APPLICATION GIS AND REMOTE SENSING FOR MONITORING THE CHANGING OF CORAL REEF AT TAM HAI COMMUNE, NUI THANH DISTRICT, QUANG NAM PROVINCE

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ABSTRACT

The coral reef plays an important role in tropical marine ecosystem. The continuous degradation of these habitats in Vietnam is serious issue. This research embodies about the changing of coral reef in Ban Than cape, Nui Thanh district, Quang Nam province. Integration of remote sensing and GIS has offered the information of the change of marine environment in Nui Thanh district through mapping the changes of coral reefs during 1990-2000 and 2000-2010.

In this study, Landsat TM images of 1990, 2000 and Quickbird image 2010 has been used for mapping the coral reef map in 1990, 2000 and 2010. A principal component analysis (PCA) technique was carried out to improve feature's information. The image classification was executed based on the images which applied PCA technique. The overall accuracy estimated was at 80.95, 80.95 and 85.71% for maps in 1990, 2000 and 2010, respectively.

The result shows that area of coral reefs in Nui Thanh district is decreased continuously during 1990-2000 and 2000-2010 periods. This valuable information not only helps the local government in assessing, monitoring and making plan for sustainable development of coral reefs in Quang Nam Province but also applying for monitoring the marine ecosystem.

Keywords: Remote Sensing, GIS, Coral Reefs, Mapping Benthic Communities, Change Detection, Marine Environment, Nui Thanh district, Viet Nam.

1. INTRODUCTION

Benthic habitat plays an important role in marine environment. Coral reefs are considered as significant habitat in the shallow water in tropical and sub-tropical region which includes Vietnam, Philippine, Thailand. There are 58 percent of the world's coral reefs are threatened by human activities. Some study shows that seagrass and coral reef in Vietnam are changing rapidly. Scientist in Nha Trang Oceanography Institute estimated that the coral reef in Vietnam is declined by more than 30% in some areas (Son, 2006). This study focuses on Quang Nam province which is located in the central of Vietnam which has a large area of coral reefs. Coral reefs in this province are mainly found in Cham Island and Ban Than cape, Tam Hai commune Nui Thanh district.

This research is an attempted to use remote sensing, GIS with field survey and local information to understand the benthic habitat preciously. The results also proved that remote sensing and GIS is useful tool to support for decision making in marine protection activities for sustainable development and management though mapping the changes of coral reefs.

2. METHODOLOGY

2.1 Remote sensing data

Remote sensing data is used for classification purpose. The Landsat TM of 1990, 2000 and Quickbird image 2010 cover Ban Than cape, Tam Hai commune, Nui Thanh district, Quang Nam province.

2.2 Digital Processing

2.2.1 Image Registration

Geometric correction and rectification are computed to correct distortion of image. It involves to the identification of the image coordinates by using several clearly points which called ground control points (GCPs). Landsat and Quickbird images cover study area in 1990, 2000 and 2010 are adjusted to the same location. The UTM zone 49 and WGS 84 as the projection and reference ellipsoid are applied for all satellite images.

2.2.2 Image Masking

The masking technique is applied for separating water body area and cloud removing. A mask is a binary format image which consist 0 and 1 value. When processing the areas with value 1 process and mask area value 0 which don't using for the calculation. The land and water of Landsat images in 1990, 2000 and Quickbird image in 2010 were separated by carrying the masking technique.

2.2.3 Water Column Correction (WCC)

When coral reefs are mapped by applying remote sensing image, the effect of water depth on reflectance of underwater objects is too much. To reduce the effect of variable depth on images, water column correction method is applied in this study, which was developed by Lynzenga, 1978.

2.2.4 Image Enhancement

The image enhancement technique is used for improving the quality of image. In this study, color composite, and principle component analysis (PCA) are conducted on all images. The principle component analysis (PCA) is one of technique which used in remote sensing image analysis for image enhancement, compressing the information and image encoding (Picchiotti et al., 1997). The PCA transformation based on the analysis of correlation among different bands and rotated the axes of a set of image bands which are uncorrelated (Jesen and Waltz 1979, Canas and Barnett 1985, Singh and Harrison 1985, Jesen 1996). The PCA provided more interpretable than the raw image (Jesen, 1996).

2.2.5 Supervised Classification

Supervised classification method which used Maximum Likelihood is carried out in this study. The images applied principal component analyses is chosen for supervised classification. These images display more appropriately information of benthic habitat than other images from enhances technique. Satellite images in 1990, 2000 and 2010 were masked out the land and water and classified into several classes. The essential classes for benthic habitat are coral coverage >35%, coral coverage 20-35%, coral coverage 10-20%, coral coverage <10% and rubble.

2.2.6 Post Classification

Post classification is one technique to improve the classified image result. “Sieve classes” and “clump classes” option are applied for reducing the misclassification pixels. Post classification help to remove “manifest salt” and “pepper”, clumping classes or absent class, which appeared after supervised classification. This technique created a smoother image by using low pass filtering. The previous research has proved that post classification is an important step in improve the quality of classified image (Harris and Ventura, 1995).

2.2.7 Accuracy Assessment Technique

The specific site and non specific sites of error matrix were carried out in this study. In the site specific error matrix, row represented classification classes and column represented ground truth data for these classes. Results of accuracy assessment help to identify the reliability of classified image.

2.2.8 Raster to Vector Conversion

All images were classified with Erdas software in form of raster data. They are converted to vector data type for utilizing and opening in GIS software. ArcGIS was used for creating shape file, editing table attribute of these classes and making the map layout.

2.2.9 Change Detection Technique

In this study, change detection technique is applied to identify the changes of coral reefs in study areas. The overlay method is applied to compare the dataset from two different images in order to indicate coral reefs changes. It means that the data of the first date is overlaid by the new situation in second date. The difference between two dates are recorded and shown in both map and attribute.

3. CONCLUSION AND DISSCUSSION

3.1 Spectral Profile Analysis

The spectral profile is analyzed by using field survey data which were converted to point data and directly compare with the DN value on satellite image.

In both Landsat image 1990 and 2000, coral reef has the highest reflectance value in band 1 (0.45 - 0.52µm) and lowest reflectance value in band 7 (2.08-2.35 µm). However, the reflectance value of sand is very near reflectance value of coral reef in band 4, 5 and 7.

In Quickbird 2010, coral reef has the highest reflectance value in band 2 (0.52 - 0.60µm) and lowest reflectance value in band 4 (0.76-0.90 µm). The reflectance value of these habitat is reduced band 1 (0.45 - 0.52µm) and band 3 (0.63 - 0.69µm).

In both Landsat and Quickbird images, the reflectance value of sand is always higher than reflectance value of coral reef in all bands and reaches the peak value in band 1 (0.45 - 0.52µm) and band 2 (0.52-0.6µm) of Landsat and Quickbird image, respectively.

3.2 Principle component analysis

For remote sensing image Landsat 1990, 2000 and Quickbird 2010, component PCA1, PCA2 and PCA3 contains nearly all image information. Therefore, PCA1, PCA2 and PCA3 of Landsat 1990, 2000 and Quickbird 2010 were used for classification image.

3.3 Field survey

In this study, the quadrat is integrated with linear transect to estimate the coverage of coral reef. The quadrat is taken five times within transect area. Four times at four corners and another time in center of transect. Percent of coral reef coverage is estimated by counting the number of quadrat cells. The average percent of coral reef for five times is percent cover of coral reef of transect site. There are twenty one transect sites was vestigated

Coral Reef Map

The coral reef in this area is taken interested in from the officer and researcher in recent years due to reducing of their areas and coverage. The coral reef map in 1990, 2000 and 2010 were computed by integrated of Landsat, Quickbird image and GIS technique.

The coral reef map results in 1990, 2000 and 2010 are shown in figure 1 a, b, and c. For the classified image of Landsat 1990, 2000 and Quickbird 2010, the accuraccy assessment is carried out which base on 21 sampling points from the field survey. The overall classification accuracy of image in 1990, 2000 and 2010 equal 80.95%, 80.95%, and 85.71%, respectively.

Table 1. Area of coral reef area in Nui Thanh 1990, 2000 and 2010

Type	Coral area (ha) 1990	Coral area (ha) 2000	Coral area (ha) 2010
Coral >35%	14.5	12.7	4.9
Coral 20-35%	30.5	23.3	4.1
Coral 10-20%	6.7	22.6	24.1
Coral <10%	39.6	15.8	15.1
Total	91.3	74.4	48.2

The area of coral reef in 1990, 2000 and 2010 is shown in table 1. In the coral reef habitat, coral reef more than 35%, coral reef 20-35%, coral reef 10-20% and coral reef less than 10% occupied in 14.5, 30.5, 6.7 and 39.6 hectare in 1990; 12.7, 23.3, 22.6 and 15.8 hectare in 2000 and 4.9, 4.1, 24.1 and 15.1 hectare in 2010, respectively.

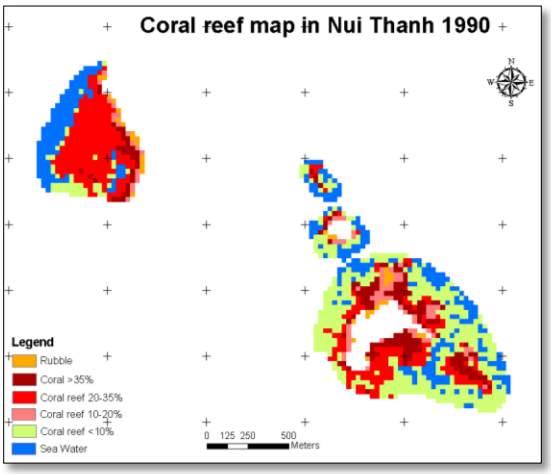


Figure 1 a) Coral reef map in 1990

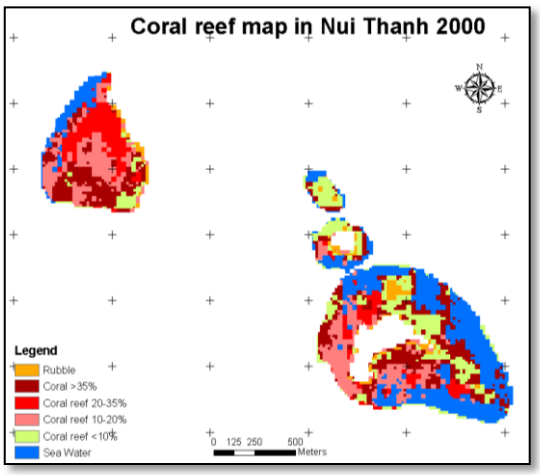


Figure 1 b) Coral reef map in 2000

As we can see from the table 1, the areas of coral reef with more than 35% coverage are decreased continuously from 1990 to 2010. The areas of coral less than 10% coverage always occupied large portion in comparing with the others in each year. The areas of coral reef 20-35% lightly decreased from 1990 to 2000 and significantly decreased from 2000 to 2010.

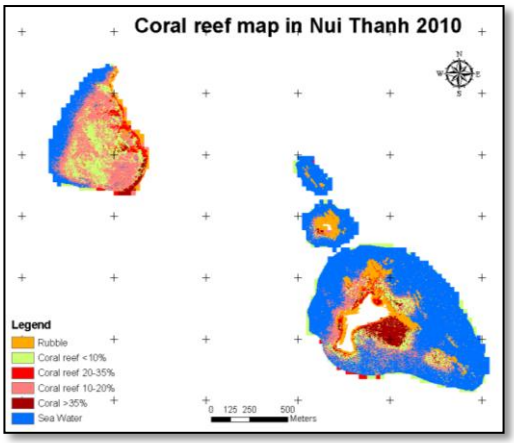
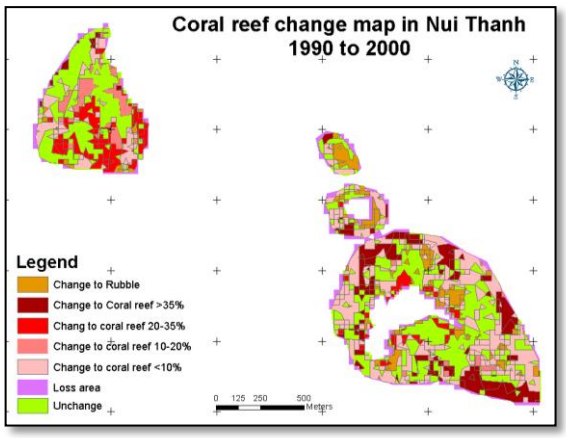


Figure 1 c) Coral reef map in 2010

3.5 Coral Reef Change Detection in Nui Thanh District

The change detection of coral reef in period 1990-2000 and 2000-2010 were analyzed. The change detection maps are shown in Figure 2 a and b.



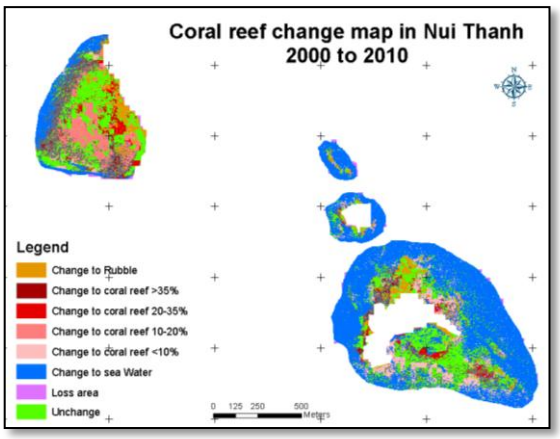


Figure 2 a) Changes from 1990 to 2000

Figure 2 b) Changes from 2000 to 2010

Table 2. Changing areas of coral reef area in Nui Thanh 1990, 2000 and 2010.

Type	Change in area (ha) 1990 - 2000	Change in area (ha) 2000-2010	Change in area (ha) 1990-2010
Coral >35%	-1.8	-7.8	-9.6
Coral 20-35%	-7.2	-19.2	-26.4
Coral 10-20%	15.9	1.5	17.4
Coral <10%	-23.9	-0.7	-24.5

(-) show the decreasing of the trend

The table 2 shows that the total areas of coral reef in Nui thanh continuously decreasing. In 1990-2000, it has decreased by 16.9 hectare and 26.2 hectare in 2000-2010. The areas of coral less than 10% were reduced 23.9 hectare in period 1990-2000 and 0.7 hectare in 2000-2010. The areas of coral reef more than 35% coverage were also reduced but the decreasing rate is less than decreasing rate coral reef less than 10% coverage. It reduced around 1.8 hectare form 1990 to 2000 and 7.8 hectare from 2000 to 2010. Among the type of corals, there is only coral reef 10-20% coverage which is increased 15.9 hectare and

1.5 hectare in term of two period, 1990 to 2000 and 2000 to 2010, respectively. The changing of this trend may be cause of dropping down from the areas of coral reef more than 35% and coral reef 20-35% coverage.

4. CONCLUSION AND RECOMMENDATION

Principal component analysis has been applied effectively to improve the reflectance and spectral characteristics. Mapping of coral reefhas achieved for Ban Than cape, Tam Hai commune in 1990, 2000 and 2010. The result of change detection shows that the areas of coral reef areas in Tam Hai have been reduced during 1990-2000 and 2000-2010 periods.

This study proved that remote sensing and GIS are useful tools to support for making decision, conservation, sustainable development and management of marine habitat.

Based on analysis and results in this study, some recommendations have given for the more depth research and related local organization as follow

- Principal Component Technique should be applied in case of detect the benthic habitat.
- Water column correction should be used to remove the effect of water when detecting the objects underwater.
- Coral reef is objects under water so we should be concern to effect of turbility of water, depth of coral reef as well as time of image acquisition.

REFERENCES

Edmund, P. G, and Edwards, 2000. Water Column Correction Techniques, *Coastal management sourcebooks*, UNESCO.

Chauvaud, s., Bouchon, c, and Manière, r., 1998. Remote sensing techniques adapted to high resolution mapping of tropical coastal marine ecosystem. *International Journal of Remote Sensing*, 18, pp. 3635-3639.

Khan, M. A., Fadlallah, Y. H. and AL-Hinai, K. G., 1992. Thematic mapping of subtidal coastal habitats in the western Arabian Gulf using Landsat TM data - Abu Ali Bay, Saudi Arabia, *International Journal of RemoteSensing*, 13:4, pp. 605 – 614.

Liceaga-Correa, M. A., and Euan-Avila, J. I., 2002. Assessment of coral reef bathymetric mapping using visible Landsat Thematic Mapper data, International Journal of Remote Sensing, 23, pp. 3–14.

Matsunaga, T., Hoyano, A., and Mizukami, Y., 2001. Monitoring of coral reefs on Ishigaki Island in Japan using multitemporal remote sensing data. In Hyperspectral Remote Sensing of the Ocean, R.J. Frouin, H. Kawamura and M. Kishino (Eds*). Proceedings of SPIE*, 4154, pp. 212–222.

Mumby, P. and Green, E., 2000. Mapping coral reefs and macroalgae Part A. Part 3 Habitat Classification and Mapping. *Coastal management sourcebooks*. UNESCO. Available at: http://www.unesco.org/csi/pub/source/rs12.htm.

Son. T. P. H., 2006. Applying remote sensing and GIS for mapping coastal ecosystem and creating GIS data for coral management in Phu Quoc, Viet Nam, *Nha Trang Institute of Oceangraphy*, Viet Nam

Zainal, A.J.M., Dalby, D.H., and Robinson, I.S., 1993. Monitoring Marine Ecological Change on the East Coast of Bahrain with Landsat TM. *Photogrammetric Engineering & Remote Sensing*, Vol. 59, No. 3, pp. 415-421.