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Using Satellite Data and Geo-Environmental Research for Environmental Monitoring of Bau Trang Lake Area, Binh Thuan Province, Vietnam

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ABSTRACT

The purpose of this study is to get more detailed information of environmental changes in Bau Trang Lake area in South Vietnam. In this area which is covered by vast sandy dunes and eroded hills, there are three lakes of Bau Ong, Bau Ba and Bau Xoai in line. These lakes are most important water resources in this region. Because all of lakes are having fresh water to be applied to human activities even though the lakes are situated in the coastal area. Recently, many urgent issues of desertification, deforestation, erosion, flooding and soil exhaustion came out in this area, and lead to many problems such as lifting the bottom of lakes by sediment materials. Latest report shows that the depths of water in Bau Ong and Bau Ba Lakes are just 14.5 and 22.0 m in maximum, compared with about 45-47 m in 1945. Also flooding and erosion were often occurred by collapse of Quaternary sediments along the coastal zone. In 1996, Phan Tiet formation composed of loose sandstone had collapsed at small coastal village, and had caused strong flooding, erosion and sand-flow. Consequently, many houses, cattle and people were disappeared with being pushed down into the sea. In order to investigate these phenomena Japan and Vietnam cooperative study team was set up and had carried out field survey. The result of this study is clearly showing the environmental degradation, and it suggests the possibilities that the natural disaster will come again and triggers unexpected damages to inhabitants and environment of this area. We discuss the suitable plan for improving the environmental changes in this area.

KEYWORD: Bau Trang, land use change, Landsat TM, JERS-1/SAR, Interferometry

1. INTRODUCTION

1.1. GEOGRAPHICAL - HUMAN FEATURES

The study area, Bau Trang lake area is located at coastal region, in the s1outh of Bac Binh district, Binh Thuan province, about 200 km in the Northeast of Ho Chi Minh City, Vietnam. The geographical coordinates are $11^{o}00'$-$11^{o}07'$ in latitude, $108^{o2}0'$-$108^{o}28'$ in longitude (Fig.1 and 3). The climate of Bau Trang lake area belongs to arid/ tropical regime with two seasons: dry and rainy seasons. The rainy season begins in June and ends in October, the dry one lasts from November to May next year. The average of temperature is $27^{o}C$, rainfall is 800 mm, evaporation: 1280mm, humidity: 72 – 86%. The population of Bau Trang lake area at present time is about 6,550 and 1,306 of households, and density of population is 337 persons / km^2. The main profession of local people is planting peanuts, corn, manioc, watermelon and fishing along seashore and in the lakes. Total land of Bau Trang area is around 19,419 ha. The ratio of land is classified as 3,317 ha (17%) for agriculture, 10,575 ha (54%) for forestry, 62 ha (0.3%) for garden, 44 ha (0.2%) for housing, and 5,421 ha (28%) is still uncultivated.

Fig.1 Location map of study area

2. GEO-ENVIRONMENTAL FEATURES

2.1. Soil

The study area is composed of the following rock formations:

+ Mesozoic hard rock Nha Trang formation (K_2 *nt*) has found in the South and Southeast of Bau Trang lake and in some drill holes at the depth 60 – 70 m below the surface. The rock is consisted of grey, greenish-grey dacite, dacite porphyrite, rhyolite, rhyodacite. It is solid, hard, strongly deformed and fractured.

+ Cenozoic uncemented rock formations occupied almost all the area. They are subdivided into following formations:

- Red sand bar Phan Thiet formation (m Q_{II-III} *pt*) is distributed in a large part of study area, which is composed of red, yellowish-red, fine-grained quartz sand. The rock is uncemented but highly compressed, having small absorption coefficient < 0.01 m/day.
- Marine sand Mui Ne formation (m QIII mn) is discovered mostly in the boreholes. The rock is light grey, composed of highly compressed fine-grained quartz sand, it has low absorption coefficient ≈ 0.01 – 0.08 m/day.
- Eolian ancient dune sand formation (vQIII) is consisted of reddish – yellow sandy silt.
- Holocene loosed sand formations include marine sand (m QIV2-3) and eolian sand (v QIV2-3, vQIV3). They are mostly composed of loosed yellowish, white, white – grey quartz sand, forming different high and big dunes in the east and northeast of Bau Trang lake. The sands have high absorpbility. At present time they are being formed, getting wider and higher day by day.
- As above mentioned formations, only the Phan Thiet (m QII-III pt) and ancient dune (v Q III) formations are giving good soil for planting vegetation.

2.2. Water

2.2.1. Surface water

In study area, there are three lakes named Bau Xoai, Bau Ong and Bau Ba lying in a line. In the East of Bau Ba, there are some small and short stream discovered closed to the beach, running into the sea with the visible discharge of 168 l/s. Among three above - mentioned lakes, Bau Ong and Bau Ba are the most important lakes for the object of study. The maximum depth in Bau Ong is 14.5m and 22m in Bau Ba that the water volume of these lakes is 12.131.900 m^3. The quality of water chemically good for use, but it is slightly polluted bacterologically. The water now is being exploited for daily life of local people.

2.2.2 Ground water

A large amount of ground water has been exploited for human activities because ground water investigation is insufficient. now. Some drilling holes have been carried out in 2000 year for geoenvironment research. The last monitoring result showed that the ground water level around Bau Ong is a little higher than the Bau Ong lake's water level, but the ground water level around Bau Ba lake is lower than the Bau Ba lake's water level. The quality of ground water is quite good for use.

3. Urgent issues to be resolved

Due to over population and un-planning development, in Bau Trang area, nowadays there are many urgent issues which had been occurred, continuously exist and will be happened at any time. They are as follows: deforestation, desertification, soil erosion degradation and exhaustion, flooding, water shortage and water pollution etc.

4 STUDY METHODS AND RESULTS

4.1. The satellite data analysis

There are urgent issues to be resolved in this area above-mentioned. In order to monitor and grasp the land changes preliminary satellite data analysis was carried out.

4.1.1. Land change detection

It is well known that remote sensing data can be useful to monitor the land cover changes on a large scale. A lot of methods of land cover classification and change detection have been developed for utilization of remote sensing data. In order to detect changes Normarized Difference Vegetation Index (NDVI) is widely applied to vegetated land cover classification. Soil Adjusted Vegetation Index (SAVI) was proposed by Huete,1988 because there are soil-induced influences on the vegetation index values. Tasseled Cap Transformation was developed by Kauth-Thomas (1976) in order to monitor crop change detection.

This study is focusing on the detection of area of water and monitoring the land changes. Because following phenomena are needed to monitor for reducing influence to the local resident.

1) vegetation change and desertification

2) migration of water from Bau Ba

Landsat TM (1989/03/06) and ETM (1999/11/12, 2001/04/08) were applied for the spectral analysis. In order to detect the land changes and the spectral variations in the different images, we register the images using 10 Ground Control Points (GCP).

1) vegetation change and desertification

NDVI derived from the ratio of band3, 4 in Landsat data was applied for the monitoring vegetation change and sand distribution by desertification. The source of desert sand is thought to be beach sediments in the sea. Those materials for the beach sediments is likely carried from the mouth of Song Luy river, which is located in the 20km north of Bau Trang area. The catchment area of Song Luy river is very wide in this district.

Imageries were acquired in the dry season (Fig.2-(a),-(c)) and rainy season (Fig.2-(b)) during 1989/11/12 to 2001/04/08. Therefore the soil moisture of Fig.2-(b) might be higher than Fig.2-(a) and Fig.2-(c). Fig. 2 shows the vegetation changes in some areas, which were decreased in the center (A), upper left (B) and upper right (C) of the images.While, the vegetation areas in the north of Bau Ba (O) and shoreline (P, Q) were increased. On the basis of the shape of the desert/vegetation boundary in this image, desertification around the biggest desert might be stopped rather than rapid progress.

Thus, vegetation index mapping images are showing that there are two areas of vegetation changes in this area. On the other hand, desert area along the coast is getting narrower and vegetation is spreading. These are likely indicating that desrtification is slowly decreasing rather than increasing.

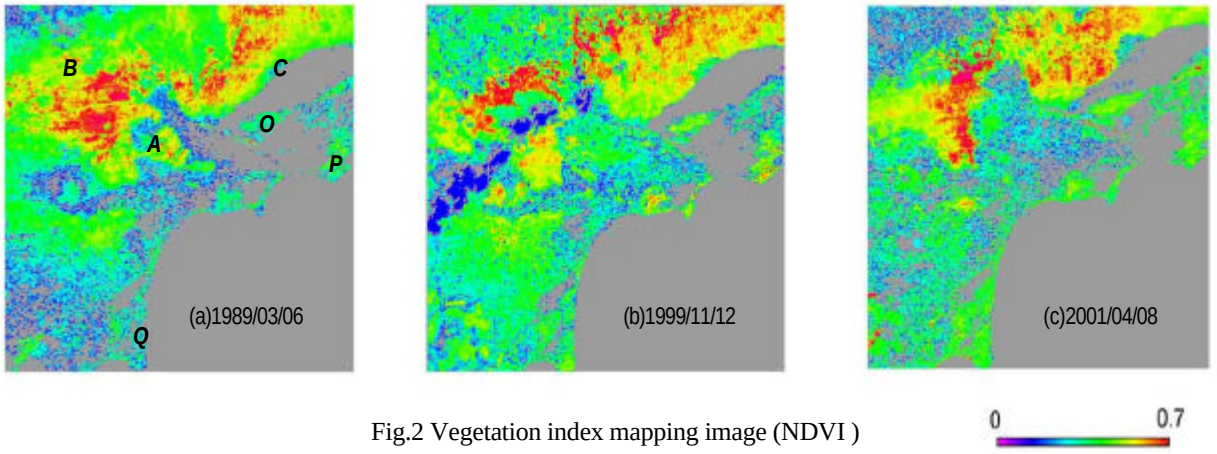

Fig.2 Vegetation index mapping image (NDVI)

2) migration of water from Bau Ba

Fig.3 shows Landsat-TM image of study area. There are some lakes and ponds in the right of image named as Bau Ong, Bau Ba, Pond A, B, C. Compared with the two images (1989/03/06, 2001/04/08), spreading areas of water were clearly recognized in some parts. Water was spreading in the western part of Bau Ong. and Bau Ba. The amount of spreading areas in Bau Ong is wider than Bau Ba. And a large amount of the water was spreading around the Pond A, B, C. The changes areas of water were estimated by manual measurement and wetness value derived from Tasseled Cap Transformation (TCT). It shows the normalized index of vegetation changes in the image by greenness, brightness and wetness. Fig.4 shows the result of wetness by TCT. Table 1 shows the estimated water area by manual and TCT. The areas of bigger

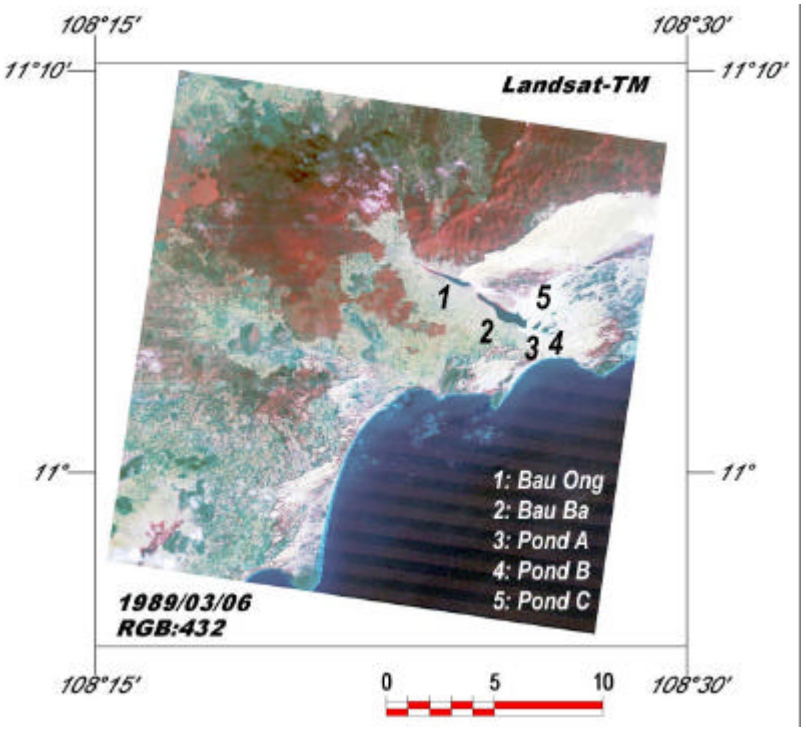

Fig.3 Landsat-TM Image of study area

lakes were fairly measured by both measurements. But the small water areas failed to detect by TCT. Because there are reflecting materials in the water/land boundary. The reflectance from grass and bottom materials in shallow water gave influence for the value of TCT. From the result of measurements, the spreading area of Pond A was two times in the period of 12 years approximately. Moreover, Pond B was changed around 3 times in the same period. Based on the topographic map, the height around of Pond A to C is lower than surrounding area. Bau Ba is 2m higher than the level of water surface of Pond A. It is possible that the spreading of water in Pond A-C was coming from Bau Ba through the under ground.

Thus it is recognized that water of lakes and ponds in this area have been spread. The causes are thought to be following factors 1) deforestation without planning, 2) filling by sand from desert 3)climate changes. However, it is possible to stop cutting down in order to prevent the acceleration for deforestation immediately.

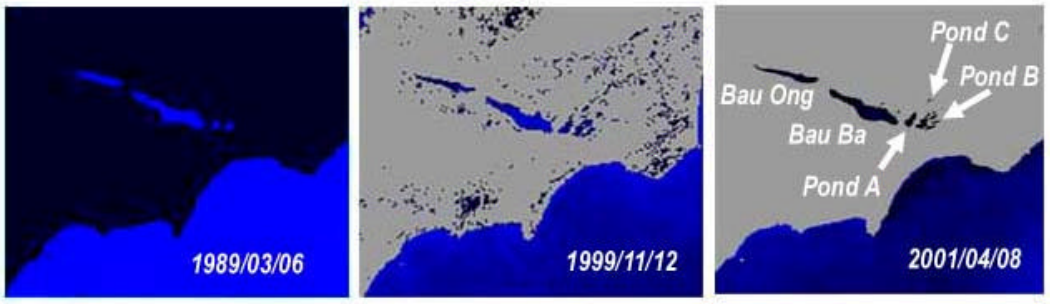

Fig.4 Wetness image derived from TCT

Table1. Estimated water area

(m^2)

	Manual (1)			TCT (2)			(2) / (1)	
	1989/03/06	2001/04/08	Changes	1989/03/06	2001/04/08	Changes	1989/03/06	2001/04/08
Bau Ong	302,900	427,300	124,400	277,900	376,900	99,000	92%	88%
Bau Ba	902,300	951,100	48,800	865,400	920,700	55,300	96%	97%
Pond A	80,200	162,500	82,300	43,100	114,100	71,000	54%	70%
Pond B	135,100	372,200	217,100	45,300	198,700	153,400	34%	56%
Pond C	16,100	27,000	10,900	0	6,600	6,600	-	24%

4.1.2. InSAR Processing

In order to investigate the potential of Interferometric SAR (InSAR) utilization for detecting the collapsed loose sand in the cost area (Target area of Fig.5 left), InSAR processing was applied. Amplitude data of SAR enhance the ground conditions and ground features. Phase data is possible to measure the small differences of ground deformation by using Interferometric SAR (InSAR) technique. It is a powerful tool that allows to detect the ground surface displacement with high accuracy. Therefore applying the technique has been increased to the fields of geology, volcanology, glaciology and natural hazard. The effective results were reported by many researches (i.e.Goldstein,1993; Massonnet et al.,1993; Murakami,1996). The numbers of total acquired data over study area is 15 scenes during the period of 1992/10/19-1998/09/14. We selected and co-registered for 45 pairs having small baselines (<1000m) to be applied InSAR processing. The event of collapse of loose sand was occurred on May, 20th, 1996. We processed the data by three passes method for InSAR technique because Digital Elevation Model (DEM) is not available in this area now.

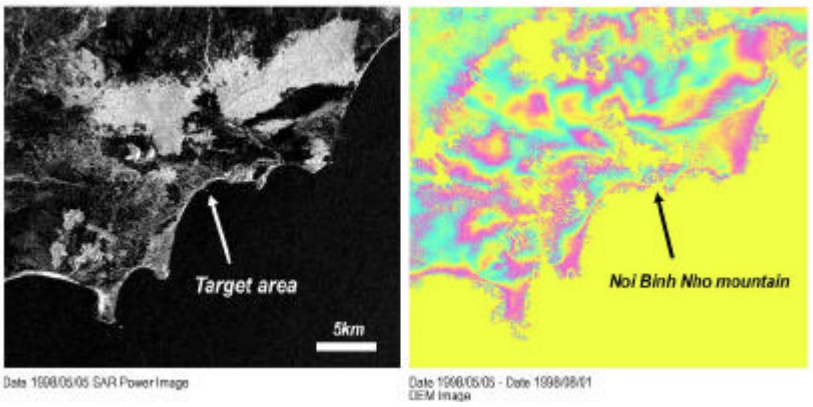

Fig.5 DEM image derived from InSAR

InSAR processing was carried out by using the VEXCEL 3D SAR Processor. The data processing was taken from

single look complex (SLC) derived from three signal data. Resampling, creating the interferograms, Filtering, Uwrapping the interferogram, Refining were carried out in SLC-1/-2 and SLC-2/-3 respectively. Multi-looking size was 2 range pixels by 6 azimuth lines. The parameter of co-registered pair is generally depending on 1) distance of baseline and 2) surface change in different time.

In this study, 16 pairs were processed to generate SLC. And then co-registration was done for each pair to generate interferogram. Among them, four pairs of SLCs were performed for InSAR processing (Table. 2). As a result, we could not generate intererogram around target area. However in some inland areas, the pair (5) made good coherent data to generate the DEM from interferogram (Fig.5). The fringe of small hill (named as Noi Binh Nho) located in the east of target area was clearly recognized. The one cycle of fringe on the image is showing 100m. It shows good correspondence with the height of hill (230m) between topographical map and DEM generated from InSAR processing.

Table 2 Perpendicular baseline and period of days of data used in Bau Trang

Date of pair	Perpendicular Baseline (m)	Period of days
1.1995/07/28-1997/05/18	382	968
2.1995/07/28-1998/09/14	478	1144
3.1995/12/07-1998/05/05	338	880
4.1995/12/07-1998/08/01	926	968
5.1998/05/05-1998/08/01 (for DEM)	607	88

4.2. Geo-environmental study

Study methods: In order to get more information, the study methods applied include: collecting existed data, monitoring new data, correlating and summarizing all data to detect environmental changing tendency. For monitoring Bau Trang area, the following works have been made: 6 drilling holes (25-40m deep), topographical works, sampling soil and water, geophysical and geological research. By carrying out the above-mentioned study methods, the first results which have been reached are as follow.

4.2.1. Soil changes:

Erosion appeared along lakes' banks and seashore. Along South-East Bau Ba lake's bank, there 5 big "V" shape trenches 3-5m deep, 8-30m wide and 30-60m long, which have been formed since 1996 by rainy water. In another place, along seashore, on the South-East of Bau Ba, there are 4 colossal "V" shape trenches 10-20m deep, 20-40m wide and 150-250m long. They were formed at very heavy rainy night of May 20th 1996. At that time, a terrible flash flooding occurred, destroying 50-60 houses, among these 15 houses with many cattle and people were completely carried away into the sea.

Sedimentation in the lakes occurs strongly and visibly. The lakes are being attcked not only by sand dunes but by sand rolled down with rainy streams from all higher parts around the lakes. The sedimentation makes lakes' bottom higher and higher. And water of lakes is migrating to the direction of Pond A to C.

From the table below, within the last 51 years, the depth of Bau Ong decreases almost 30m, and that of Bau Ba decreases about 25m. This is an alarm rate of filling up the lakes. It may be seen in the table 1. Desertification has been caused by three actors: hot-arid climate, sand dunes' attacking and deforestation made by local people.

Table 3 Changes of depth of water in Bao Ong and Bau Ba

Name/Year	1945	1967/09	2000/11/29
Bau Ong	45-47m	30m	14,5m
Bau Ba	45-47m	30m	22,0m

4.2.2. Water changes:

Since the geo-environmental research project has been set up, water in Bau Ong and Bau Ba are sampled and analyzed systematically. The last laboratory test results on water show that during an year, from dry to rainy season, the quality of water in both Bau Ong and Bau Ba is being changed visibly. At rainy time, commonly chemical parameters slightly increase, but bacteriological parameters sharply decrease. It happens because in rainy season, especially in June and July, the rainy water all around the lakes rush down into them to make changes. From 1995 up to now, the water sampling is not carried out sufficiently to understanding. It is difficult to say any thing, but looking at some parameters, it seems the water quality is getting worse. General speaking, chemically the quality of water in Bau Trang area is still good for use, but bacteriologically water in both Bau Ong and Bau Ba are slightly polluted.

Table 4 Chemical compositions of water in Bau Ong and Bau Ba

Place of sampling	Bau Ong			Bau Ba		
Date of sampling	1995	2000/11/29	2001/06/18	1995	2000/11/29	2001/06/18
pH	7,2	7,71	6,97	6,8	7,70	7,33
SiO_2 (mg/l)	13,75	8,25	46,75	11,7	6,50	19,75
CO_2 free (mg/l)	7,09	7,04	11,00	3,96	14,08	2,20
Hardness (meg/l)	-	1,000	1,500	-	1,950	0,700
Ca^{++} (mg/l)	11,69	6,01	15,43	5,39	28,06	8,02
Mg^{++} (mg/l)	11,95	8,51	8,88	4,41	6,69	6,06
NH_4^{++} (mg/l)	0,16	0,40	0,00	0,05	0,25	0,00
Fe^{++} (mg/l)l		<0,01	0,02		<0,01	0,00
Fe^{+++} (mg/l)l		2,00	0,00		0,90	0,02
Al^{+++} (mg/l)l		0,20	-		0,02	0,00
$Na^{+} + K^{+}$ (mg/l)		119,39	77,78		82,80	43,20
Cl^{-} (mg/l)		88,75	112,38		113,60	52,47
SO_4^{--} (mg/l)	9,12	19,80	4,80	15,744	18,50	9,61
CO_3^{--} (mg/l)l		0,00	0,00		0,00	0,00
HCO_3^{-} (mg/l)	90,09	207,46	97,63	36,85	122,03	54,92
NO_2^{-} (mg/l)		0,65	0,06		<0,01	0,01
NO_3^{-} (mg/l)		0,90	0,00		1,82	0,00
DO (mgO_2 /l)	6,81	4,1	4,3	7,68	4,0	4,5
COD (mg/l)	6,14	25	9		15	11
BOD_5 (mg/l)		10	6		5	8
SS (mg/l)l	6,5	10	18	-	15	10
Coliform		$150x10^2$ ml	$21x10^1$ ml		$15x10^2$/100ml	15/100ml
E.Coli		$9x10^1$/100ml	9/100ml		$4x10^2$/100ml	0/100ml
Streptococcus faecalis		0/50 ml	0/50 ml		0/50ml	0/50ml
Clostridium perfringens		0/10 ml	10/10 ml		18/10ml	0/10ml

5. CONCLUSIONS AND RECOMMENDATION

In order to protect Bau Trang area's environment from getting worse, the following recommendation and measurements may be deputed to be applied:

1. Monitoring for land use management
2. Prohibiting cutting down trees and planting trees much more around the lakes to diminish desertification.
3. Exploiting water from the lakes to supply more water for not only for daily needs as nowadays, but for irrigation targets for whole area.
4. Carrying out hunger erase and poverty diminish program to help poor households, especially the households living closest the lakes, to help and educate all local people to carry out civilization life to protect the environment.
5. Improving impoverished soil by adding more cattle manure and clay to the soil.

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