need to be repaired and upgraded effectively. Moreover, building levees around rice growing areas such as Tam Xuan, My Nhon, My Thanh Communes is also a method to reduce the impact of sea level rise.

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