GEO-ENVIRONMENTAL RESEARCH FOR ENVIRONMENTAL CHANGES OF CAN GIO MANGROVE FOREST, VIETNAM

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ABSTRACT

The purpose of this study is to understand the environmental changes of Can Gio mangrove forest using geo-environmental information and satellite data. During the Vietnam War, Can Gio mangrove forest was almost destroyed by bombing. After the War, with many efforts of mangrove replanting, Can Gio mangrove forest has been recovered. However, in the recent years, Can Gio mangrove has been threatened by geo-environmental changes and human induced issues. In order to grasp those changes, we have applied land use maps and satellite data. Comparing satellite imageries from 1973 to 2001, the whole Can Gio area was immensely changed. Especially, on the imageries between 1973 and 1989, reforestation can be confirmed in the whole area of Can Gio.

1. INTRODUCTION

Can Gio mangrove forest is located 50km in the south of Ho Chi Minh City in Southern Vietnam. During the Vietnam War, Can Gio mangrove forest was almost destroyed by bombing. However, at the end of the War, mangrove-replanting was started to restore the mangrove ecosystem by the Vietnamese government and international organizations. With many efforts of mangrove replanting, which is mainly composed of Rizophora apiculata, Can Gio mangrove forest is the first Biosphere Zone by the United Nations' Educational Scientific and Cultural Organization (UNESCO). The Can Gio ecosystem has been recovered in the whole area and is now covering more than 38750ha of dense mangrove (Hong, 2000). It forms a good ecosystem and natural protection against environmental degradations such as coastal erosion. However, in the recent years, Can Gio mangrove has been threatened by following causes;

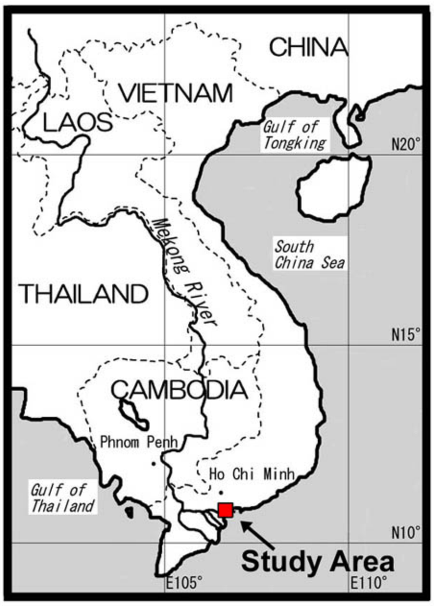

Fig.1 Location map of study area

1) geo-environmental changes / erosion and sedimentation along the coastal area
2) human induced issues / shrimp farming, sewage pollution, oil spill, etc.
In order to protect the Can Gio ecosystem from the environmental changes, studies on environmental impacts are needed.

2. GEO – ENVIRONMENTAL INFORMATION

2.1. Geography

Study area is around 71,360 ha (Hong, 2000) and nearly 25 percent of this area is covered by surface water. As the study area is located at the estuary of Dong Nai – Sai Gon river system, it has a 20 km shoreline composed of Long Tau, Cai Mep, Go Gia, Thi Vai, Soai Rap and Dong Tranh. The main waterway is Long Tau that is leading to the port of Ho Chi Minh City (HCMC). The study area is rather flat and it is divided into 5 categories according to inundation frequency:

- Inundated twice a day: altitudes from 0.0 – 0.2 m.
- Inundated once a day: altitudes from 0.2 – 0.5 m.
- Inundated once a month: altitudes from 0.5 – 1.0 m.
- Inundated once a year: altitudes from 1.0 – 1.5 m.
- Inundated once in years: altitudes higher than 1.5 m.

2.2. Climate

The climate is typical monsoon with rainy and dry seasons. Rainy seasons normally start in April and dry seasons in November. The temperature is annually stable varying from 25^oC to 29^oC throughout a year. Up to now, the maximum and minimum temperatures have been recorded as 38.2^oC and 14.4^oC respectively. The mean annual relative humidity is approximately 80%.

2.3. Geology and Soil

2.3.1. Geology

The study area is a flood plain composed of Neogene to Quaternary sediments. Holocene sediments cover most of the surface of the area. They are fluvial sediments, fluviomarines, and kukersite. The geomorphologic processes of this area are lateral erosions which has formed river cliffs, gully erosion which has formed the river mouth formed with tidal currents, and marine erosion which has formed coasts formed with waves and tides. The main bank can be divided into three types: Mangrove coast, flood land, and wind/ wave deposition coast.

2.3.2. Soil

The main soil types are as follows: (1)Proto-thionic fluvisols, (2)Orthi-thionic fluvisols, (3-1)Glayic-,Salic-protothionic fluvisols, (3-2)Glayic-,Salic-protothionic fluvisols.
(1) Proto – thionic Fluvisols: Total area is around 1480ha. It is salinated in dry season. Humus is high in the ground surface. Total content of alkali and phosphate are medium.
(2) Orthi-thionic fluvisols: Total area is around 4380ha. Salinated boundary varies by season. Heavy soil and alum zone are near the surface, suitable for rice growing. Humus and Mg content are high. Ca and Mg are not in proportion, restraining the growth of plants. pH:5.8–5.5(0- 70m).

(3-1) Glayic-,Salic-protothionic fluvisols: Total area is around 27,280ha. This soil is regularly inundated by sea water. Humus and salinity are high content. This is suitable for Rhyzophora.
(3-2) Glayic-,Salic-protothionic fluvisols: Total area is around 4870ha. This soil is inundated by sea water in the high tide. Humus and salinity are high content. This is not suitable for Rhyzophora.

2.4. Water System

2.4.1. Surface Water

The Can Gio area has a complicated network of rivers and channels which are influenced by the semi–diurnal–tidal regime (maximum: around 4m). The main rivers in Can Gio are as follows;

- Nha Be River: it is the confluence of the Dong Nai – Sai Gon River. Width: 1300 – 1500 m. Depth: 10 – 18 m.
- Soai Rap River: It is the downstream of the Nha Be River. Width: 2000–3000 m. Depth: 6–8 m.
- Long Tau–Nga Bay River:
- Long Tau River: Width: 400–600 m, Depth: 10–21 m. The mouth of the Nga Bay River is 800–1500 m width.
- Thi Vai–Go Gia River: It is a system which has been strongly controlled by the Eastern Sea. Width: 400 – 600 m. Depth: 30–40 m.
- The mouths of the rivers: Soai Rap, Dong Tranh, Nga Bay, Cai Mep.

The complexity of the rivers – channels network has caused the complication of the hydrographycal regime, however, it also makes the advantages in developing waterway networks and marine products.

2.4.2. Sedimentation and Erosion

Beside the specialty of the estuarine area, study area has a waterway from port of HCMC to the Eastern Sea. Therefore, erosion and sedimentation of this area are complicated and the both have affected the nature and human activities.

-Erosion

The erosion types include overwash, scour, and avalanch. The erosions strongly occur in main waterways: the LongTau – NgaBay River, the Dua River and TacDinhCau

-Aggradation

Alluvial plains formed along channels and river banks are not influenced by human actions. The water environment is relatively quiet, and there usually are the vegetation types of Sonneratia griffithii Kurz and Avicennia alba Bl.

The analyzed results about waterlines in CanGio in 1967, 1984, and 1997 show that:

1967 – 1984: Waterline changes were caused by loss of vegetations. The banks extended equally, and confluenced places are the places that have strong waterline changes.

1984 – 1997: Waterway actions were strong in the area, so the waterline changes were caused by two factors: the nature and human actions. Human actions are the main reason.
Generally, waterline changes in this period did not obey the nature: aggradation on protrudent banks and scour on sunken banks.

1997 – 2001: Erosions were more and more stronger because of vigorous development of the waterway, especially in the Tac Dinh Cau–Dua River. Besides, some erosional places were stabilized.

2.5. Biology and Botany

About 105 plant species, belonging to 48 genera are found in CanGio mangrove forest, including *Rhizophora apiculata, Bruguera gymnorrhiza, Bruguiera parviflora, Ceriops sp, Kandelia candel, Rhizophora mucronata, Sonneratia alba, Sonneratia ovata, Sonneratia caseda, Avicennia alba, A. officinalis, A. lanata (stunted trees in abandoned salt fields), Aegiceras majus, Thespesia populnea, Hibiscus tiliaceus, Lumnitzera racemosa, Xylocarpus granatum, and Excoecaria agallocha.*

There are about 150 known species in the aquatic fauna. The fish fauna is very abundant since mangrove forests serve as nurseries as well as sources of foods for many species of fish like *Lates calcarifer and Mugil affinis, prawns such as Pangasius spp, Penaeus spp, Meta penaeus spp, and the mudcrabs (Scylla serrata.)*

Within the area, there is a variety of wildlife such as wild pig (sus scrofa), monkey (Macaca fascicularis), otter (Lutra lutra), saltwater crocodile (Crocodylus porosus), many species of snakes, etc.

3. SATELLITE DATA ANALYSIS

3.1. Land cover change

The data set utilized in this study is described in Table 1 with tidal levels. False color composites images (1973/01/01-2001/01/02) are shown in Figure2.

Table 1. Data sets and Tidal levels (cm)

Sensor	*Landsat/MSS*	*Landsat/TM*	*JERS-1/OPS*	*JERS-1/OPS*	*Landsat/ETM+*	*ASTER*
Date	1973/01/01	1989/03/06	1994/11/16	1997/01/16	2001/01/02	2001/09/15
Tidal level (cm)	395	64	298	245	275	340

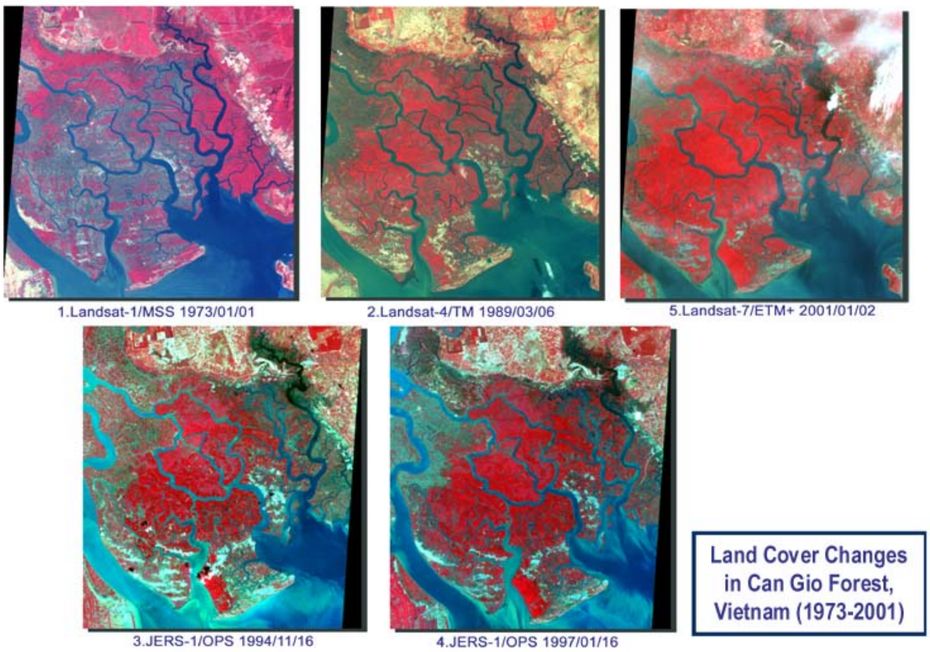

Fig.2 False color images over the study area (1973/01/01-2001/01/02)

The destroyed mangrove area is shown as grayish parts on the Landsat/MSS image (1973/01/01). More than 50 percent of the mangrove was disappeared. After the War, the mangrove replanting program begun and mangrove has been recovered as shown on the Landsat/TM image (1989/03/06). Comparing Landsat/MSS with Landsat/TM, we found that many areas had been recovered. Accordingly JERS-1 and Landsat/ETM+ images show the good reforestation of mangrove. To extract the changes of the mangrove areas we compared the band 4 (near-infrared) data between Landsat/TM and Landsat/ETM+. After registration of two images, color composites image was generated (Fig.3-a; red, blue: ETM+, green: TM). As a result, regenerated mangrove area is shown as magenta in color. The regenerated mangrove area in area A and B are clearly recognized. In the area B, the regenerated mangrove area is recognized in two parts: inland and offshore. The regenerated mangrove on the offshore range from around 100m on ASTER image (15m spatial resolution).

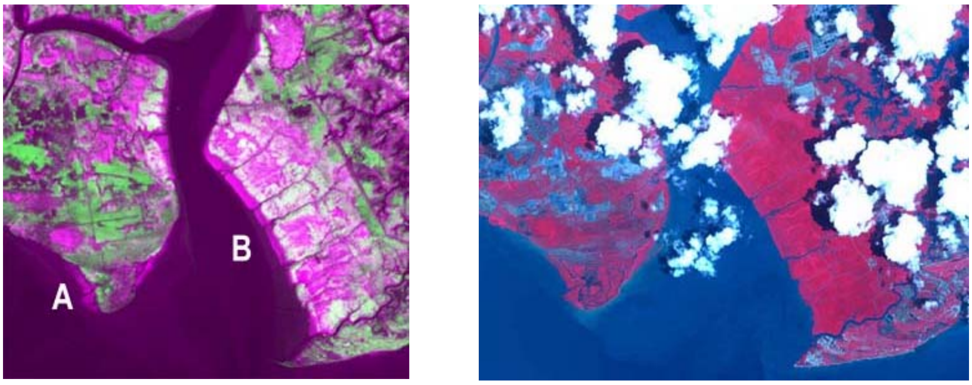

Fig.3 (a: Left) Color composites image of band-4 (R,B: 2001/01/02,G: 1989/0306)
(b: Right) ASTER/VNIR (2001/09/15, RGB: 321)

3.2. Sedimentation and Erosion changes

Sedimentation and erosion in the river mouth zone are changeable under the strong influence of tidal currents. Figure 4 shows sedimentation changes in the south part of Can Gio during 1973/01/01-2001/01/02. Figure 4-b) was acquired at a low tide time. Figure 4-a) and Figure 4-c) were acquired at high tide times. Sediment material in area A gradually extended during this period. Sediment material of area B extended during 1973/01/01 -1989/03/06, but it seems disappeared during the period of 1989/03/06-2001/01/02. Sediment material of area C and D extended during 1973/01/01-1989/03/06. Accordingly, it extensively extended because the tidal level was high in 2001/01/02.

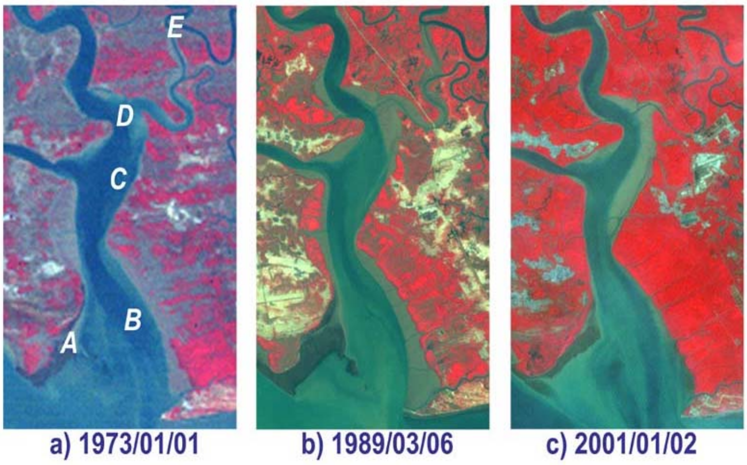

Fig.4 Sedimentation change images (1973/01/01-2001/01/02)

3.3. SAR data analysis

Since SAR data is very useful for a tropical forest study, many researchers have conducted SAR data analyses for their researches. Phase coherence image of JERS-1/SAR is shown in Fig. 5 (Right). Despite a repeat cycle of 88 days, a significant coherence was acquired. Comparing with JERS-1/OPS image, the coherence image shows a different coherence in the mangrove forest. It can be derived from density and different age of the mangrove. Luckman et al. (2000) estimated the biomass of tropical forest using phase coherence and the backscattering coefficient of JERS-1/SAR (L-band) as L-band microwave data is penetrative and very sensitive to forest. Biomass of Can Gio mangrove can be estimated by L-band SAR data.

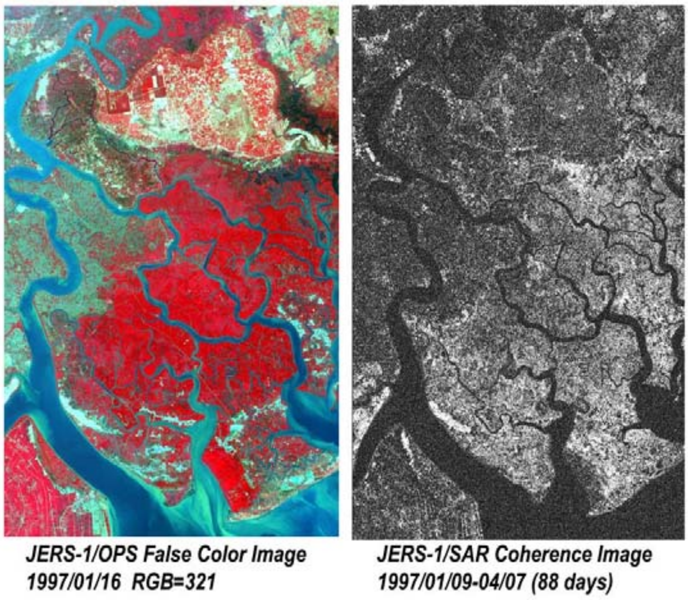

Fig.5 False color image and Coherence image of JERS/1

4. RECOMMENDATION

In order to understand environmental changes of the Can Gio mangrove forest and protect its ecosystem, following items are recommended.

1. Monitoring for land use management using satellite data
2. Prohibiting local communities from felling of mangrove showing satellite image of land cover changes. Moreover a comprehensive reforestation program should be organized using satellite data as well as geo-environmental information.

5. REFERENCES

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