Analysis of land use change around coastal zone in Tuvalu Funafuti atoll

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Abstract: The purpose of this research is to analyze the land use change around the coastal zone at Fongafale island in Tuvalu by using map information, aerial photograph and satellite image. Now, it was reported that the Global warming is advanced by heat-trapping gas. And, it has misgivings about coastal erosion along with the sea-level rise. Then, to make the prior information used to settle on the adjustment plan, it advanced the analysis of the geographic information in this research.According to the examination, it has understood that the vegetation area on the Fongafale island decreases for the long term. And, it has understood that the vegetation of the lagoon coastal zone decreases by development in recent years.
Keywords: Land Cover, Land use, High Resolution satellite image, coastal zone, Tuvalu

1. Introduction

Rising sea levels, a consequence of changes in global weather patterns, have a dramatic effect on countries at a low altitude. At its highest point, Tuvalu, an island state composed of various atolls, rises only 5m above sea level. In order to create effective strategies for managing the national land in response to rising sea levels, it is necessary to consider the effects of various forces, such as human activities and the ocean's waves and currents on the geography of the land. The aim of the current research is to analyze changes in coastal vegetation in order to develop background data that can be used in formulating countermeasures. The area to be covered is Fongafale, an island belonging to the main Funafuti atoll group, where the capital is located.

2. Data for Analysis

Field surveys were undertaken for a total of eight days, from August 12, 2004 to August 19, 2004. The field survey included the following.

(1) Information from the South Pacific Application Geoscience Commission (SOPAC)
(2) Maps
(3) Hearings with local residents
(4) Ground truth data to be used in the analysis of the satellite image

The data that was collected was organized in the following ways.

(1) Creation of a digital record of the field survey

(2) Creation of a searchable GIS-driven database

The digital record included notes taken during the field survey combined with images from a GPS camera. The database was created with a GIS engine of satellite images in the background using co-ordinates obtained from GPS.

1) Correction Processing of the Satellite Image and Maps

The data used in this research is shown in Table 1. In order to compare and analyze land use change, it is necessary to set an accurate positional point of reference among the different data sets. In this research, a high resolution satellite image was used to set positional standards, and various drawings and aerial photographs were adjusted with a polynomial method of geometric correction. Aerial photos that were composed of a collection of scenes were fit into a mosaic after correction. The accuracy of the GCP correction was standardized by setting the RMS error margin to within 2 pixels.

2) Ground Truth Data

A GPS camera was used in order to record the data with as much accuracy as possible. The digital images that resulted included information about both the azimuth and position of the picture, along with the time the photograph was taken. The field survey record book allowed us to capture physical characteristics such as the points of investigation and the time, along with providing the option of including sketches. In this way, we were able to use both photos and sketches of representative cross-sections of the island. As can be seen in Figure 1, data was collected from 16 traverse lines in the northern part of Fongafale and 11 lines in the south and central regions. Because of the distance between the lagoon side and the ocean side, the investigation was divided into two parts: the coastal region and the central region. The resulting data was arranged into a relational database with GIS software (see Figure 2).

3. Land Cover Change Analysis Method

A high-resolution satellite image produced land cover maps and normalized difference vegetation index (NDVI) images that allowed for the analysis of land cover change.

1) Land Cover Classification Maps (Figure 3)

The maximum likelihood method was adopted as the classification method. Before the analysis can be performed, the results of the classification must be checked for accuracy. For the current study, a GIS engine driven database was used to set the classes for classification. The current study used division accuracy (Table 2) and Probability of Correct Classification (PCC, Table 3). Both the training area and other areas were checked for accuracy.

2) NDVI Images (Figure 4)

NDVI was calculated as in Expression 1.

$$NDVI = (BAND4-BAND3) / (BAND4+BAND3) \quad (1)$$

BAND4 in Expression 1 is the near infrared wavelength from the high resolution satellite image. BAND3 is the

Table 1 Data List

Data	Content	Making Year
Satellite Image	IKONOS	2004
Aerial Photograph	Fongafale Island	1984
Maps	Vegetation	1992
	Geologic	1896

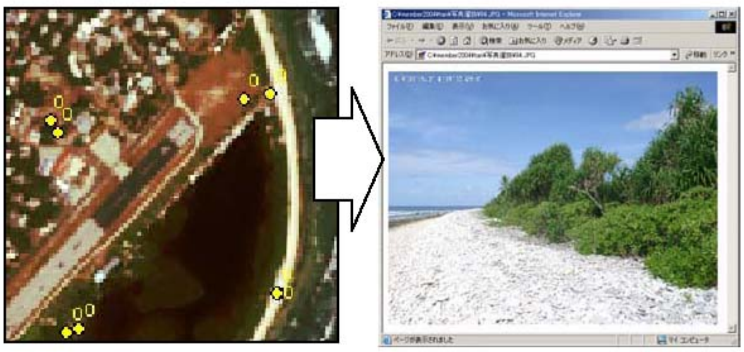

Figure 2 Database with GIS Engine

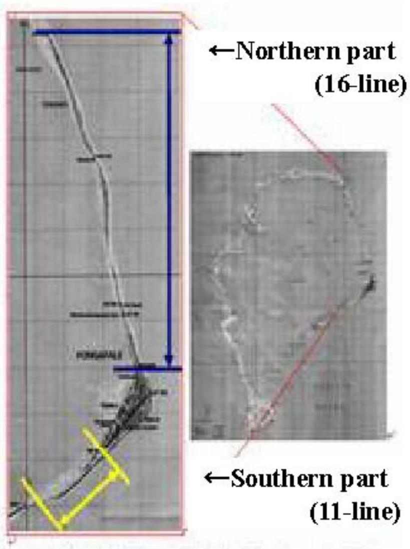

Figure 1 Fongafale Island

Table 2 Result of Division Accuracy

Class	Accuracy(%)	Class	Accuracy(%)
Glide Slope-1	100	Shallow Water-1	100
Glide Slope-2	100	Shallow Water-2	100
Glide Slope-3	100	Vegetation-1	100
Landside Water-1	100	Vegetation-2	91
Landside Water-2	100	Vegetation-3	96
Coast	100	Vegetation-4	100
Structure-1	75	Road	0
Structure-2	100		

Table 3 Result of Probability of Correct Classification (PCC)

Class	Accuracy(%)
Bare Field-1	100
Bare Field-2	44
Vegetation(Coco)-1	93
Vegetation(Coco)-2	100

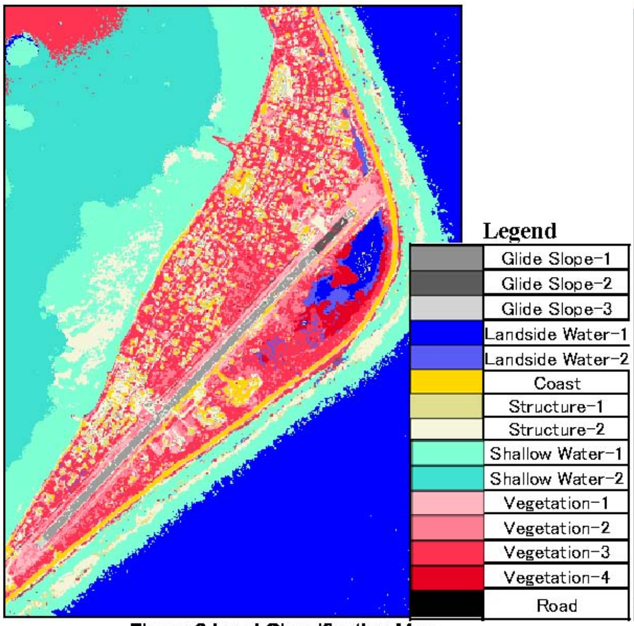

Figure 3 Land Classification Map

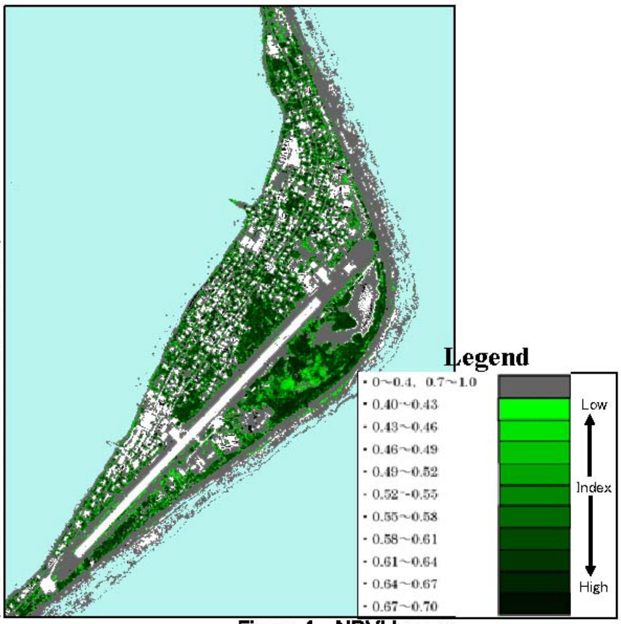

Figure 4 NDVI Image

wavelength of the visible region (red). After NDVI was calculated as in Expression 1, the range index value (NDVI=0.4～0.7) used to express the vegetation regions confirmed in the field survey was discovered through experimentation. The NDVI value of that range was then divided into 10 ranks and an NDVI image was created (Figure 4).

4. Results

1) Land Cover Change in Coastal Regions as Confirmed by Aerial Photographs

The satellite image and the aerial photographs are shown in Figure 5. In the interests of conserving space, only the southern region of Fongafale is shown. As can be seen in this image, the forests along the road that runs down the center of the island have thinned and several areas have been turned into residential zones, sandy beaches, and gravel. Also, on the lagoon side, it seems that the beaches have decreased since 1984, but since the tide level at the time the pictures were taken is unknown, it is not possible to confirm this theory.

2) Coastal Vegetation as Confirmed by Land Cover Classification Charts and NDVI Images

An NDVI image, an aerial photograph and a ground photograph are shown in Figure 6. In the interests of conserving space, only the southern region of Fongafale is shown. In the central area, there are still productive green areas and other green areas that are not suitable for human occupation. One of the main reasons for the decrease in green space is residential development in the southern and northern parts of the island that, until recently, had not been inhabited. Furthermore, in the residential zones on the coast of the lagoon side, there are certain areas in which the vegetation has been clear cut. If coastal vegetation continues to decrease because of such human activity, it will become more difficult to prevent coastal erosion or damage from high waves during typhoons.

5. Conclusions

As a result of the comparison of aerial photographs, a satellite image, and the field survey data, it was confirmed that the development of residential areas in the northern and southern parts of the island have resulted in a decrease in coastal vegetation. If the green areas continue to decrease, the ability of the coastal regions to withstand the effects of future climate change will be greatly reduced.

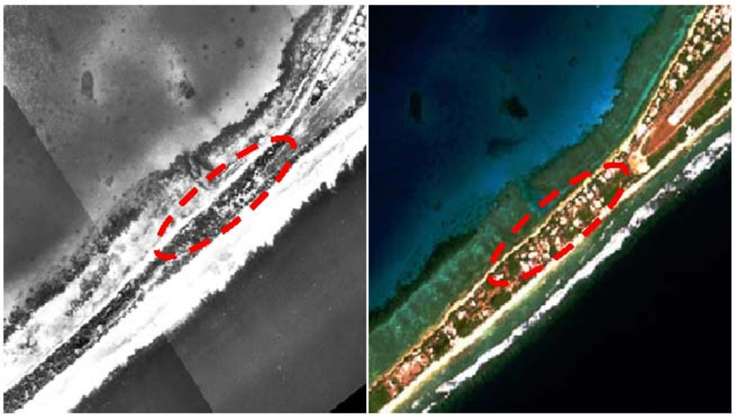

Figure 5 Satellite Image and Aerial Photograph

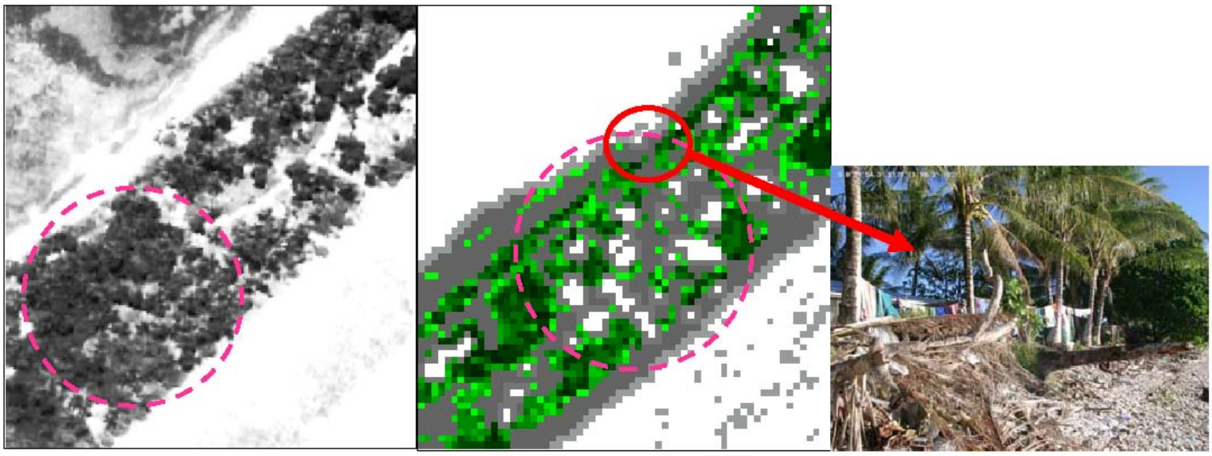

Figure-6 NDVI Image and Aerial Photograph

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