EVALUATION OF MANGROVE CONDITION IN COASTAL AREA OF KOTANIA BAY, MALUKU PROVINCE, INDONESIA USING LANDSAT MSS DATA

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1. INTRODUCTION

Maluku Province is consist of 1000 islands, and so well known as "Province of Thousand Islands" in which 90% of these areas are covered by sea. Three unique tropical ecosystems, namely coral reef, sea grasses and mangrove are generally found along the coastal zone.

As coastal zone is being more and more the object of land development and demographic pressure, monitoring upon it becomes necessary. Recently, satellite remote sensing has proved as an effective tool for observing or monitoring or evaluating the environment, because they provide us multidate data over a wide area in a regular basis.

The objective of this study is to evaluate the mangrove condition in coastal area of Kotania Bay, Maluku Province, Indonesia using two Landsat MSS data.

2. STUDY AREA

The study area mentioned above is located between the latitude of 2° 57'-3° 07' South and the longitude of 128° 02'-128° 09' East (see Fig. 1). According to ground observation, the prevailing mangrove species in the region are Rhizopora apliculata (futabana hirugi), R. stylosa (yaeyama hirugi) and Bruguiera gymnorhiza (o hirugi).

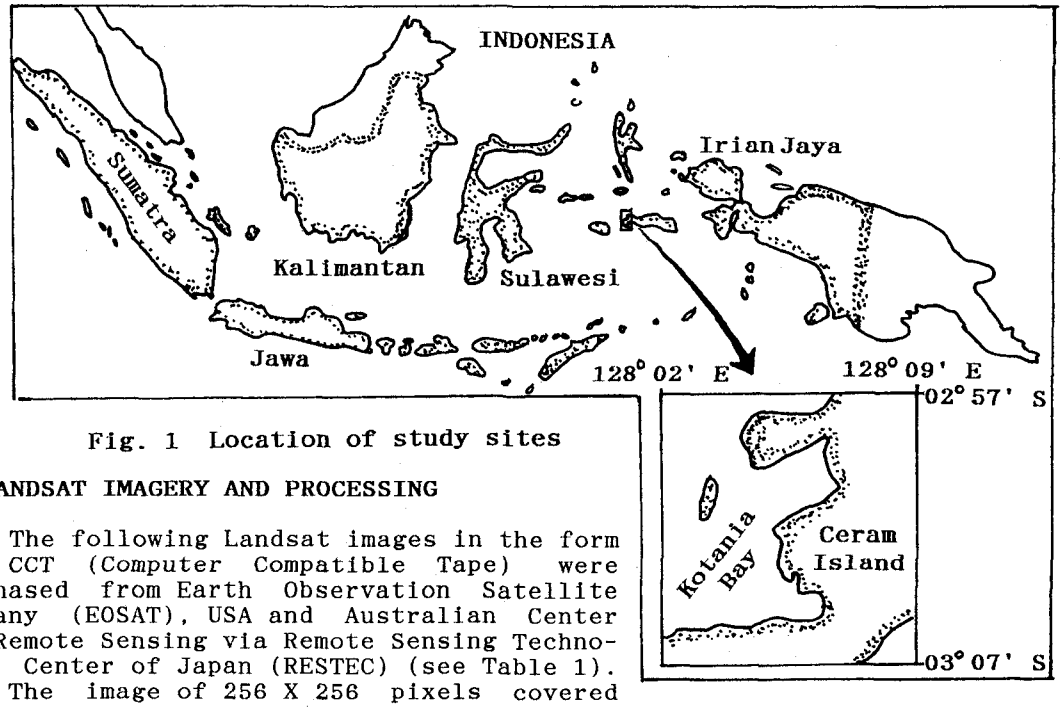


Fig. 1 Location of study sites

3. LANDSAT IMAGERY AND PROCESSING

The following Landsat images in the form of CCT (Computer Compatible Tape) were purchased from Earth Observation Satellite Company (EOSAT), USA and Australian Center for Remote Sensing via Remote Sensing Technology Center of Japan (RESTEC) (see Table 1).

The image of 256 X 256 pixels covered Kotania Bay were extracted from CCT tape and recorded on 5.25" floppy disk. The above Landsat images then were processed with digital image processing using JAFSA program, running on a personal computer.

Table 1 Data used in analysis.

Image date	Satellite & sensor	Path - Row	Band	Sun elevation
October 4, 1972	Landsat-1 MSS	116 - 062	4, 5, 6 and 7	58°
May 16, 1986	Landsat-5 MSS	109 - 062	4, 5, 6 and 7	43°

Because the data were taken from two different Landsat satellites and dates, the differences of digital count (DC) values due to the effect of different sensor and atmospheric condition must be corrected. Here we adopted a simple atmospheric correction procedure described by Ritchie at al. (1987). The corrected DC values of two Landsat data were calibrated by transversing them into the reflectance values as pointed out by Robinove (1982). The equation is expressed as follows :

$$Ref_{(date)} = \left[\frac{(DC - DC_{min})}{DC_{max}} * (b-a)+a \right] * \left[\pi/(E \sin \theta) \right]$$

where $Ref_{(date)}$: Reflectance of a certain date,
DC : Digital count,
DC_{min} : Minimum DC value in 256 X 255 pixels block,
DC_{max} : Maximum DC value in 256 X 255 pixels block,
a and b : Landsat calibration factors,
E : Irradiance at top of atmosphere, and
θ : sun elevation.
The values of a, b and E are listed in Table 2.

Table 2 List of Landsat calibration values and E values.

Band (nm)	Landsat-1 all a	Landsat-1 all b	Landsat-5 after Nov.9,84 a	Landsat-5 after Nov.9,84 b	E mW/cm^2
4 (500 - 600)	0	2.48	0.03	2.68	17.70
5 (600 - 700)	0	2.00	0.03	1.79	15.15
6 (700 - 800)	0	1.76	0.05	1.48	12.37
7 (800 -1100)	0	4.00	0.11	3.69	24.91

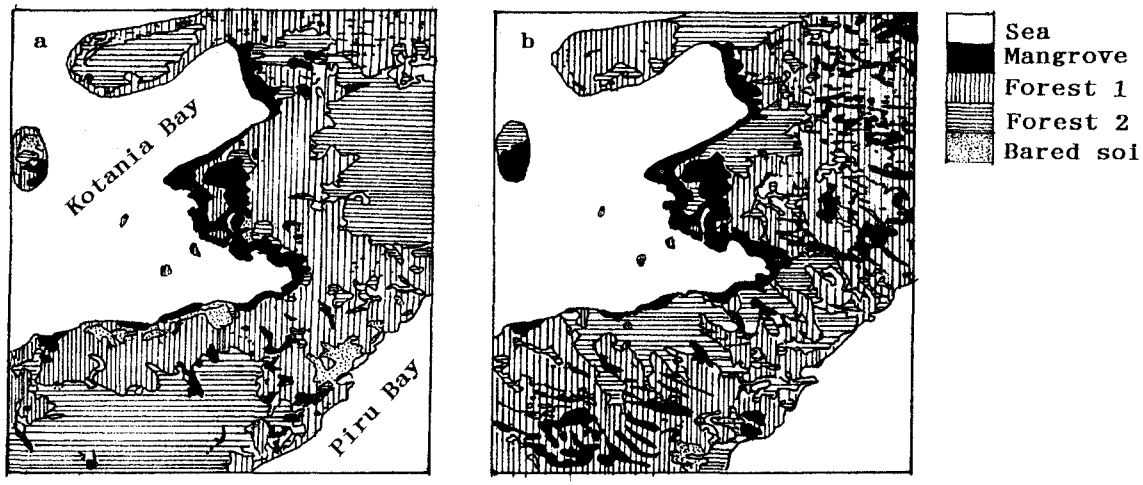
Corrected reflectance of MSS band 5 and band 7 data were then separated into five classes (sea, mangrove, forest 1, forest 2 and bared soil), and supervised using Multi Spectral Classification with Minimum Distance Method algorithm to produce a thematic map.

4. RESULTS AND DISCUSSION

Figs. 2a and 2b show the thematic map of five classes features, namely sea, mangrove, forest 1, forest 2 and bared soil obtained by processing corrected reflectance data of MSS band 5 and band 7 using minimum distance method algorithm. The mean value of separability correctness of five classes indicated in Figs. 2a and 2b are 99.1% for October 4, 1972 data and 99.7% for May 16, 1986 data respectively (see Table 3).

Table 3 Separability correctness of five classified areas based on minimum distance method.

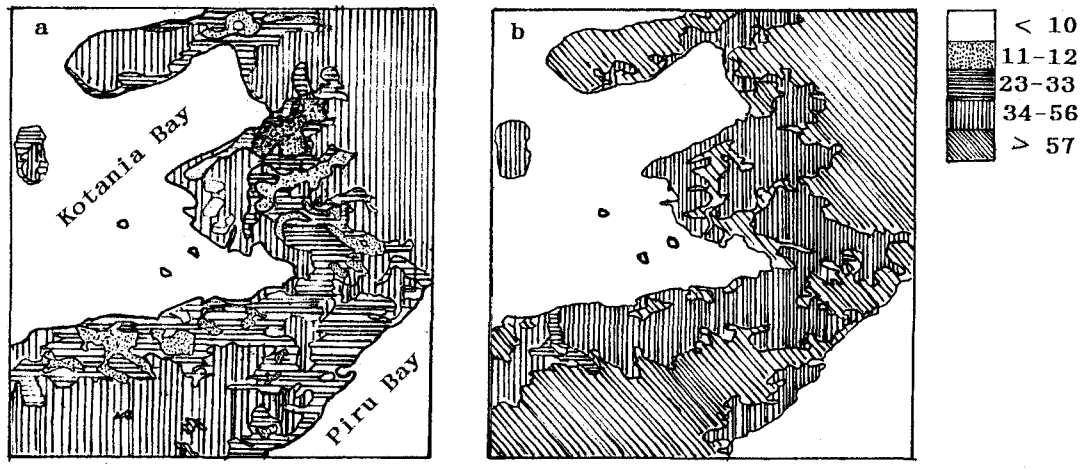
Class code	Percentage of correctness	
	October 4, 1972	May 16, 1986
Sea	100.0	100.0
Mangrove	96.9	99.3
Forest 1	99.3	99.3
Forest 2	99.2	100.0
Bared soil	100.0	100.0
Overall mean	99.1	99.7



Figs. 2a, 2b Thematic map of sea, mangrove, Forest 1, Forest 2 and Bared soil based on minimum distance method classification using MSS band 5 and band 7. a: October 4, 1972; b: May 16, 1986.

From Figs. 2a and 2b one should notice that some vegetations which have the same spectral with those of mangrove are found in the area such as forest 1. Therefore, in order to calculate the actual mangrove areas, only pixel which exits along coast line were calculated. Based on this calculation, the real mangrove areas are 2566 pixels (833.7 ha) for October 4, 1972 and 2609 pixels (847.7 ha) for May 16, 1986 respectively. Thus the mangrove increased about 14 ha within 14 years.

The bared soil areas in 1972 image were larger than 1986 image, and this is due to the different climate condition. In this site, October is the middle of dry season, on the other hand May is the end of rain season. Therefore, on May bared soil areas are probably covered with healthy grass or other vegetation which grew well due to enough rain water than dry season on October. Figs. 3a and 3b show vegetation condition which expressed as "Transformed vegetation index (TVI)". This index was obtained by the equation: $TVI = \sqrt{VI + 0.5}$ where VI = (band 7-band 5)/(band 7+band 5) (Colwell, 1983). It was appeared that TVI values for October 4, 1972 were lower than for May 16, 1972, except in mangrove area (see Fig 3a and 3b), because the mangroves which grow in tidal zone do not so depend on the water such as in the upland vegetation. In this study, all of the spectral data were corrected for atmospheric and sensor difference effect, therefore the difference of TVI image in Figs. 3a and 3b are really due to the physiological factor of the vegetation them shelves.



Figs. 3a, 3b Image of transformed vegetation index (TVI) derived from MSS band 5 and band 7. a: October 4, 1972; b: May 16,1986.

5. CONCLUDING REMARKS

In contrast with some other part of Indonesian areas where mangrove gradually decrease due to the deforestation or changed them such as for making

shrimp pond, we found that at least until May 1986, the mangrove grew well and this indicated that the destruction of mangrove caused by human activity are few. This study is also proved that the satellite remote sensing technique is an effective tool for evaluating or monitoring the coastal environment. The results could be used as basic data sources for making a good planning and management of coastal zone. Therefore, the continuity of this study is necessary.

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