Time series analysis of environmental changes in Dili city, Timor-Leste by using satellite images remote sensing and GIS technique

○Nattha Okajima, Masahiko SEKINE and Ariyo KANNO

1. Introduction

Timor-Leste or East-Timor became an independent country on 20 May 2002. In 16th century to 1975, Timor-Leste was occupied by Portugal. After that Timor-Leste was under Indonesia since 1975 to 1999. In 1999 to May 2002, United Nation (UN) was a sponsor for majority of Timorese and voted for independence from Indonesia (FAO, 2010) [1]. Since Timor-Leste was under administration of many countries, there were many conflicts and fighting. The major infrastructures of the country including house, school, water supply was destroyed by antiindependence Timorese. Many environmental data were lost and/or not recorded during these periods of confsion. In Dili city, is facing water pollution problem(Michael H., 2006) [2].

Our laboratory conducted water quality surveys in streams and wells in Dili, and found high organic, toxic, and bacterial pollution in their water mainly because of their untreated household waste water. Although the government and people notice the pollution, there is almost no action for it since they have luckily not experienced epidemics. To motivate a quick action, it would be necessary to show the proof that the stream pollution is causing deterioration in the coastal area, since they are promoting tourism and beautiful sea is the measure resource for the country. For this purpose, we have started to measure some water quality items like coliform group, and we have found that the coliform group concentration is not fit the water quality standard for bathing. However, there are many animals in the basin and existence of coliform group is not enough to show the relationship between the anthropogenic stream pollution and coastal pollution. Although showing the historical change of population and water quality is one possible method to prove it, there is no historical environmental data as I already mentioned. Remote sensing and GIS technique are powerful tools for acquiring data in the past and providing data for hard to reach areas, with low cost and effectively. By using multi spectral analysis to identify the bottom type in shallow coral reef ecosystem, the spatial resolution, atmospheric and water column correction are needed (Manessa Masita D.M. et al., 2012) [3]. Remote sensing and GIS can be provided essential source information for planers and decision makers can use to sustainably plan the environment (Rwanga S.S. et al., 2017) [4]. However, time series data needs Landsat data for the purpose of this research.

The purpose of this study is to describe the relationship between water quality and population change by applying remote sensing and GIS techniques, with Landsat data in Dili city, TimorLeste.

2. Study area

The study area is located in Dili capital city, Timor Leste. The total area of the study area is 94.85 km^2. The northern is border on the seaside. The eastern is the Cristo Rei city at latitude -8° 31' 10.27" N, longitude 125° 37' 52.43" E and latitude -8° 37' 39.32" S, longitude 125° 29' 39.06" W. The country has a quite dramatic topography, dominated by the central mountain range of Ramelau. As much as 44% of East Timor's area may have a slope of more than 40%.

Key Words : Time series, Landsat, Seaweed mapping, Land use change, Population change

Address:2-16-1 Tokiwadai, Ube, Yamaguchi, Japan

TEL NATTHA-San telephone number

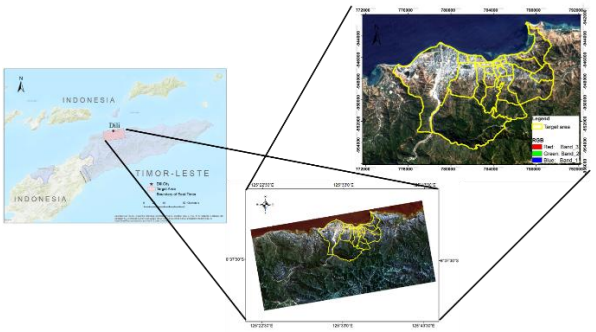

Fig.1 Location of Dili city

3. Research Method

we have been applied Landsat 5 TM and Landsat 8 OLI images for monitoring land use and applied Landsat 5 images for estimating seaweed area in Dili city. The convertion of Digital Number (DN) to spectral radiance and exoatmospheric Top of Atmosphere (TOA) reflectance for Landsat TM (Chander G. et al., 2009) [5]. Landsat 8 OLI images were converted DN to TOA reflectance according "LANDSAT 8 (L8) DATA USERS HANDBOOK by USGS".

(1) Textural Feature of images
Textural feature is one of procedure for categories or classifying of images based on grey tone spatial dependency. The standard deviation was applied for blue band and green band, with window size 5x5. Mean was applied for red band, near-infrared band and NDVI band, with window size 5x5 also.

(2) Land use classification
Supervised classification was applied for multispectral satellite imageries. Maximum likelihood algorithm was applied for five appropriate textural feature images. The selection training area (region of interest) is an essential to classify by using Maximum likelihood algorithm. Ground truth points point were utilized to create error matrix of classification.

(3) Chlorophyll analysis
Firsly, we tried to estimate the chlrophyll concentration by applying the Global Chlorophyll Concentration estimation. The estimation of the coastal Chlorophyll concentration (Chl) was performed by apply CI algorithm (Hu et al., 2012) [6] and OCx algorithm (O'Reilly et al., 2000) [7].

(4) The Seaweed area estimation
There were two methods are examined. First medthod is applied CI and OCx algorithm and second method is applied supervised classification.

(5) Accuracy assessment of classified images
The error matrix and Kappa coefficient were applied to assess accuracy of land use class and seaweed area in Dili. The overall accuracy is accuracy measure of the map. Kappa coefficient or KHAT statistics is the measure the overall agreement of a matrix as below

$$Kappa = \frac{P_o - P_e}{1 - P_e}$$

Where P_o = Observed agreement accuracy, $\frac{\sum X_{ii}}{N}$, P_e = estimated of chance agreement, $\frac{\sum X_{i+}X_{+i}}{N^2}$, N = total number of observations, X_{ii} = observation in row i and column i, X_{i+} = marginal total of row i and X_{+i} = marginal total of column i.

4. Result and discussion

(1) Land use classification
Supervised classification, which better accuracy was applied for land use classification and seaweed estimation by using Landsat images and selection of the position of the ground truth points. The detection of land use change was carried out by satellite image, with the main concern is that accuracy. Overall accuracy and Kappa were 78.0% and 0.7515 for 2015, 75.0% and 0.7515 for 2010, 82% and 0.8050 for 2005 75.0% and 0.7158 for 2000, 81% and 0.7802 for 1995, 68.0% and 0.6203 for 1990 and 77% and 0.7277 for 1986. From 1986 to 2015, the residential area and building has been increased over 62%. The Error matrix method and Kappa coefficient were applied for assessment accuracy in Table 1. According historical of Timor-Leste, there was many fighting during 1975-1999. Many people were killed by tragic conflict. This even may cause of decreasing of building in 2000 in Figure 6. Dili's land use was affected from former events. Many tragic conflicts and fight occur during Timor-Leste was under administration of many countries. The variable of Dili's land use is depended on increasing of population settlement and traditional of plantation like cutting and burn. Mostly, plains area in Dili was used for settlement. farmland or agriculture areas are in higher land areas like mountain or alluvial mountain. The climate are an important impact for vegetation growth and increasing amount of water source in Dili.

(2) Population estimated base on Land use
Sum of residential area and building area shows good accordance with Dili city population in Figure 2.

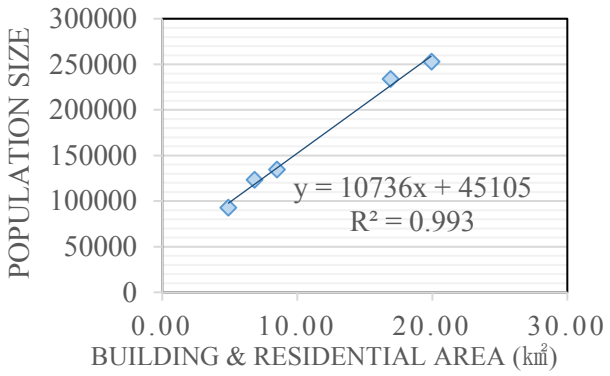

Fig.2 The formula to estimate the population growth in Dili

(3) Estimation of Chlorophyll concentration

We estimated several months of available scenes from Landsat 8. From January of 2015 through the year of 2015 by applying Global Chlorophyll Concentration estimation. We found there was Very small amount of Chl in Dili's coast in Figure 3.

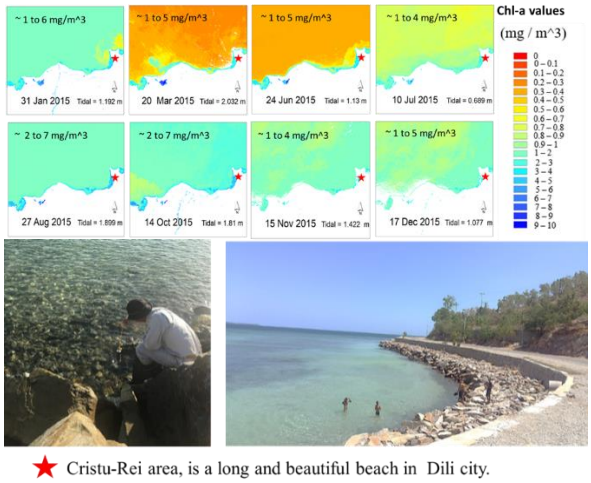

Fig.3 The Chl-a concentration retrieval from Landsat 8 OLI of 2015 in several months

(4) Seaweed area estimation

Supervised classification was applied for seaweed area estimation along the Dili's coastal. In 1995, seaweed area has been decreased (0.51 km^2) in Figure 4.

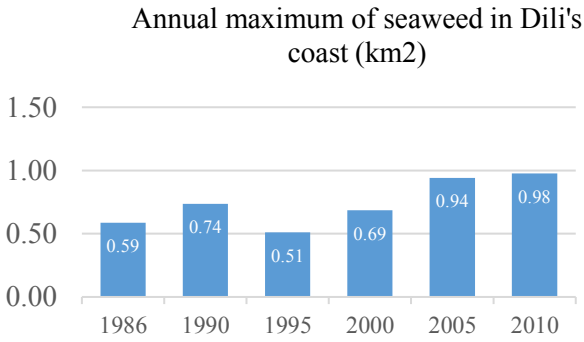

Fig. 4 Seaweed estimated in Dili's coast

(5) Description the relationship between population growth and seaweed estimated

The population of Dili is an impact of increasing of seaweed around Dili's coastal area in the past. The result show that during period 1990-1995, the population was slightly growing up. Seaweed area estimated was going down in Figure 5

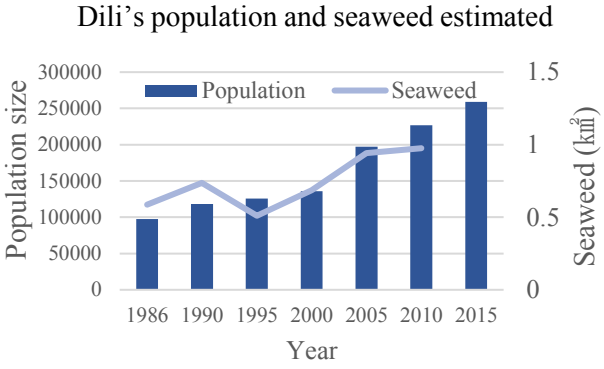

Fig.5 The relationship between population and seaweed estimated

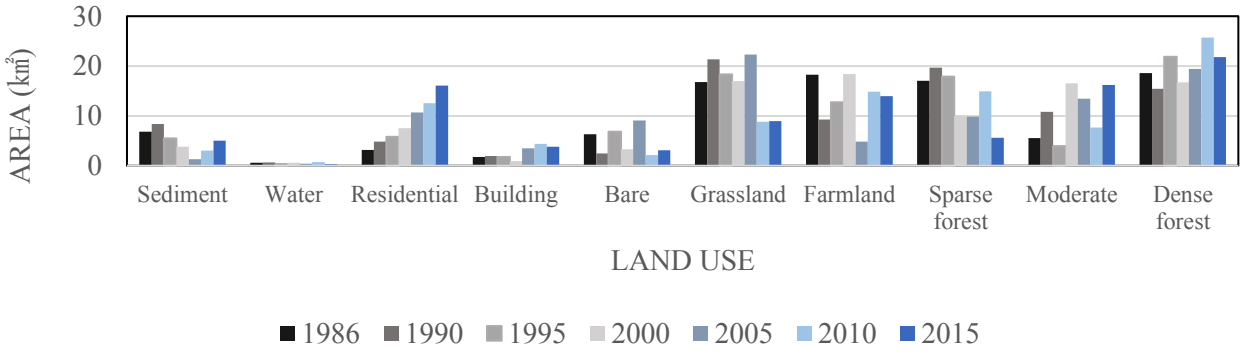

Fig.5 Annual comparison of the total area for ten land use categories

Table 1 An example of assessment accuracy by Error matrix method and Kappa of 2015

	Ground truth points (2015)										
	Bd	R	W	S	G	B	F	DF	SF	M	total
Bd	7	0	0	0	0	2	0	0	0	0	9
R	1	9	0	0	2	0	2	0	1	0	15
W	0	0	3	0	0	0	0	0	0	0	3
S	0	2	0	5	0	0	0	1	0	0	8
G	0	0	0	0	10	0	1	0	3	0	14
B	2	0	0	0	0	4	0	0	0	0	6
F	0	0	0	0	0	0	15	0	1	1	17
DF	0	0	0	0	0	0	0	11	0	2	13
SF	0	0	0	0	0	1	0	0	5	0	6
M	0	0	0	0	0	0	0	0	0	9	9
total	10	11	3	5	12	7	18	12	10	12	100
PA%	70	81	100	100	83	66	79	92	50	75	
CA%	77	60	100	62	71	66	88	84	83	100	
Overall Classification Accuracy = 78%											
Overall Kappa Statistics = 0.7515											

Note: Bd:building, R:residential, W:water, S:sediment, G:grassland, B:bare, F:farmland, DF:dense forest, SF:sparse forest, M:moderate, PA:Producer's accuracy, CA:User's accuracy

5. Conclusion

We found a strong relationship between population and residential and building area. We also found a relationship between population and seaweed in the coastal area. Seaweed can be an indicator for coastal water quality in the past. The histrical change of these parameters showed that the population increase in Dili has been causing a possible nutrients increas in the coastal area.

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