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A new approach for estimating mangrove canopy cover using Landsat 8 imagery

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Normalized Difference Water Index

A B S T R A C T

Due to background reflectance, it is difficult to accurately map sparse canopy vegetation using moderate-resolution satellite imagery. Information contained in virtually all the pixels is a mix of leaf vegetation, soil, branches and shadow. Presented in this paper is a novel approach to improving the accuracy of mapping mangrove canopy using Landsat 8 imagery by incorporating seven indices: Normalized Difference Vegetation Index, Infrared Index, Leaf Area Index, Green Atmospherically Resistant Index, Optimized Soil Adjusted Vegetation Index, Normalized Difference Built-up Index and Normalized Difference Water Index. Results demonstrated that the accuracy of mapping mangrove can be significantly improved using this approach.

1. Introduction

Fragile ecosystems, such as mangroves, require continuous monitoring to detect threats, including human activities, pollution, over- grazing, disease, fire, storms and desiccation. A monitoring system is also needed for mangrove plantations as it provides empirical data for measuring the rate of growth and identifies areas needing remedial attention.

Canopy cover is an indicator of the status of mangrove stands and it is an indicator useful for assessing the impact of deleterious pressure factors on mangroves. Therefore, a method to accurately estimate mangrove canopy cover is needed for monitoring.

The study area was the southern-most mangrove stand in the Abu Hamrah al Bahray Bay located along the Egyptian Red Sea coast as shown in Fig. 1. Two Landsat 8 scenes, dated 29 June and 6 July 2013, were used. The area on 6 July 2013 is shown in Fig. 2.

The mangrove stands of Abu Hamrah al Bahray stands extend 1 km with a width ranging from 50 m to 140 m. They have a total area of approximately 68,000 square meters. The mangroves can be subdivided into north, middle and south stands. The south stand faces the sea and grows over two horseshoe shaped sand bars. Individual mangrove trees are located in the front part of the horseshoe. The middle stand is a small bay with soil enriched by fine black detritus. The bay is connected to the north strand via a narrow channel which is 8–11 m wide. The north strand is an elongated inland creek that is 360 m long and 60 m wide.

Landsat 8 images are free-of-charge online, while other earth remote sensing satellite imagery such as RapidEye, WorldView, QuickBird or GeoEye cost several thousand dollars per square kilometer. Landsat 8 provides the multispectral bands necessary for the majority of vegetation indices. The revisit time of Landsat 8 is eight days so that monitoring can be done frequently. In contrast, most earth remote sensing satellite systems require pre-acquisition ordering and so the number of images for any particular site is low.

The downside of Landsat 8 is that, due to an instantaneous field of view (IFOV) of 30 m × 30 m, while some of the area within the IFOV we be vegetation, some will be sand, shadow, dead branches and detritus. These "mixed pixels" result in inaccurate classification because they do not represent a homogeneous land cove type. The research in this paper shows a technique to overcome that problem.

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0168-1699/

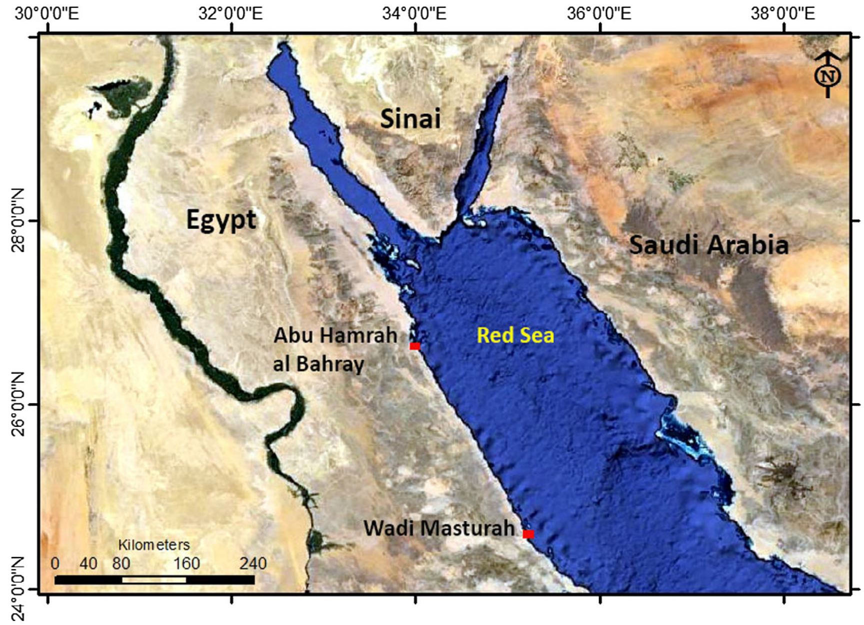

Fig. 1. Landsat 8 scene study area on 6 July 2013.

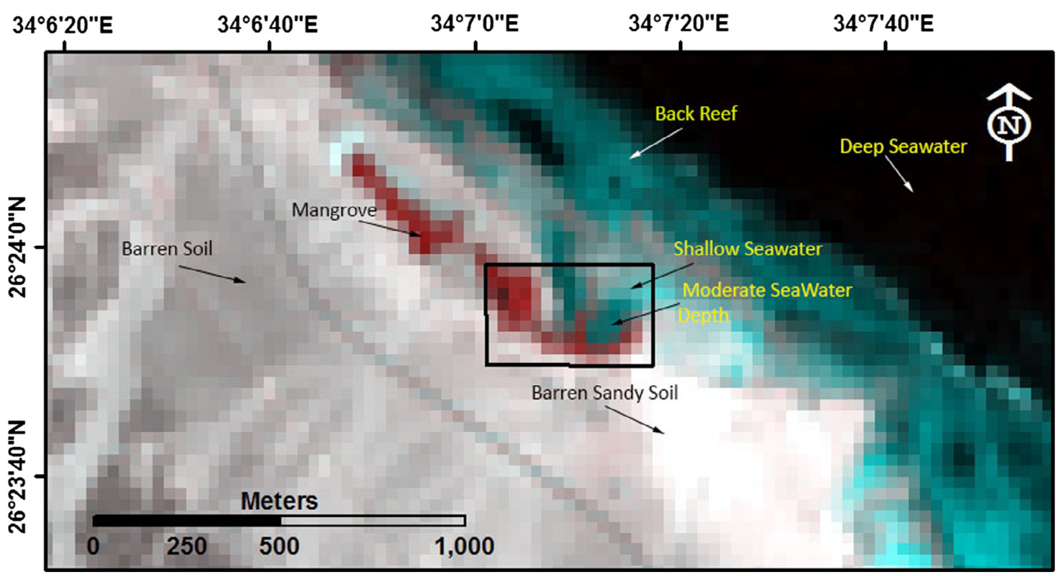

Fig. 2. Landsat 8 image of study area. Mangrove stands are in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The Normalized Difference Vegetation Index (NDVI) is commonly used for vegetation monitoring systems, but imagery is costly because it works best with very high spatial resolution (i.e., 1 m) satellite images such as WorldView, QuickBird or GeoEye. The high spatial resolution imagery is needed to get a nearly "pure IFOVs" with a spectral characteristic affected only by the vegetation and not mixed with other reflectance's.

The ideal condition is when each IFOV of the image can be assigned to a single spectrally homogeneous land cover type. However, satellite images such as Landsat 8, with a 30 m × 30 m IFOV, this condition is rarely found in nature. Mangrove stands usually have a small areal extent and consist of widely dispersed patches of trees. Therefore, the 30 m by 30 m IFOV usually includes more than one type of land cover. The measured spectral radiance of an IFOV is the integration of the radiance reflected from all the area within the IFOV and so data in an IFOV is from a mixture of land cover types. In order to accurately identify the mangrove canopy, the percent of it in each image IFOV needs to be estimated. Spectral unmixing is based on the assumption that several primitive classes or endmembers of interest can be selected. Each have primitive classes has a pure spectral signature which can be identified and the mixing between these classes can be adequately modelled as a linear combination of the spectral signatures (Small, 2004).

The spectral signature of an object can be defined as the amount of electromagnetic radiation emitted, reflected or absorbed at varying wavelengths from an object. The accuracy of unmixing process is affected by many factors, including atmosphere attenuation, scattering, terrain and similarity between the object spectral signatures. In this study, we overcame these problems with the unmixing process by using band indices instead of spectral bands