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Hyperspectral Mapping Methods for Differentiating Mangrove Species along Karachi Coast

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***Abstract*—**It is necessary to monitor and identify mangroves types and spatial extent near coastal areas because it plays an important role in coastal ecosystem and environmental protection. This research aims at identifying and mapping mangroves types along Karachi coast ranging from 24.79^0 to 24.85^0 in latitude and 66.91^0 to 66.97^0 in longitude using hyperspectral remote sensing data and techniques. Image acquired during February, 2012 through Hyperion sensor have been used for this research. Image pre processing includes geometric and radiometric correction followed by Minimum Noise Fraction (MNF) and Pixel Purity Index (PPI). The output of MNF and PPI has been analyzed by visualizing it in n-dimensions for end member extraction. Well distributed clusters on the n-dimensional scatter plot have been selected with the region of interest (ROI) tool as end members. These end members have been used as an input for classification techniques applied to identify and map mangroves species including Spectral Angle Mapper (SAM), Spectral Feature Fitting (SFF) and Spectral Information Diversion (SID). Only two types of mangroves namely Avicennia Marina (White Mangroves) and *Avicennia germinans* (Black Mangroves) have been observed throughout the study area.

***Keywords*—**Mangrove, Hyperspectral, SAM, SFF, SID.

I. Introduction

MANGROVES are one of the most important objects for maintaining coastal ecosystem and environment [2]. This importance is due to their intermediate position between the marine and terrestrial environments [3]. It provides a natural barrier and helps to prevent shoreline erosion, shielding inland areas from severe damage during hurricanes and tidal waves [3], [4]. Precise information of mangroves status plays an important role in conservation of mangrove ecosystems. It is almost impossible to gather this information by using traditional field surveys because mangrove swamps are extremely difficult to access [5]. Remote sensing applications in mangrove resource include inventory and change detection studies [6]. But the application at the species level, which is necessary for studying mangrove species diversity, is still inconclusive [5], [7], [8].

Mapping mangroves at the species level is required for a thorough understanding of mangrove biodiversity studies and mangrove management [9]. Although multispectral data play an important role in mapping mangrove but their relatively low spatial resolutions may have compromised the classification results for areas with small patches of mangrove stands or for areas with multiple mangrove species and similar plant species [3]. However, because mangroves are difficult to differentiate a proper understanding of the local situation requires ground-survey activities to verify and calibrate image-analyses results [10]. Furthermore, such intensive field work is often hindered by the inaccessibility of areas within the mangrove ecosystem [10].

The potential of hyperspectral remote sensing to store data in hundreds of contiguous bands provide useful information to assess, enhance and discriminate mangroves species. This greatly increases the level of detail of the complete spectra of mangrove cover types [11]. The objective of this study is to compare hyperspectral remote sensing techniques including Spectral Angle Mapper (SAM), Spectral Feature Fitting (SFF) and Spectral Information Diversion for mapping *Avicennia marina* (White Mangroves) and *Avicennia germinans* (Black Mangroves) along Karachi coast.

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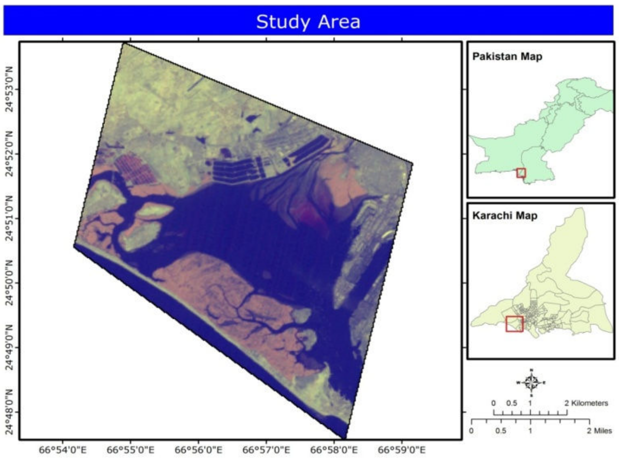

Fig. 1 Study Area Map

II. Study Area

Location of the study area is on the coast of Arabian Sea along Karachi city. It is a natural harbor area having two main gateways, one facing the sea and other Lyari river known as Kharadar and Meethadar respectively. Its geographic location ranges from 24.79^0 to 24.85^0 in latitude and 66.91^0 to 66.97^0 in longitude. The average annual rainfall is approximately 250 millimeter. The monsoon season occurs during July-August. During April - August the temperature ranges from 30 to 45 degrees Celsius; however, the humidity and sea breeze relieves the heat. The winter months, December and January are mostly cloudy with pleasant weather conditions. Study area map is shown in Fig. 1.

III. Dataset and Methodology

Hyperion sensor onboard Earth Observing-1 (EO-1) satellite data have been acquired through USGS website. Hyperion is a space borne hyperspectral sensor with 220 spectral contiguous bands ranges from VNIR to SWIR (400 nm to 2500nm), 30 meter spatial resolution, 12 bit digitization, 10nm spectral bandwidth and 7.75km swath width [12]. Several preprocessing steps have been applied on the acquired image, where each band separately available in tiff format. Some bands have bad data and cannot be used for analysis. Therefore, layer stacking of 155 bands with less or no bad data have been performed for further computations. Study area has been extracted from the layer stacked image. In the next step, atmospheric corrections have been applied to correctly identify the remotely sensed signatures [13]. Hyperspectral Imaging generates vast volumes of data in 100s of contiguous bands, all of these might not be necessary to identify and separate the surface materials to a particular study [11]. Furthermore, Minimum Noise Fraction (MNF) has been used to determine the inherent dimensionality of image data, to segregate noise in the data, and to reduce the computational requirements for subsequent processing [14]. First 40 MNF bands have been selected. Pixel Purity Index (PPI) has been applied on selected MNF bands to find the most spectrally pure pixels that can be used as input end members. The resultant MNF and PPI have been analyzed in n-dimensions for end member extraction. Visually interpreted well distributed auto clusters on the n-dimensional scatter plot have been selected with the region of interest as end members. These end members have been used as an input for classification techniques including Spectral Angle Mapper (SAM), Spectral Feature Fitting (SFF) and Spectral Information Diversion [1] to identify and map mangroves species.

IV. Results and Discussion

The results from SAM, SID AND SFF methods have been analyzed and compared. The SAM classifier uses the vector direction to differentiate between features on spectral reflectance properties. The features that have less spectral angle with the class have been categorized in the same. This method classified pure classes and remained the rest unclassified. *Avicennia marina* (White Mangroves) built up area and bare lands have been classified; however, water and *Avicennia germinans* (Black Mangroves) have been remained unclassified. The problems we have faced during SAM have been minimized using SID. This method has been applied on the same signatures to classify the unclassified and mixed landcovers in the study area. Results from this method show that water, bare land and built up area have been correctly classified comparatively however, some part of both type of mangroves have been mixed with each other. The reason of this miss classification was the water content in *Avicennia marina* that matched its signature with *Avicennia germinans*. The third method that we have applied in this project was SFF. SFF generates SCALE and RMS image of each input spectral signature. The resultant ratio image of each SCALE and RMS followed by a suitable threshold produces a single feature classified. All features have been classified by this method with *Avicennia marina* near accurately classified. Some portion of *Avicennia germinans* has been classified while the remaining part results unclassified. Furthermore, it is the most time consuming method, but the results produced still needs to be enhanced. Figs. 2–4 show the study area landcover classification maps using SAM, SFF and SID respectively.

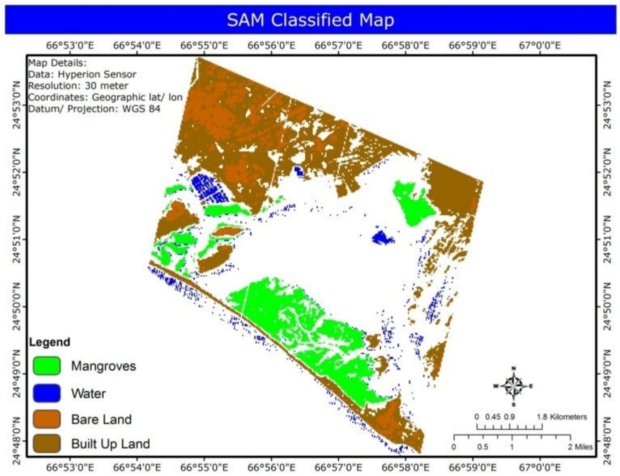

Fig. 2 Classified Study Area Map using SAM Technique

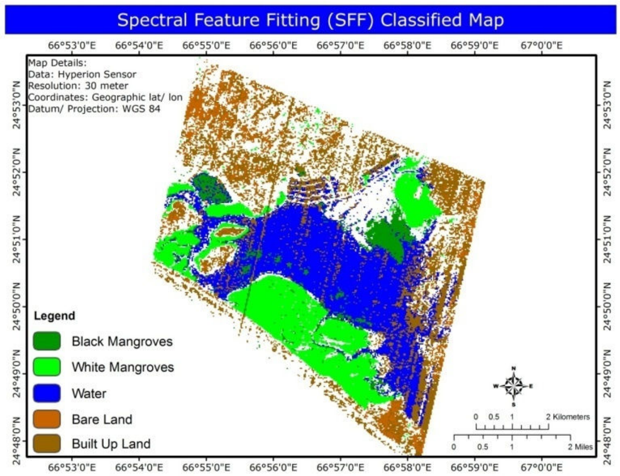

Fig. 3 Classified Study Area Map using SFF Technique

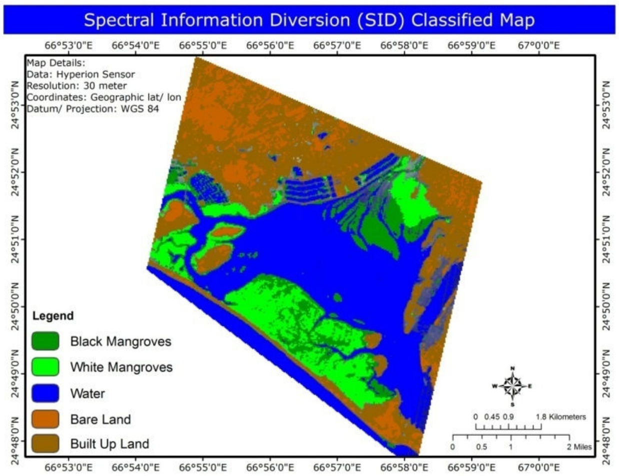

Fig. 4 Classified Study Area Map using SFF Technique

V. Conclusion

Hyperspectral preprocessing plays a vital role to extract within and between classes features. A number of hyperspectral mapping method have been developed to extract spectral information. Three of these methods have been applied in this project including SAM, SFF and SID. In the absence of spectrally diverse features, SAM produces unsatisfactory results. SFF processing is most extensive but the results comparatively inaccurate. The third method has the most suitable and acceptable results, although some mangroves types have been mixed in some region but the part of mangroves were mixed with water that produced such miss classification.

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