Extraction of mangrove forests in Sri Lanka using satellite images

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Abstract: This paper describes the methodological study that developed for mapping mangrove forests using two unique features of mangroves. (1) Reflected radiance of mangrove forests in short-wave-infrared bands is lower than that of ordinary vegetation. (2) Mangroves can form forests only in the intertidal zones between the mean and the highest sea levels. Landsat/ETM+ images and a digital elevation model that based on Shuttle Radar Topography Mission data were used to extract mangrove forests in Sri Lanka. The extracted results agreed well with ground truth data and gave high accuracy with aerial photographs.
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1. Introduction

Mangrove forests are unique and important ecosystems existing only in the intertidal zones between the seawater and the coastal land, supporting wide variety of coastal species. They also have a function of disaster prevention, protecting coastal areas from tsunami or high tide by absorbing wave energy. They are, however, disappearing at a rapid rate due to human activities such as industrial, residential, agricultural and aqua cultural development. It is urgently needed to investigate their current status and distribution, and take effective measures for the preservation of mangroves.

2. Data and Methodology

Mangrove forests have two unique features which can be used for extracting their areal extent: (1) their reflected radiance in short-wave-infrared (SWIR) wavelength (1,500~2,500 nm) is lower than that of ordinary non-mangrove forests, and (2) they can exist only in the intertidal zones between the mean and the highest sea levels. Utilizing these two features, a decision tree classifier is constructed for extracting mangrove forests.

Fig. 1 shows the flow chart of the research. Landsat/ETM+ and SRTM DEM data was used for this classification. Observations by satellite sensors such as Landsat/TM shows that mangrove forests have lower reflected radiance in the SWIR bands than other ordinary non-mangrove forests [2]. Fig. 2(a) is a Landsat/ETM+ false color image of south region, Sri Lanka. Bands 4, 5 and 7 are displayed by red, green and blue colors respectively. The images was acquired on year 1999to 2001. Fig. 2(b) displays spectral profiles of the sample areas taken in mangrove forests (green), water body (blue), and non-mangrove area (red).

Locations of the sample areas are shown in Fig. 2(b) with the area colors corresponding to the line colors. From these spectral lines, we see that mangrove forests have lower reflected radiance in the SWIR bands (bands 5 and 7) than non-mangrove forests.

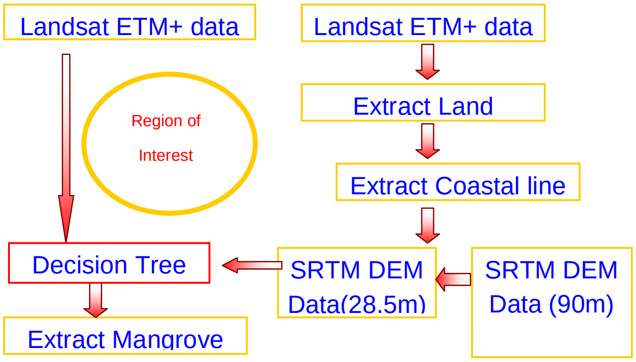


Fig.1. flow chart of the research

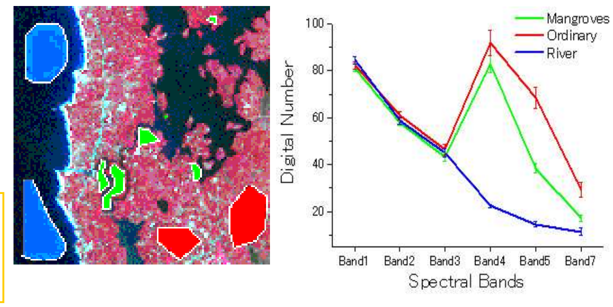
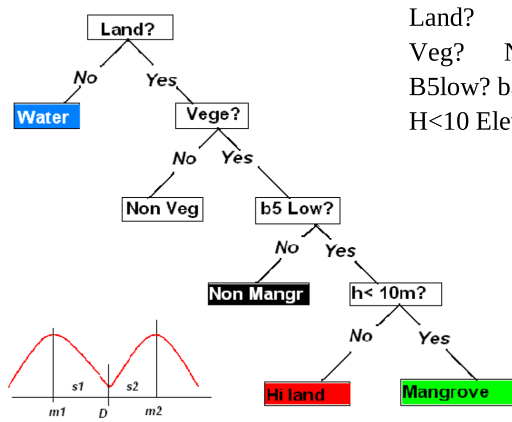


Fig.2.(a). Locations of sample areas for spectral profiles of Landsat/ETM+ image of Madu River, South, Sri Lanka. Band combination: (R:b4, G:b5, B:b7). (b). Spectral profiles of sample areas with the line colors corresponding to the area color.

Based on the analysis above, a decision tree classifier was constructed for extracting mangrove forests from Landsat/ETM+ images and the SRTM DEM data. The node [land?] distinguishes land and sea by elevation. The node [veg?] uses NDVI to distinguish vegetation and non vegetation. The node [b5 low?] discriminates candidate mangrove and non-mangrove by a threshold value for band 5 (threshold1), which is determined by the following equation:



<u>Values of the decision tree for South region in Sri Lanka</u>

Land? B4>10.2
Veg? NDVI>0.2
B5low? band5<69.5
H<10 Elevation<10m

Fig.3. the decision tree that composed of 6 nodes.

$$\left|\frac{D-m_1}{s_1}\right| = \left|\frac{D-m_2}{s_2}\right| \qquad (1)$$

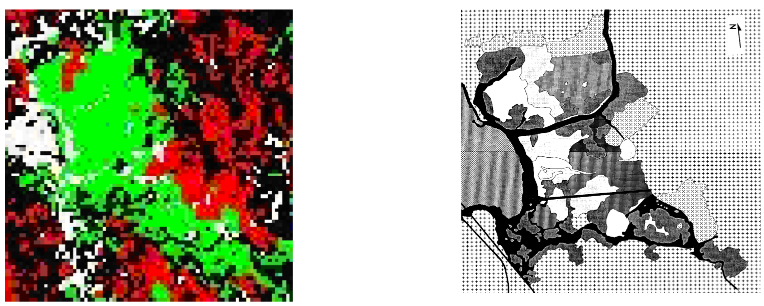
Where D is the threshold value, and *m1, m2and s1, s2* are means and standard deviations. The node [h<10m?] further narrows candidate mangrove by removing shaded vegetation using an elevation threshold, which is set at 10 m by taking account of the tidal range calculated by annual (hourly) tide level data and the standard deviation of the SRTM DEM map.

3. Results

The satellite classifications of mangrove areas apparently agree with ground truth data. Quantitatively assess the accuracy of the results, mangrove areas in satellite and ground truth data, and producer's and user's accuracy of the extracted mangrove areas were calculated using aerial photographs. Fig. 4(a) shows previous research has done by *F.Dahdouh-Guebas* (1) and Fig.4 (b) shows the extracted mangroves in same area. Mangrove forest area in green colors respectively, agree with previous vegetation data and ground truth data. The causes of few errors at the other places could be explained mainly clouds and shadows , effect of Salt pan, Lagoon, Plants on water body and effect of other palm trees.

Palm trees like *Nypa Fruticans* and plants like *Najas marinas* on wet ground and lagoon are classified with mangroves. They are often found on the landward side just behind mangrove habitats, in water bodies or mixed with mangroves. Because their spectral reflectance is similar to those of mangroves in the SWIR bands (not shown in this paper), it is difficult to discriminate them from mangroves especially when the forest floor is wet.

Further investigation is needed on how to differentiate screw pine trees on wet ground from mangrove forests.



(a) (b)

Fig.4(a) shows the vegetation map of mangrove in Galle (1994), respectively, on the basis of sequential aerial photograph. Fig.4(b) shows Extracted Mangroves in same area centered (06°01'38"N, 080°14'50''E)

4. Conclusion

A method has been developed for extracting mangrove forests from a satellite image using their unique spectral characteristic and habitat requirement. Mangrove forests have lower reflected radiance in the SWIR bands than ordinary non-mangrove forests and their habitats are restricted to the intertidal zones between the mean and the highest sea levels. In this method, vegetated areas with low SWIR (band 5) values are delineated in a Landsat/ETM+ image, and then mangrove forests are extracted by narrowing the possible existence areas to the intertidal zones with small inclination using a digital elevation model. The method was applied for extracting mangrove forests in Southern area Sri Lanka. Aerial photographs constituted a valuable tool to study the mangrove forests on topographic basis. The results agreed fairly well with ground truth data such as field survey and aerial photographs (86% in accuracy).

5. References

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