VOL 2, NO.2 (2022) 163-173
https://jagst.utm.my

JAGST
Journal of Advanced Geospatial Science & Technology

Minimum Noise Fraction (MNF) Based Mangrove Species Identification Using Hyperspectral Data (Hyperion) in Muthupet Lagoon, Tamil Nadu, South India

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Abstract – The multispectral imagery contains three to ten bands and measures the reflected electromagnetic energy in the specific bands, whereas hyperspectral remote sensing provides 200 continuous spectral bands along with smaller bandwidth; hence, hyperspectral remote sensing techniques have great potential to detect a difference among the features of the earth. The Hyperion is a hyperspectral imager onboard Earth observing the EO-1 Platform launched by the National Aeronautics and Space Administration (NASA) in 2000. It consists of 242 spectral bands between 400 nm to 2500 nm in the electromagnetic spectrum. It is first attempted to identify the mangrove species in the Muthupet mangrove forest using a hyperspectral approach. The post level 1Gst of EO-1 (Hyperion) data has been exploited, radio-metrically corrected and geometrically re-sampled, and registered to the geographic map projection. Before analysing the hyperspectral data, proper organisational steps for pre-processing data have been carried out. The minimum noise fraction enabled data dimensionality to extract more information about the study area. The first ten MNF bands were selected to identify the unique pixels for various classes. The detailed field was made to collect ground truth points and built a spectral library for six prominent valid mangrove species such as *Acanthus ilicifolius*, *Aegiceras corniculatum, Avecennia marina, Excoecaria agallocha, Rhizophora apiculata* and *Rhizhophora mucronata* using the Analytic Spectral Device. The first two bands of minimum noise fraction effectively provided the pure pixels for Mangrove species. Post-processing can be computed for the classified image; the area of distribution of *Aegiceras corniculatam* is 1204.22 Ha, which is dominant occupancy. Areas of other species such as *Rhizhophora apiculata, Avecennia marina*, *Excoecaria agallocha, Acanthus ilicifolius, Rhizhophora mucronata* are 221.5 Ha, 861.3 Ha,24.8 Ha,114.9 Ha and 85.03 Ha respectively.

Keywords - Field spectro-radiometer, Mangrove species, Mangrove associates, MNF, Spectral angle mapper

Article History: Received 1 July 2022, Accepted 25 August 2021, Published 31 August 2022

How to cite: Selvaraj, A., Saravanan, S., Tamane, S. and Ahire, V. (2022). Minimum Noise Fraction (MNF) Based Mangrove Species Identification Using Hyperspectral Data (Hyperion) in Muthupet Lagoon, Tamil Nadu, South India. Journal of Advanced Geospatial Science & Technology 2(2), 163-173.

1. Introduction

The mangrove forests are vegetation community of salt-tolerant woody hydrophytes and originate in the intertidal zones of tropical and subtropical coastlines and survive as an ecosystem, cover of estuaries, lagoons, creeks and intertidal mudflats, Pneumatophores [1,2]. The Hyperspectral remote sensor is spectral measurement ability over the conventional remote sensor systems, which can be helpful for the detection, and modelling of terrestrial ecosystem characteristics [3]. Earth-observing mission (EO-1) is the first spaceborne hyperspectral satellite of the National Aeronautics and Space Administration (NASA), launched on 21st November 2000; it focuses primarily on advanced land imaging techniques. This study exploited the hyperspectral remote sensing data for mangrove species classification. This technique describes the simultaneous acquisition of images in many narrow contiguous spectral bands. [4,5]. The Hyperion sensors have two radiometers - one operates in the visible and the other in the near-infrared region (VNIR). The former in a wavelength between 300 nm to 1000 nm having 70 bands, and the latter operates in the shortwave infrared region (SWIR), with a wavelength of 900 nm to 2500 nm having 172 bands [6]. Atmospheric correction is used in hyperspectral images to obtain the absolute reflectance from the radiance image. Various commercial packages are available to carry out the atmospheric correction process, such as Atmospheric and Topographic correction (ATCOR 4) [7]. Hyperspectral data. Most of them are MORTRAN-based packages. FLAASH algorithm results exhibit strong absorption between 900 nm to 1200 nm, unlike other algorithms such as IARR, Log residual, and ELM. As Hyperion is a push broom type sensor, errors in the calibration of the detectors generate a high-frequency error in the VNIR and SWIR region, which are seen as vertical strips in the images [8].

The potential of hyperspectral remote sensing is to accumulate data in hundreds of contiguous narrow bands, which provide helpful information to assess, enhance and distinguish individual absorption features. This, to a great extent, increases the level of detail by an entire spectrum of a feature [9]. Nevertheless, it isn't easy to extract, analyse or classify hyperspectral satellite data without the proper image processing algorithm owing to its high dimensionality [10]. The central objective of the manuscript is to carry out the identification of mangrove species using MNF. This is the first attempt to exploit the Hyperion data for identifying mangrove species in the Muthupet mangrove forest. The MNF bands have been used to get unique classes from the data clouds. The spectral signatures for the species were derived with the help of ground-based signatures. Finally, SAM provides the mangrove mapping.

2. Study Area

The Muthupet mangroves forest is located at the southernmost end of the Cauvery delta, Tiruvarur District, Tamilnadu, India, between 10°22’33’’ N and 79°29’33’’ E (Figure 1). A recent botanical survey provides a total number of 8 true mangrove species available in the Muthupet mangroves. The three species, *Ceriops decandra, Rhizhophora apiculate* and *Rhizhophora mucronata,* were reintroduced recently [11].

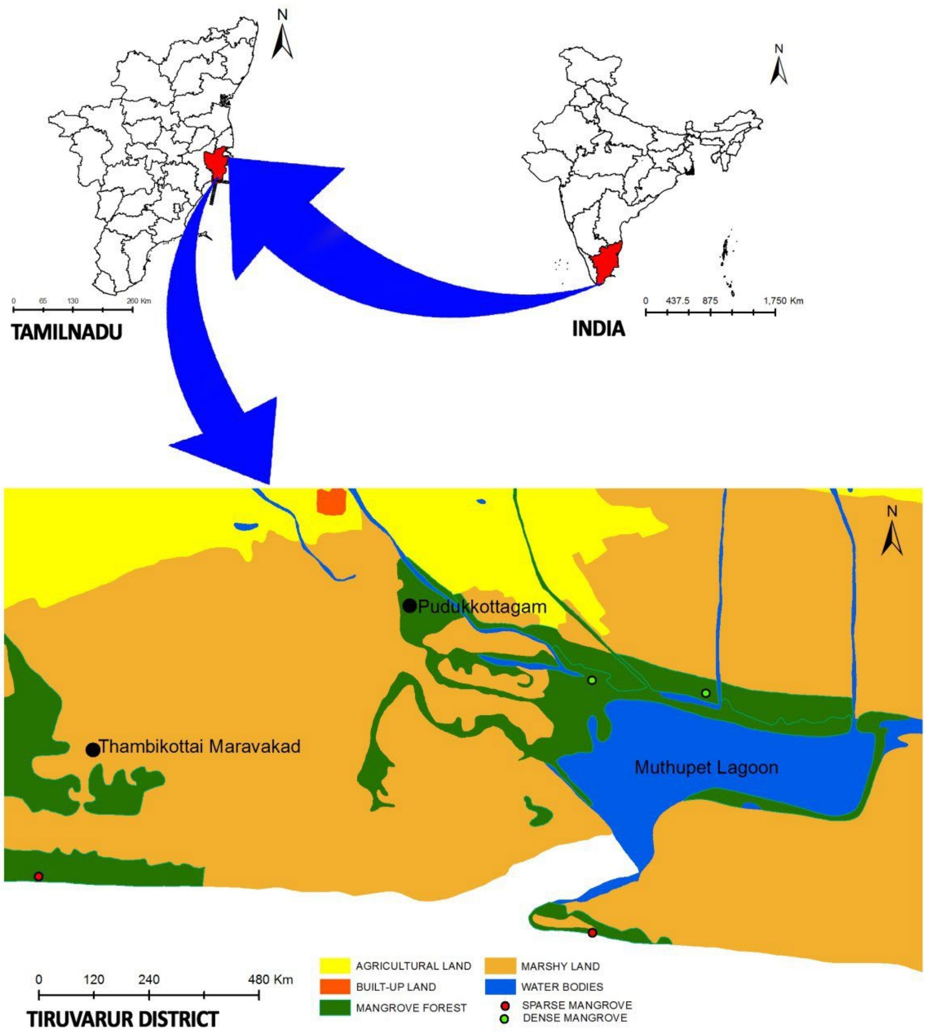

Figure 1. Location of the study area

3. Materials and Method

Figure 2 shows the methodology; it started with a radiance image as input for classifying mangrove species.

3.1 Pre-processing

Raw data of Hyperion contains errors such as bad column, unwanted bands, and Atmospheric correction; it should be carried out before the information is exploited for the end members extraction using MNF scatter plot. The Hyperion data is therefore processed with the calibrated 198 non-zero bands (bands 1 to 7 and 225 to 242 intentionally removed) for mangrove species matching [12,13]. In this study, among the 198 non-zero bands, some fall in the overlap region of the two Spectro-radiometer (bands 56 to 78); thus, bands 77 and 78 are ignored due to their higher noise level, which leaves us with 196 unique bands. In addition to the water vapour absorption bands. The other bands which have to be eliminated were identified to be bands 120 to 132 (1346 nm to 1467 nm), bands 165 to 182 (1800 nm to 1971 nm) and bands 221(above 2356 nm) and higher. The water absorption band absorbs all the incident solar energy and is visually identified. Finally, 162 bands are chosen. The bad column can be rectified by taking the average of a neighbour pixel, shown in Figure 3. The list of eliminated bands is given below in Table 1.

Table 1. List of unused bands

Bands	**Description**
1 to 7	Not illuminated
58 to 78	Overlap region
120 to 132	Water absorption band
165 to 182	Water absorption band
185 to 187	Identified by bad band list
221 to 224	Water absorption band
225 to 242	Not illuminated

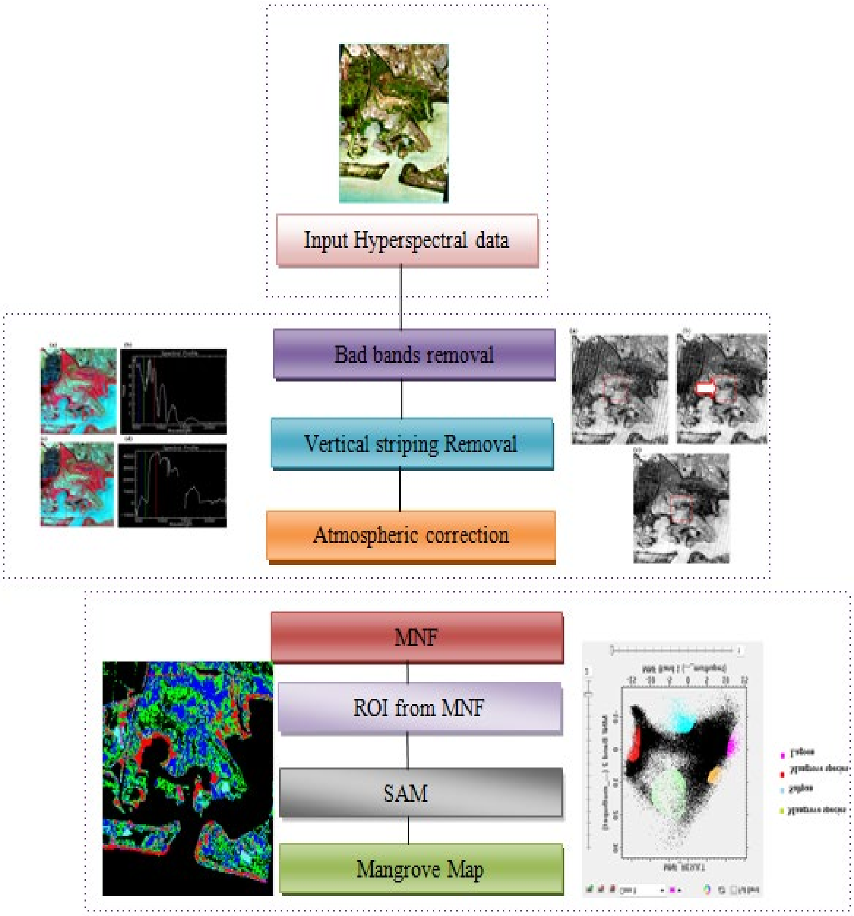

Figure 2. Research methodology

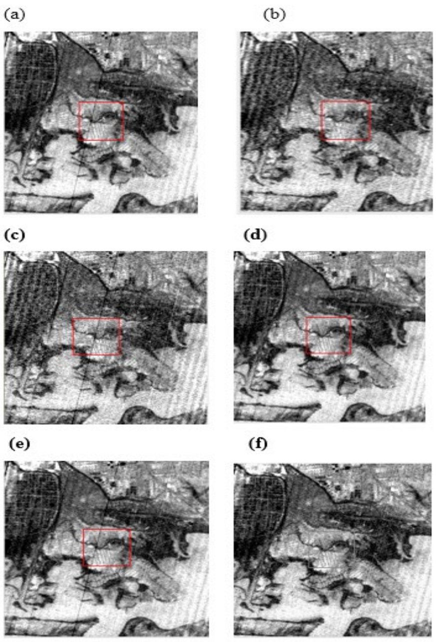

Figure 3. Bad column removal. (a) Bad column present at band 8, (b) After removing bad column of band 8, (c) Bad column present at band 9, (d) After removing bad column of band 9, (e) bad column present at band 10, and (f) after removing bad column of band 10

The electromagnetic signals measured by the spaceborne or airborne hyperspectral sensors combine the signals from the earth's surface, atmospheric constituents and sensor errors [13]. The ENVI's FLAASH module retrieves the spectral reflectance images from the radiance images. Spectral Sciences, Inc developed the FLAASH module; under the sponsorship of the U.S. Air Force Research laboratory. It compensates for the atmospheric effects and corrects the wavelengths in the visible region of the electromagnetic spectrum through NIR and SWIR regions. The output of the FLAASH Module is shown in Figure 4.

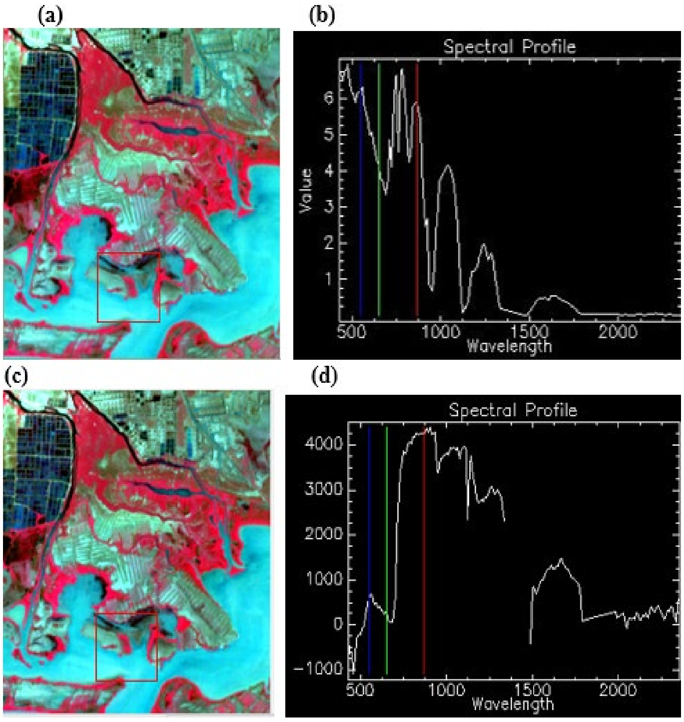

Figure 4. FLAASH Output

3.3 MNF Scatter Plot

A minimum noise fraction is used for redundancy of the unwanted bands. It computes the noise statistics information for effectively removing the noise from the dataset proposed by [10]. The MNF provided the first ten bands, which contain all the information. Typically, the first two bands are selected for the 2-D Scatter plot (Figure 5) to derive ROI for the supervised classifier.

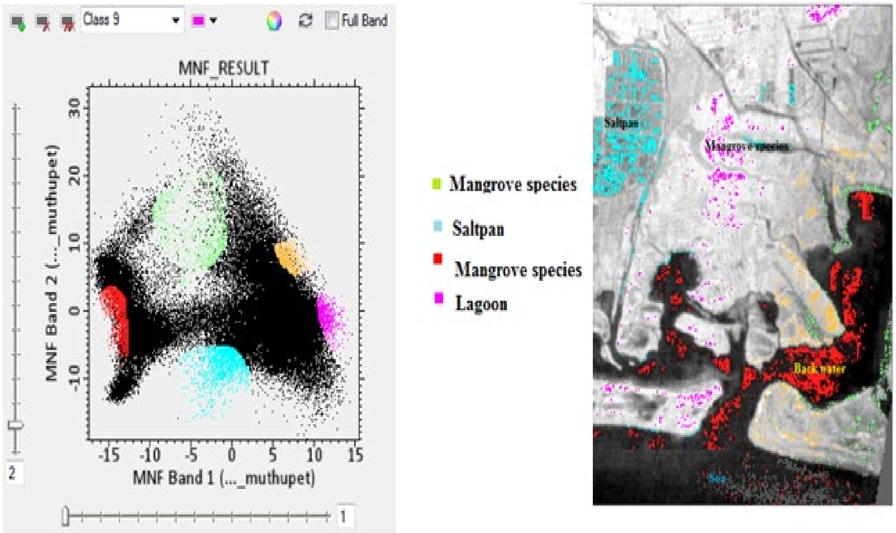

Figure 5. MNF Plot

From the data cloud, randomly pixels are extracted, and these random pixels are in the form of ROI. This ROI is exported to n-D Visualizer, where a comparison is made with reference spectra.

3.4 Reference Spectral Library

The spectral library can be built for it. Ground-based spectral signature is developed by using an analytical spectro- radiometer (ASD). The spectral library is shown in Figure 6.

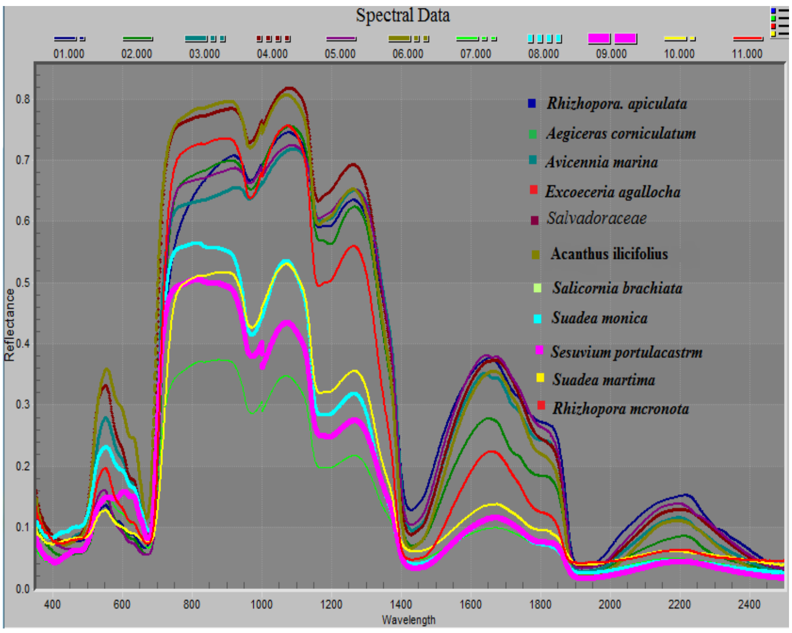

Figure 6. Spectral library

The leaves from canopies were freshly picked from the mangrove forest. Then the collected leaves were packed in air-tight plastic covers and arranged for laboratory spectral measurements to measure the optical properties of leaves [14]. The spectral acquisition can be made from one 512 channel silicon photodiode, which measures in the VNIR region of the spectrum (350 - 1000 nm), and two thermoelectrically cooled indium gallium arsenide (InGaAs) detectors which measure in SWIR 1 (1000–1830 nm) and SWIR 2 (1830–2500 nm) regions [14]. The laboratory spectra data were collected for the six true mangrove species and five mangrove associates on July 29, 2018. Before assembling all the species, authors frequently visited the Muthupet mangrove forest, and observations were made about each species' leaf structure and root, location and abundance of mangrove species and associates. The following observations were made during the field visit—Seaward zone occupied by *Avecennia marina* was dominant, followed by *Aegicerascorniculatam.* The mid-zone mixes *Avecennia marina* with small patches of *Rhizhopora apiculata* and *Rhizhopora mucronata.* Souadazone occupies the terrestrial area with small patches of *Prosopisjuliflora.*

4. Result and Discussion

The current study attempted to classify mangrove species in the Muthupet lagoon. To improve the classification accuracy, ground-based reference spectral signatures were built for present existing species. *Acanthus ilicifolius* provided high reflectance in the near-infrared region among the mangrove species. *Aegiceras corniculatum* is the dominant species occupancy, followed by *Rhizhophora apiculata*. The input image for the machine classifier should be reflectance retrieval imagery free from atmospheric effects. The FLAASH module is used to compute the absolute reflectance. Imagery, this module accepts radiance images; therefore, radiometric calibration has been done for the post-level 1 data, scaling factor for each band is 0.1.SAM classifier is most suitable for the Hyperspectral based data. This method computes the similarity of the two spectra by the angle between them, which is treated as the vectors in a space dimensionally equal to its number of bands [11]. Assigning the angle between the two vectors is a crucial factor. In this study, a smaller angle is set for end members as mangrove species belong to vegetation. The SAM Result covers all the species with vector angle for species, namely *Acanthus ilicifolius, Aegiceras corniculatum, Avecennia marina, Excoecaria aagallocha, Rhizhophora apiculata,* and *Rhizhophora mucronata* are 0.2, 0.3, 0.4, 0.5, and 0.6 respectively. Missed classification belongs to rivers, lagoons, mudflats, and dunes. A unique spectral signature is computed by comparing it with a ground-based spectral signature—the classified mangrove map, as shown in Figure 7.

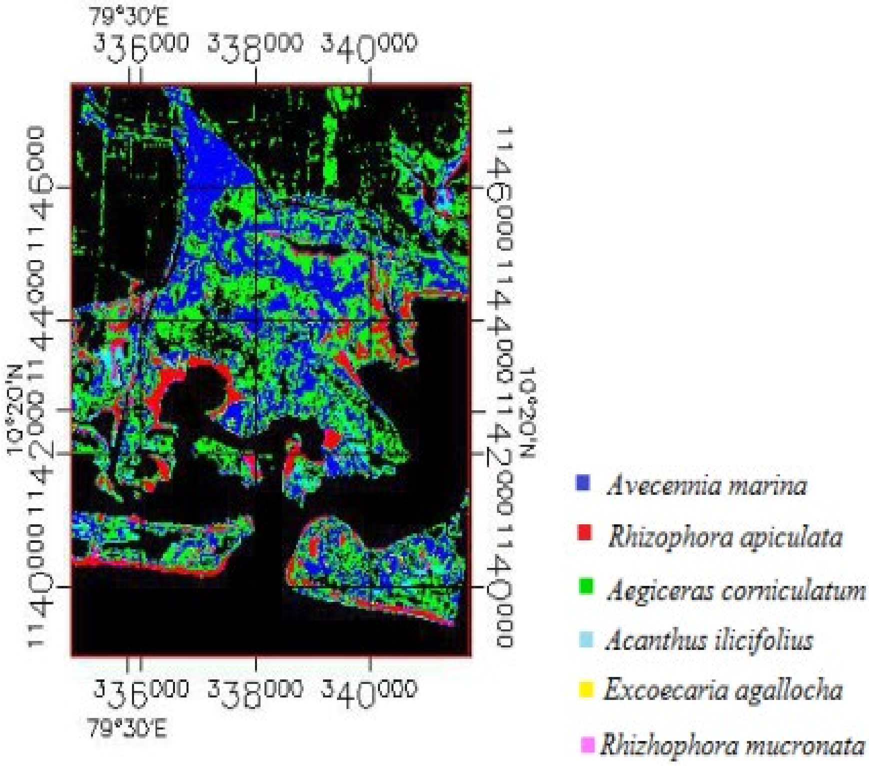

Figure 7. Mangrove mapping

5. Conclusion

This present study first attempted to identify the Mangrove species of the Muthupet mangrove forest. The data from the Hyperion sensor is exploited for the native mangrove classifications. The data is initially fed into pre-processing techniques, which involve bad band removal, vertical destriping, and Atmospheric correction of the data. The MNF is applied to all the selected bands. After MNF, only ten MNF bands only considered. For the scatter plot module, the first two bands are regarded as they contain inherent information, i.e. 90% of data can be obtained. The pure random pixel is allowed into n-D Visualiser to identify pure endmember, representing the mangrove species. The unknown end members were compared with the reference spectral library. Finally, once the species were found, they were exported as endmembers. It was also imported into SAM classifier with the vector angle of each species. The SAM result shows all the species within the study area. Six true *mangrove species (Acanthus ilicifolius, Aegicerascorniculatum, Avecennia marina, Excoecaria agallocha, Rhizophora apiculata and Rhizophora mucronata).* Post-processing can be done for the classified image; the area of distribution of Aegicerascorniculatam is 1204.22 Ha, which is dominant occupancy. Areas of other species such as *Rhizophora apiculata, A*vecennia *marina,* *Excoecaria agallocha*, *Acanthus ilicifolius*, *Rhizhophora mucronata* are 221.5 Ha, 861.3 Ha,24.8 Ha,114.9 Ha and 85.03 Ha respectively.

Acknowledgements

The authors would like to express their profound gratitude to the Forest department of Tamil Nadu and the Faculty of UDICT, MGM University, Aurangabad, Maharashtra.

References

[1] Tomlinson, P.B “The Botany of Mangroves (Cambridge, UK: Cambridge University Press). 1986.

[2] Manjunatha, K.R Kumar. T, Kundu, N, Panigrahy.S. “Discrimination of mangrove species and mudflat classes using in situ hyperspectral data: a case study of Indian Sundarbans, *GIScience & Remote Sensing,* 2013.

[3] Kumar Arun Prasad, Lakshmanan Gnanappazham, VaithilingamSelvam, RamasamyRamasubramanian& Chandra SekarKar “Developing a spectral library of mangrove species of Indian east coast using field spectroscopy” *Geocarto International*, 30:5, 580-599, 2015.

[4] Goetz, A.F.H, KindelFerri, B.C, Qu, M Hatch Z. Results from simulated radiances, AVIRIS and Hyperion”. *IEEE Trans Geosci Rem Sens* 41 1215– 1222. 2003.

[5] Miglani, A Ray, S. S, Pandey, R Parihar, J.S. “Evaluation of EO-1 Hyperion Data for Agricultural Applications” *J. Indian Soc. Remote Sens*.vol36 255–266.

[6] R. O; Green, B.E; Pavri, T.G; Chrien, “On orbit radiometric and spectral calibration characteristics of EO-1 Hyperion derived with an under flight of AVIRIS and in situ *Measurements*at Salar de Arizaro, Argentina.*Rem Sens Envir* 411194–1203. 2003

[7] Meroni, M; Colombo, R; Panigada C; Inversion of a radiative transfer model with hyperspectral observations for LAI mapping in poplar plantations. *Rem Sens Envir vol* 92, pp 195–206. 2004.

[8] V. N; Ostrikov, O.V; Plakhothikov, Correlation between Hyperspectral imagery preprocessing and the quality of the thematic analysis, Izvestiya, *Atmospheric and oceanic physics*, vol9, 887-891. 2014.

[9] V. Selvam. “Environmental classification of mangrove wetlands of India” *Current science*, 84, NO. 6, 25 March 2003.

[10] A. Green, M. Berman, P., Switzer, and M. D Craig, "A transformation for ordering multispectral data in terms of image quality with implications for noise removal", *IEEE Transactions on Geoscience and Remote Sensing*, 26,65-74. 1988.

[11] JB Campbell Introduction to remote sensing, 5th Edn. Taylor and Francis, London, 2009.

[12] MA Folkman "EO-1/Hyperion hyperspectral imager design, development, characterisation, and calibration, Second International Asia-Pacific Symposium on Remote Sensing of the Atmosphere, Environment, and Space. 40–51, 2001.

[13] E Green "The assessment of mangrove areas using high resolution multispectral airborne imagery". Int J Remote Sens, 19: pp 433–443, 1998.

[14] C., Vaiphasa, A.K., Skidmore, W.F Deboer, T.Vaiphasa, "A hyperspectral band selector for plant species discrimination". ISPRS Journal of Photogrammetry and Remote Sensing, 62, (2007) 225–235.