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Comparative Study of MLH and SAM Classification Techniques using Multispectral Data of EO-1 Satellite

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Abstract

This paper presents a case study on classification of multispectral image in the Kajali Dongari near Meghnagar Jhabua Distt. Madhya Pradesh. The purpose of this research study is to find the feasible technique for mapping of research area. Preprocessing of ALI sensor of Earth observing 1(EO 1) satellite data is required for conversion from digital value to reflectance. MNF and PPI method is used for endmember fraction. For vegetation endmember fraction can be easily extracted by NDVI image. Maximum LikeHood (MLH) and Spectral Angle Mapper (SAM) techniques are used for classification. Finally study area is classified in five feature namely natural rocks, exploited rock, vegetation, soil, and water. After analysis of results, Research area would be classified with better accuracy by SAM technique and area of rock is 55.827%, exploited rock is 12.106%, water is 0.841%, vegetation is 11.564% and soil is 19.685% of total area of research field..

Keywords: Endmember Extraction, MLH, MNF, PPI, Radiometric Correction, SAM

INTRODUCTION

Remote sensing offer an immense source of data for studying spatial and temporal variability of the environmental parameter [1].Remote sensing provides a view of earth surface, over a number of wavelengths. One of the most important and one of the primary objective of remotely sensed data is to create a classification map of the identifiable or meaningful features or classes of land cover referred to as natural vegetation, water bodies, rock/soil etc[2]. Advanced classification technologies large quantities of remotely sensed imagery provide opportunity for useful results. In this study two different supervise classification method were compared for evaluating features are a maximum likelihood classifier [3] and SAM classifier [4].

Geological mapping methods have been undergoing continuous change along with technological and scientific advances in other relevant fields. Remote sensing techniques are now being increasingly used to prepare geological information in which further detailed work is based. The defined region posses a diversity of land cover classes including urban, suburban, agricultural land, rocky or hilly terrain. The performance of the classifier depends upon the data comparative studies of classifier. Successful classifier requires experience an experimental results. At present it is not possible to state which classifier is best for all situations as the characteristics of each image and circumstances for each study vary so greatly [5].

RESEARCH AREA

The Jhabua district is situated in the extreme western part of Madhya Pradesh. The Jhabua District of Madhya Pradesh is well known for economic mineral deposits and provides an excellent case history of complex minerals such as Manganese, copper and Phosphorous mapped and explored using field mapping and mining. The use of Multispectral/Hyperspectral remote sensing for material mapping is unexplored in the area. The pictorial representation of study area is showing below in Figure 1. Figure 1(a) and Figure 1(b) is district map of Madhya Pradesh and Jhabua district map respectively, provided by mapsofindia. Figure 1(c) is overlay image with ALI image and 1:50,000 scale SOI toposheets (45J/5), published by Geological Survey of India.

EO 1 satellite was launched November 21, 2000 as a one year technology demonstration/validation mission. It's acquiring information about earth surface by means of three sensors. Name of sensors are Advance Land Imager (ALI), Hyperion and Linearly Etalon Imaging Spectrometer Array (LEISA) Atmospheric Corrector (LAC). ALI instrument operates in a pushbroom fashion, band 1 is panchromatic with 10 m spatial resolution and 9 bands are multispectral with 30 m spatial resolution.ALI data of this area is easily collect from USGS (U. S. Geological Survey) website [6]. All further data Processing and analysis was performed using ENvironment for Visualizing Images (ENVI) software.

METHODOLOGY

Following steps have been adopted for methodology in this research. Direction of steps which is taken to achieve the target is showing in Figure 2. For classification of image, extraction of endmember fraction should be well defined. Preprocessing of satellite data is also necessary.

Preprocessing :

GeoTiff format data image is radiometrically and geometrically corrected and it is available in USGS server. It's not given data in the form of reflectance value, first convert digital value to radiance value with the help of following equation.

$$\rho_{rk} = Gain_k * B_k + offset_k \quad (1)$$

Where

ρ_{rk} is radiance value of corresponding k band.

B_k is digital value of corresponding k band. Gain and offset value listed in Meta file.

From radiance to reflectance conversion, following mathematical equation has been applied.

$$\rho_l = \frac{\pi * \rho_{\lambda} * d^2}{ESUN_{\lambda} * \cos\theta_s} \quad (2)$$

Where

ρ_l = Planetary reflectance

ρ_{λ} = Spectral radiance at sensor's aperture

$ESUN_{\lambda}$ = Mean solar exoatmospharic irradiances for ALI solar radiances listed in EO 1 sensor document

θ_s = Solar zenith angle in degrees.

d = Earth sun distance in astronomical unit from nautical handbook

Endmember extraction:

Endmember is idealized pure signature (pixel spectra) pixel for a class in pixel cloud. For classification/mapping extraction of endmember is fundamental and difficult task. For finding pure signature (spectra) from ALI data, many Endmember Extraction Algorithms (EEAs) have been developed.

NDVI measurement is to help for selection of vegetation endmember abundance. It is most suitable indicator of environment and vegetation abundance. NDVI is derived from ratio between difference and addition of Band 6(Infrared) and Band 5(Green). The spectral contrast between the visible red and the near infrared is an important feature captured with the NDVI (Y. Wei, Z. Liu), e.g. the NDVI is high if the difference is high (for vegetation) and is zero if the difference is zero as well (in figure 3 (a)).

$$\text{NDVI} = \frac{B6 - B5}{B6 +} \quad (3)$$

Where

B5 and B6 is Red band and near infrared band respectively [8].

The Minimum Noise Fraction (MNF) Transform takes linear combinations of the input data to produce new, uncorrelated components ordered in terms of increasing signal-to-noise ratio [9]. The MNF transform produces a set of principal component images ordered in terms of decreasing signal quality. This method was developed specially for analysis of multispectral and Hyperspectral remote sensing data. The MNF transform has the appealing property of sorting its components in descending order of SNR according to image quality, thus it might be possible to tune the amount of noise in the reconstructed data by setting an ad-hoc threshold [10]. It can be used for noise filtering. Since, ALI data have 9 bands therefore, MNF transform calculate up to 9 bands but here it takes only 5 bands from starting. First band, land and water are the prime feature and well separated. Second band, areas high and low (urban) biomass are represented. Third band, salt marsh is well discriminated [11].

Pure pixel index (PPI) is one of the most popular EFAs, which is developed by Boardman et al [12]. Pure pixel Index is used in multi bands image for analysis of endmembers extraction. By ENVI software, it can be easily calculated. PPI was designed to search for a set of vertices of a convex geometry in a given data set that are supposed to represent pure signatures present in the data [13].

In figure 3(b) shows PPI image of study area. Brightest value in the PPI is showing purest pixel. On the base of PPI result and scatter plot of MNF bands, was used in Endmember extraction. 2D scatter plot is created in between MNF bands and mapped it with the PPI and NDVI result. In 2d scatter plot values appeared like a triangle that is called mixing triangle.

Vertices of mixing triangle is showing unmixed pixel of the features and middle of mixing triangle is showing mixed pixel. In study area, there are four type of endmembers abundance mapped namely soil, vegetation, water and rock impervious. Figure 2(a) and Figure 2(b) is showing 2 D scatter plot. For identification geometry shape (triangle), it is simulated with pure pixel index and NDVI. With the help of MNF band 1 and MNF band 3 is extracted water, soil and vegetation with each region of interest (ROI) have 108, 49 and 104 pixels respectively.

Above figures are showing the spectral signature (average spectra) of four type of endmembers fraction. Spectral signature is plot between wavelengths (micro) versus reflectance.

Classification of image:

Final step of methodology is classification. Here two types of classification methods used namely Spectral Angle Mapper and Maximum Likehood, both methods come under supervised classification.

In Spectral Angle Mapper determines the degree of similarity between two spectra by treating the spectra as vectors in a space with dimensionality equal to the number of bands. Spectral Angle Mapper (SAM) is a physically-based spectral classification that calculates the spectral angle between the spectrum of image pixel and the sample reference spectrum which is the purest spectrum and takes the angle as the pixel value of output image [14]. Mean spectra is taken as reference spectra for SAM classification. Threshold angle suitable of the image under analysis is found by various trials by altering the angle until suitable SAM classified image is got.

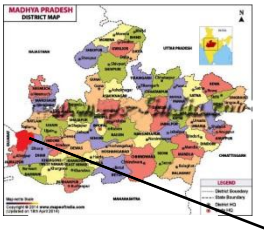

Figure 1(a)

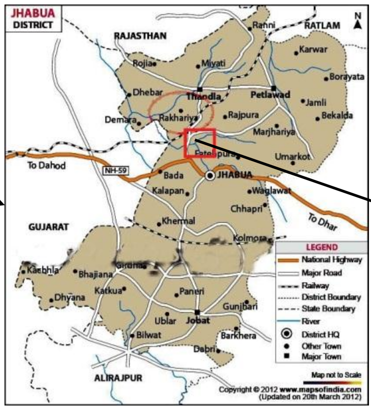

Figure 1(b)

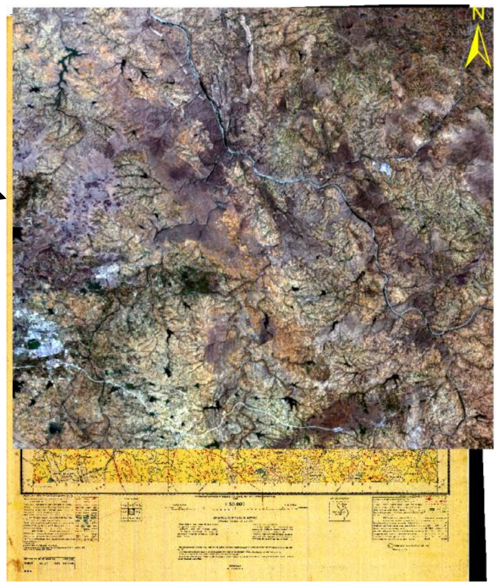

Figure 1(c)

Figure 1: Study Area

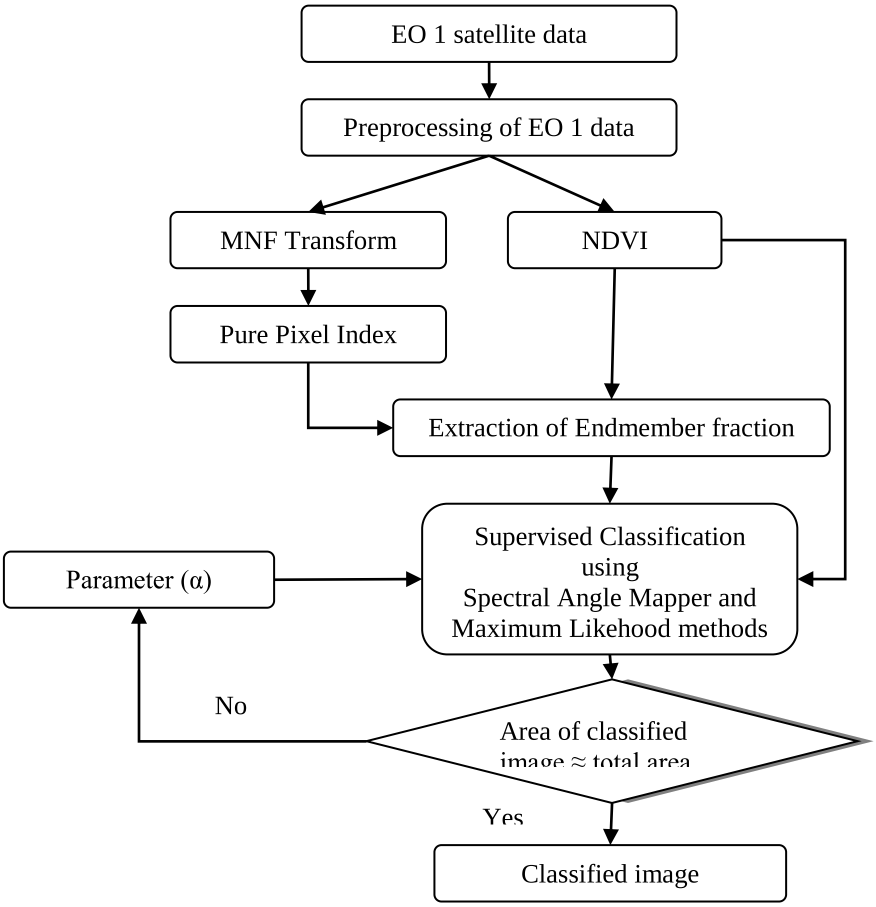

Figure 2: Proposed Methodology

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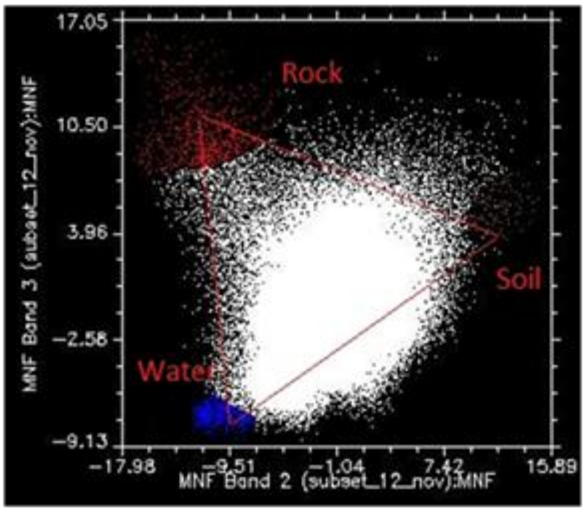

Figure 2(a) plot MNF 1 and MNF 3

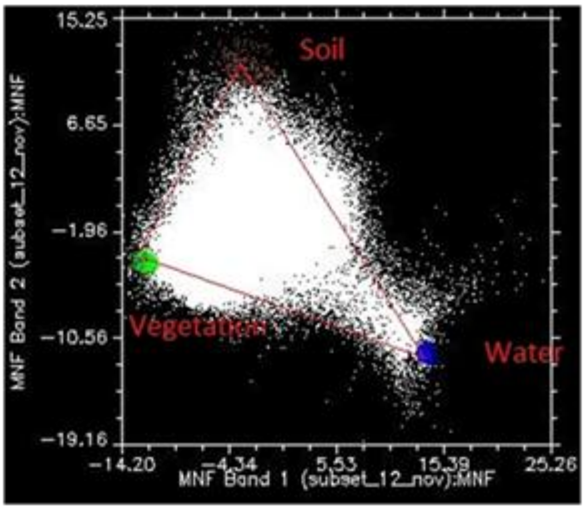

Figure 2(b) plot MNF 2 and MNF 3

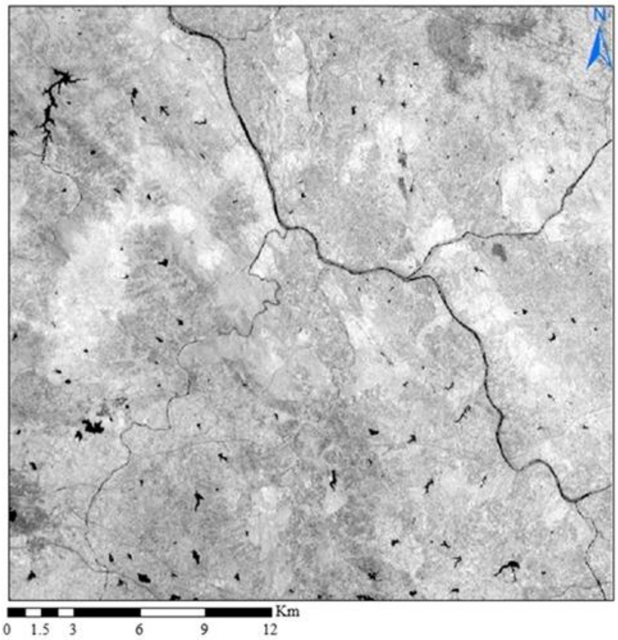

Figure 3(a) output image of NDVI algorithm

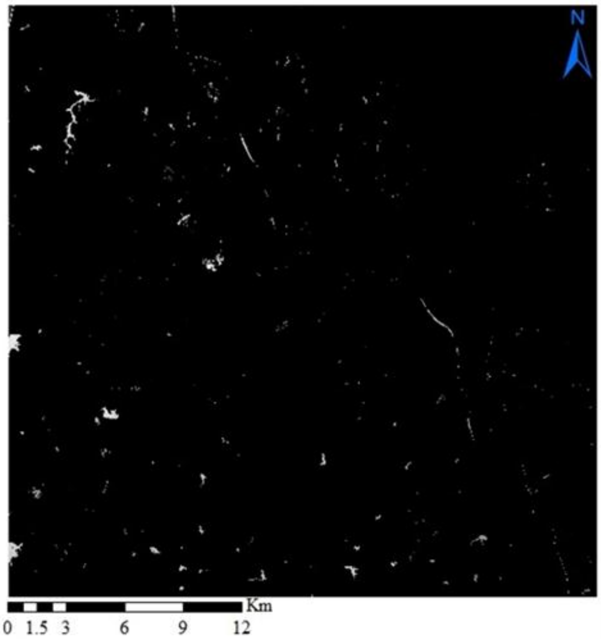

Figure 3(b) output image of PPI algorithm

In Maximum Likelihood Classifier uses the training data by means of estimating means and variances of the classes, which are used to estimate probabilities and also consider the variability of brightness values in each class. This classifier is based on Bayesian probability theory. It is the most powerful classification methods when accurate training data is provided and one of the most widely used algorithm [3].

RESULT AND ANALYSIS

Classification diversified the study area into five land cover types comprising agriculture surface, rock, exported rock, forested area and water which is represented in sienna, red, yellow, green and blue color respectively and unclassified region is shown in black color in classified image Figure 3.

Class Distribution Summary

Statistics Analysis of classification of remote sensing data, research area was the kajali Dungari Jhabua Madhya Pradesh, is represent in tabular form as shown below.

The most widely used method for extracting information from remote sensing imagery is classification 5 end members including unclassified, water, forest, rock, agriculture, Explored rock extracted from EO-1 Imagery. According to Figure 5(a), Figure 5(b) and Table 1, Table 2 it is clearly stated that in comparison to both MLH and SAM. The unclassified class % are less in MLH because it is based on covariance and variance parameter where mean value of each class is calculated and unclassified pixel gives to that class whose mean is nearly equal to unclassified pixel that is why the MLH is better as compared to SAM classifier. Here SAM is classified that an angle 50.

As for SAM, this explain that we need more than the direction of vector in order to separate the tropical forest species, which are spectrally similar in nature that is why forest, rocks and agriculture shows clearly in SAM.

For this image MLH is suffered from mixed pixel problem and SAM shows better result because small angle between two spectrum shows high similarity and wide angle indicate low similarity , whereas pixel with an angle larger than the tolerance level, the specified maximum angle threshold are not classified.

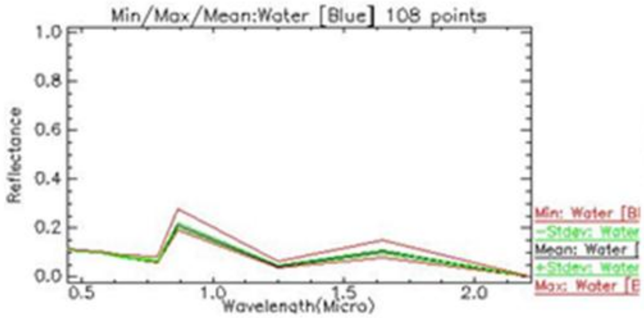

Figure 4(a) spectra signature of water ROI

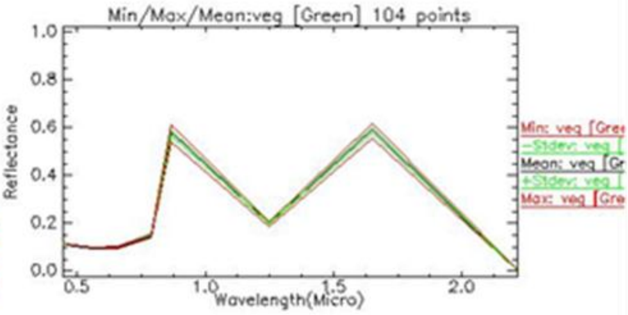

Figure 4(b) spectra signature of Forest ROI

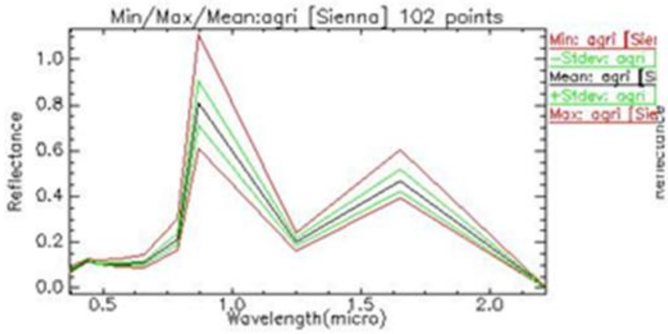

Figure 4(c) spectra signature of Agriculture field ROI

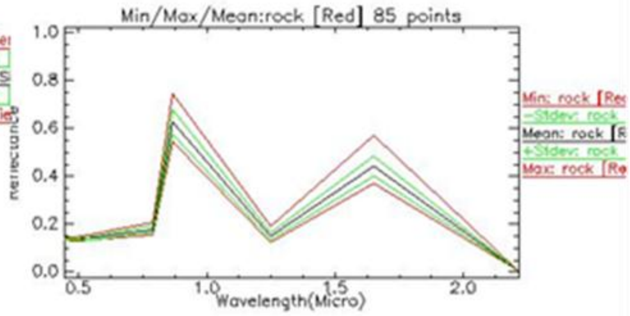

Figure 4(d) spectra signature of Rock ROI

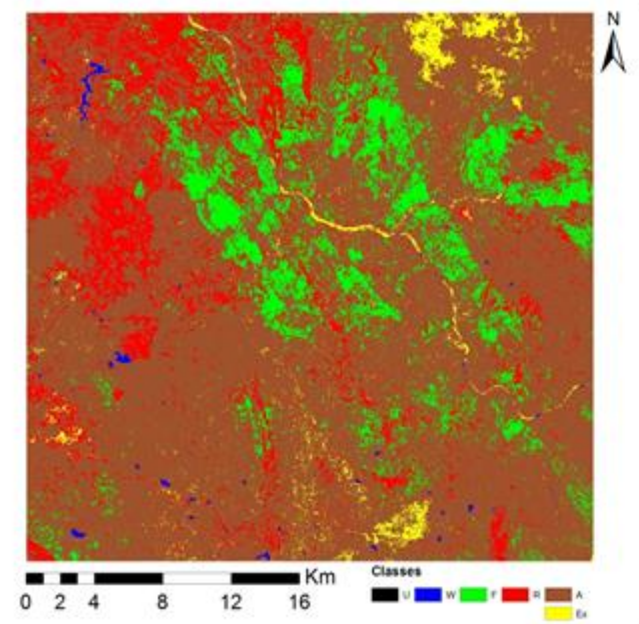

Figure 5(a) classified image by MLH technique

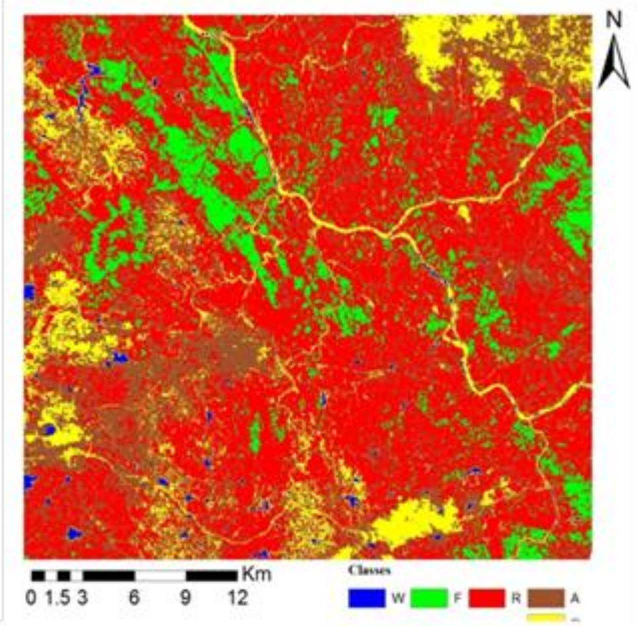

Figure 5(b) classified image by SAM technique

Table 1: Maximum Likely hood (MLH)

Features (color)	Area (%)	Area (meter^2)
Unclassified (Black)	0.000	0.00
Water (Blue)	0.291	2,689,186.50
Forest (Green)	11.164	103,310,707.50
Rock (Red)	14.008	129,623,293.80
Agriculture Soil (Sienna)	72.124	667,415,548.80
Expored Rock (Yellow)	2.413	22,331,509.20

Table 2: Spectral Angle Mapper (SAM)

Features (color)	Area (%)	Area (meter^2)
Unclassified (Black)	0.004	37,837.80
Water (Blue)	0.841	7,780,172.40
Forest (Green)	11.564	107,008,902.00
Rock (Red)	55.827	516,603,987.90
Agriculture Soil (Sienna)	19.658	181,913,331.60
Expored Rock (Yellow)	12.106	112,026,014.10

CONCLUSION

This paper mainly focused on the mapping and classification of reseach area with capitalizes on different features. From the results of this study, it can be concluded that SAM and MLH, which utilizes the accuracy of spectral signatures generated from MNF&PPI techniques, both of methods are the efficient, easy and effective way of mapping. Way of manipulating of data is different of both methods so results came different. But SAM gave batter result for this research study area. Impervious area and vegetation plant can be studied from the mapped image and this mapped data can be utilized for urban/rural, agriculture field and forestry development planning in near future.

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