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Land use Land Cover Mapping using Modified Ant Colony Optimization Technique

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Abstract: ***Land use Land cover classification is an important aspect for managing natural resources and monitoring environmental changes. Urban expansion becomes one of the major challenges for the administrator. The LANDSAT 8 images are processed using the open source GRASS (Geographic Resource Analysis Support System). Unsupervised classification technique based on Ant Colony Optimization (ACO) algorithm has been modified and proposed as Modified Ant Colony Optimization (MACO) for LULC classification. In order to improve the classification accuracy of the proposed algorithm, we have combined spatial, spectral and texture features to extract more information of homogeneous land surface. The classification accuracy of the proposed algorithm has been compared with other unsupervised classification methods such as k-means, ISODATA and ACO algorithms. The overall classification accuracy of proposed unsupervised MACO algorithm has been increased by 11.24 %, 8.24% for open space and water bodies class, respectively as compared to ACO algorithm.***

Keywords: Remote sensing, Image enhancement, Modified ant colony optimization, Classification accuracy.

I. INTRODUCTION

In the world, land resource is one of the most important resources for human beings. The development of human society is achieved by exploring and using land resource reasonably, hence, LULC classification is an extremely valuable subject for urban as well as rural development. LULC classification is broadly divided in unsupervised and supervised classification technique. The materials present on the earth's surface, land Use Land Cover (LULC) and its signature plays a significant role on the ecosystems of respective area [1, 2]. LULC information is generated from regional level to global level with the help of its spatial and spectral representation of the earth surface.

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The temporal coverage of specific region indicates the change in that area [3]. Now days more number of studies conducted on geographic distribution of LULC mapping analysis and its dynamic change over time, space and scale due to the high resolution sensors, improved computing resources as well as data analysis tools [4]. There are multispectral and hyperspectral sensors are available for remote sensing and LULC mapping analysis. The multispectral sensors consists the less no. of spectral bands around ten bands and hyperspectral sensors provides approximately 200 to 250 band. The urban area characterized various elements such as roads, gardens, buildings and commercial complexes [5]. For these kinds of images detailed land cover mapping does not perform well with low resolution. High spatial resolution sensor provides detailed spatial and spectral information in the urban as well as ruler areas. However, the availability of sensors and cost of sensing data is not affordable for developing countries for such a land cover mapping. This increase the demand of some advanced algorithms which improves the classification accuracies with the help of low and medium resolution sensors [6, 7]. Still there remains a challenge for researchers to improve the classification accuracy for such environments [8]. This paper gives the detailed and reliable LULC information from LANDSAT 8 imageries of Malshiras, Solapur District, Maharashtra state, India. Normalized Differential Vegetative Index (NDVI) and morphologies are derived from Digital Elevation Model (DEM) of ASTER [9, 10].

II. STUDY AREA , DATA AND METHODOLOGY

The study area is 'Malshiras Taluka', Solapur District, of Maharashtra, which is located in west of India, about 350 km east of Mumbai as shown in the Figure1. The western region is mainly situated on the Deccan Basaltic plateau, with diverse landforms, hills, streams, canals etc., Deccan trap basaltic lava flows, which in turn covered by thin mantle of soil. These lava flows on account of weathering give rise to undulating topography. The Soil in the area is Black, Coarse red, Reddish. The climate of the region is agreeable and free form extremes of hot and cold, except hot months of March, April and May. There are many fractures in the region so that the area can better act as a recharge zone of watershed.
Malshiras is located at 17.6° Latitude and 74.90°Longitude. The elevation range of this area is in between values 386 to 905 meters from sea level. The economy of this area is completely depending upon the agricultural products. There are many Milk Industry and Sugar Cooperative which has come up and due to which the traditional cropping is getting replaced with Sugarcane crops which gives high returns. But the rapid shifting of crops to more water intensive crops will trigger shortage of water in future.

There is need to bring more barren landscapes under cultivation at the same time to grow sugarcane.

There is need to increase the cropping area for fodder milk industries, Sugarcane-Sugar industries. The regional planning strategy will help the sufficient new rural and agricultural development. The proposed study will give the more focus on this developmental aspect by analyzing and quantifying land use and land cover.

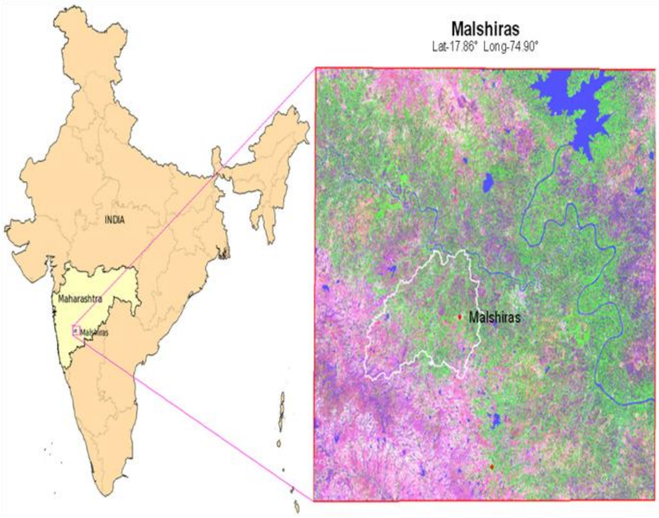


Figure 1: Study area

Data is downloaded from the LANDSAT 8 satellite which is freely available on the USGS site [15]. LANDSAT 8 satellite provides the data in eleven bands with 30 meter resolution except one band. It also gives temporal data after every sixteen days. It is acquired on 13th December 2016. The training samples are collected from the Google Earth images for classification and the clusters of signatures were generated for different classes. For each class 5 to 6 samples are collected and arranged in different layers which are further imported in GRASS software.

The LULC mapping of the selected area is carried out by unsupervised techniques such as k-means, ISODATA, ACO algorithms and MACO. The block diagram of the proposed unsupervised classification technique is as shown in the Figure 2. Unsupervised classification system consist band extraction, image pre-processing and enhancement, selective feature extraction and classifier [11]. There are total 11 bands are available in Landsat8 image and each band has significant features. In the proposed algorithms selective features have been extracted using DWT and further NLM filtering is applied in pre-processing stage for enhancement.

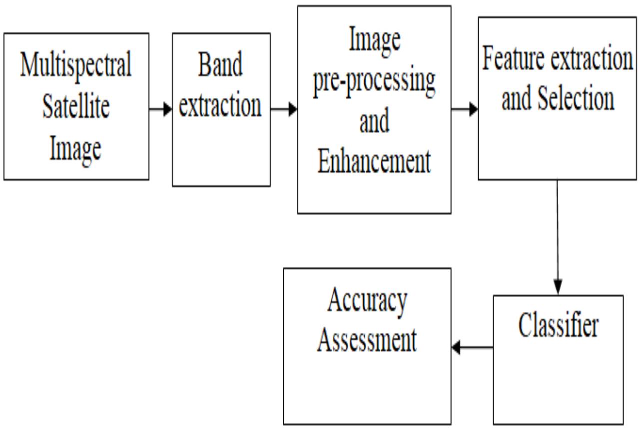


Figure 2: Unsupervised classification technique

The features are extracted in spatial, spectral and texture form which has been used for proper clustering of LULC in unsupervised classification. The purpose of feature extraction is to obtain relevant and compact information from the multispectral satellite image for accurate LULC classification.

III. PROPOSED CLASSIFICATION ALGORITHM

The proposed algorithm classifies a given set of input attributes into predefined classes based on the feature of either input data or training samples. In this unsupervised classification techniques clustering approach is used to classify the different classes based on the features of the input image [13, 14]. The proposed algorithm combines the spectral, spatial and texture for classification of the input Landsat8 satellite image. GLCM has been used for extraction of texture features and probability concept has been used for merging the input pixels from one class to another class. The proposed algorithm has been tested on GIS based GRASS software with Landsat8 images of said geographical location [12]. The performance of the proposed algorithm has been evaluated with classification accuracies and found to be encouraging as compared to other traditional clustering algorithms such as K-means, ISODATA and ACO algorithms. The block diagram of the proposed MACO technique for LULC classification is as shown in Figure 3.

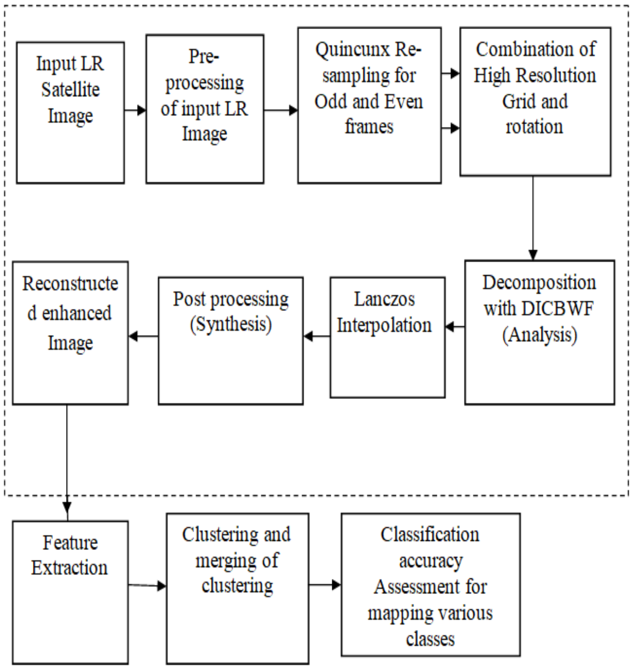


Figure 3: Block diagram of the proposed MACO technique for LULC classification.

The Landsat 8 satellite image consists eleven bands and further bands are extracted. The spectral, spatial and texture feature of the input image has been extracted and selected for the clustering of the classes. Initially clusters have formed using the texture features calculated from GLCM. Various classes have been identified through the unsupervised classification technique, hence merging of the clusters is essential to classify the input image into the broad classifications such as agricultural, hills and waste, water bodies, settlements and open land.

A. Proposed Algorithm of MACO for LULC Classification

In order to improve overall classification accuracy of homogenous structure of said geographical area, along with spatial features textured features have been combined in the proposed MACO to extract more and correct information. Initially, textured features such as Homogeneity, Dissimilarity, GLCM mean and GLCM standard deviation have been calculated to form basic clustering. Further, probability concept has been used for merging the cluster to identify desired LULC classes. For unsupervised classification MACO algorithm is described as below:

Step 1: Accept the enhanced image $g\ (x, y)$ obtained from the proposed satellite image enhanced algorithm.

Step 2: Calculate gray level co-occurrence matrix of $g\ (x, y)$.

Step 3: Find textured feature Dissimilarity, Mean and Variance of $g\ (x, y)$.

Step 4: Form Basic clusters from textured features.

Step 5: Initialize the parameters *N*, *m*, *β*, *r*, $T_{i,j}(t)$ and $P_{i,j}(t)$ with zero value.

Step 6: Calculate the weighted distance $d_{i,j}$ between $X_{i,k}$ and $Y_{j,k}$ of two points and expressed as,

$$d_{i,j} = \sqrt{\sum_{k=1}^{m} p_k \left(X_{i,k} - Y_{j,k}\right)^2} \qquad (1)$$

where,

$d_{i,j}$ is weighted distance between $X_{i,k}$ and $Y_{j,k}$

p is weight factor.

Step 7: The amount information on path $T_{i,j}(t)$ between $X_{i,k}$ and $Y_{j,k}$ is estimated using,

$$T_{i,j}(t) = \begin{cases} 1 & for\ \ d_{i,j} \le r \\ 0 & for\ \ d_{i,j} \ge r \end{cases} \qquad (2)$$

Step 8: Calculate probability of $X_{i,}$ to Y_j and expressed as,

$$P_{i,j}(t) = \frac{T_{i,j}(t)\eta_{i,j}^{\beta}(t)}{\sum_{s\epsilon S} T_{i,j}(t)\eta_{i,j}^{\beta}(t)} \qquad (3)$$

where,

$T_{i,j}(t)$ is the information path

$S = \{X_s |\ d_{sj} \le r\ ,\ s = 1,2, \dots \dots j, j + 1, N\}$

$\eta_{i,j}^{\beta}(t)$ is inspiration extended from i to j,

β *is* Inspiration information while choosing the path.

Step 9: If the $P_{i,j}(t) \ge P_o$ then $X_{i,}$ merged into Y_j .

Step 11: Calculate cluster centre as expressed,

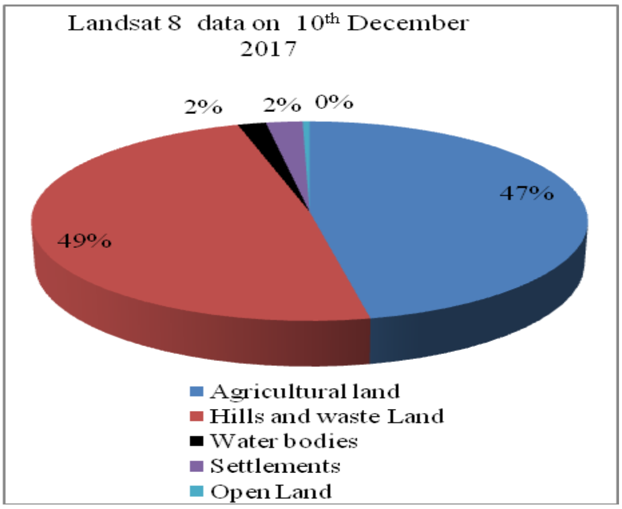
$$C_j = \frac{1}{j}\sum_{k=1}^{j} X_k \qquad (4)$$

Step 10: Assign the value of cluster centre C_j of Y_j to X_i .

Step 11: Calculate classification accuracy.

IV. RESULTS AND DISCUSSIONS

The proposed method (MACO) has been used for LULC classification of Malshiras taluka geographical location into different classes such as agricultural land, hills and waste land, water bodies, settlements and open land using Landsat 8 satellite image. MACO has been tested on Intel core (TM) i5 processor, 32 bits, 2.3 GHz operating frequency and 2.4 GB RAM with GIS based GRASS software. The data for the different dates of same geographical location and season have been collected on 13th December 2016, 10th December 2017 and 27th November 2018. The performance analysis for different classes has been compared with the ground truth analysis in the same season. The ground truth analysis has been carried out through the field visit of the said geographical location with the help of government approved local land survey agency (A.D. Geoinfo. Associates) for validation. Figure 4 shows the percentage land cover of the particular class as compared to ground truth analysis on 10th December 2017 data set. Similarly, Figure 5 shows the percentage land cover of the particular class as compared to ground truth for 27th November 2018 data set. The change detection analysis of the geographical study area has been carried out for period of one year (2017-2018) as shown in Figure 6. It has been observed that 2% hills and waste land has been converted into vegetation land and settlement area has been increased with 1%. Subjective results are shown with False Color Composition (FCC). Figure 7 shows the comparison of overall classification accuracy of different unsupervised classifiers such as k-means, ISODATA and ACO. It has been observed that overall classification accuracy of the vegetation class is less due to the variation of that class in the form of cropland, shrubs, horticulture area and forest. Also, it has been observed that the overall classification accuracy of the uniform land surface such as water bodies and open space have more classification accuracy. Figure 8 shows the FCC of different classes for the proposed MACO and other unsupervised classifiers. The black color has been represented as water source and it has been clearly identified Ujani dam and Bhima River near to the said geographical location. The hills and waste land has been spread more towards the south-west side of the said geographical area. Vegetation land has been observed relatively large towards the east and north side of the Malshiras taluka study area. Finally, overall classification accuracy of the proposed (MACO) algorithm has been improved significantly due do the combination of spectral, spatial and texture features as compared to other techniques. Normalized Differential Vegetation Index (NDVI) of the study area is shown in Figure 9. Digital Elevation Model (DEM) of the study area have been generated as shown in the Figure 10.



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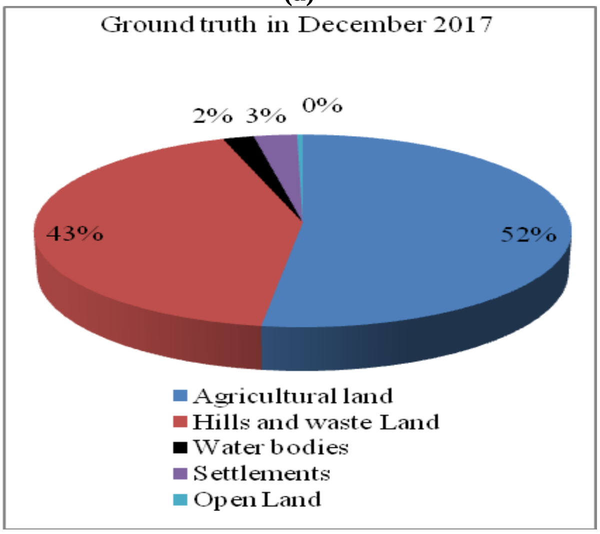

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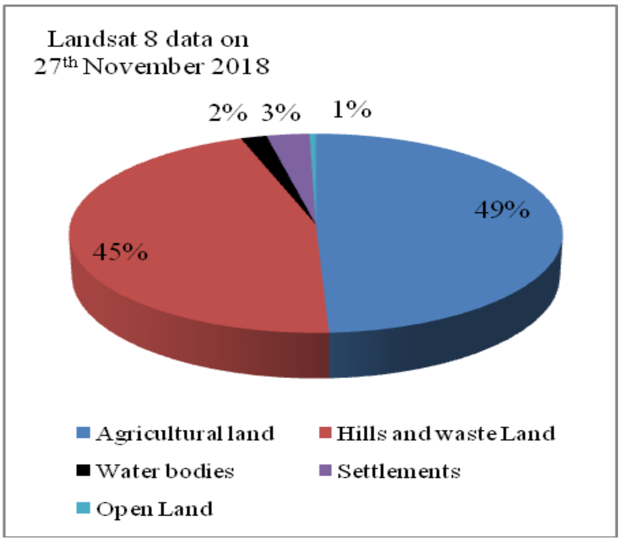
Figure 4: Percentage land classes of the Malshiras taluka for December 2017: (a) MACO classification, (b) Ground truth classification.



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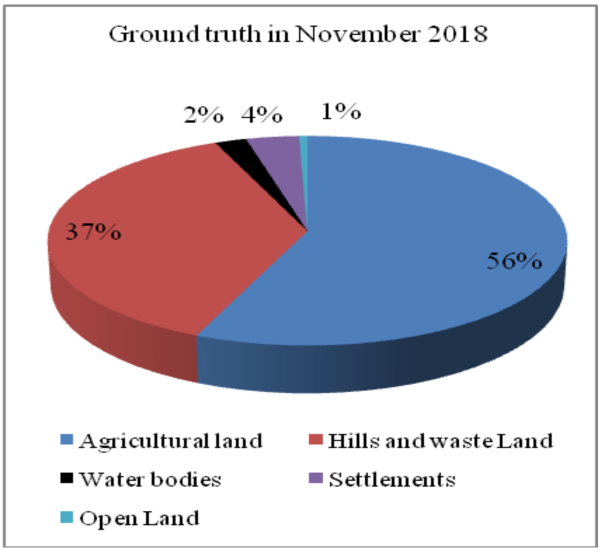
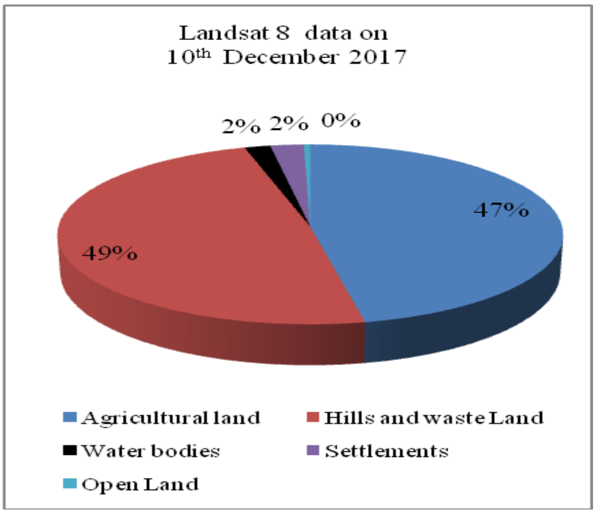


(b)

Figure 5: Percentage land classes of the Malshiras taluka for December 2018: (a) MACO classification, (b) Ground truth classification.



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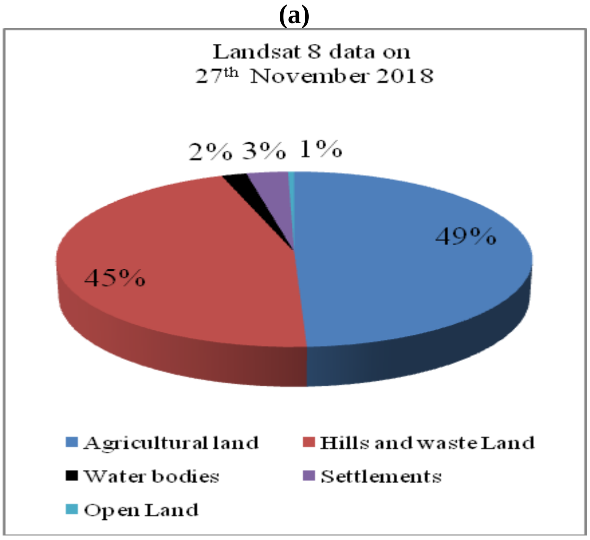

(b)

Figure 6: Percentage change detection of the Malshiras taluka between two consecutive years (a) MACO classification for December 2017, (b) MACO classification for November 2018.

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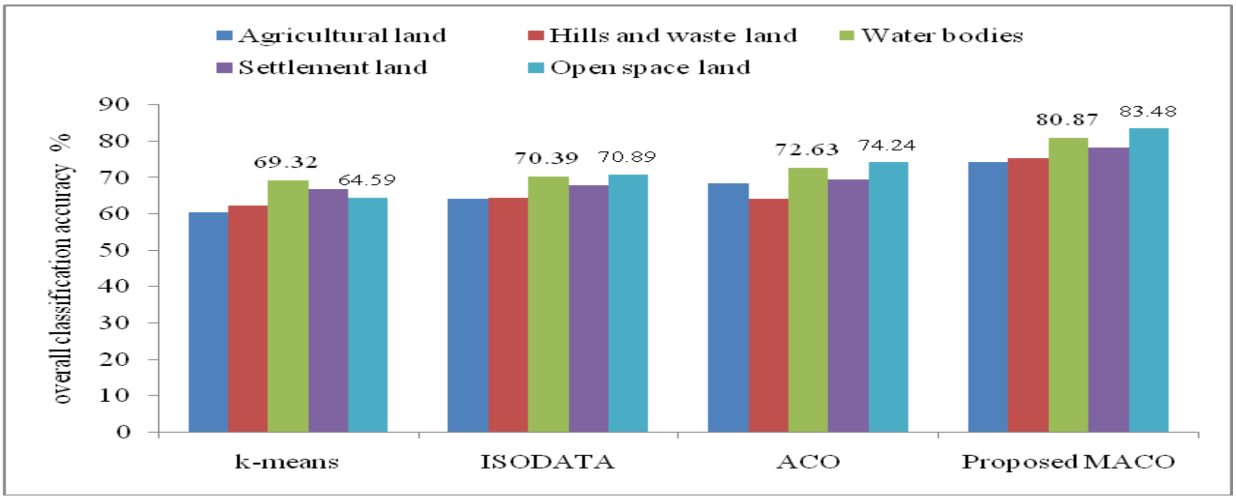
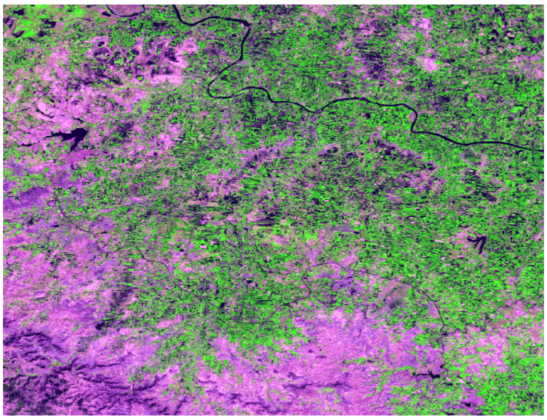


Figure 7: Overall classification accuracy of unsupervised classifiers for each class.



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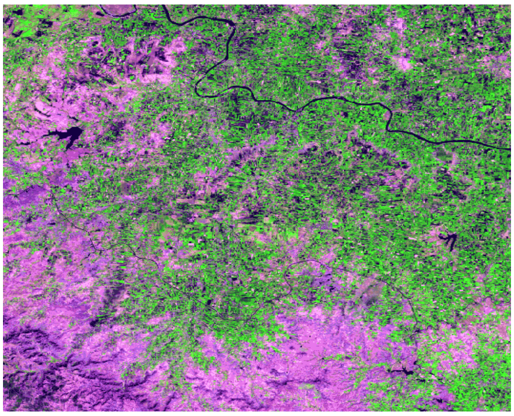

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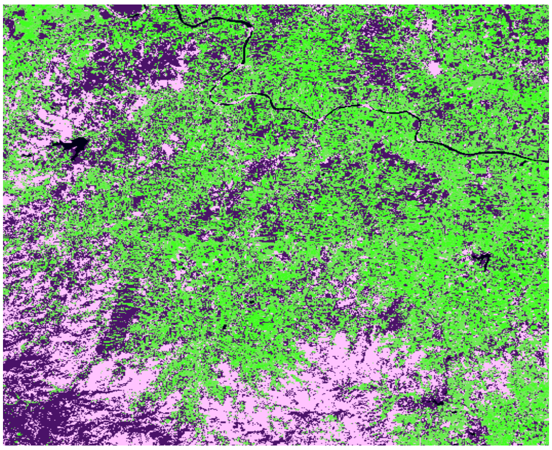

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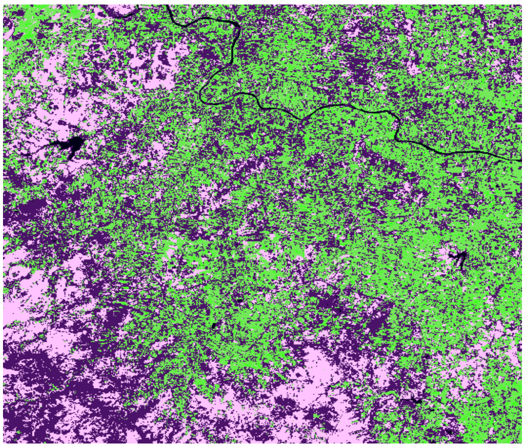

(d)

FCC Image Attributes	
	Vegetation
	Settlements
	Hills and waste Land
	Water
	Open space

(e)

Figure 8: Classification results of different classifier with FCC: (a) k-means, (b) ISODATA, (c) ACO and (d) MACO (e) FCC Image Attributes

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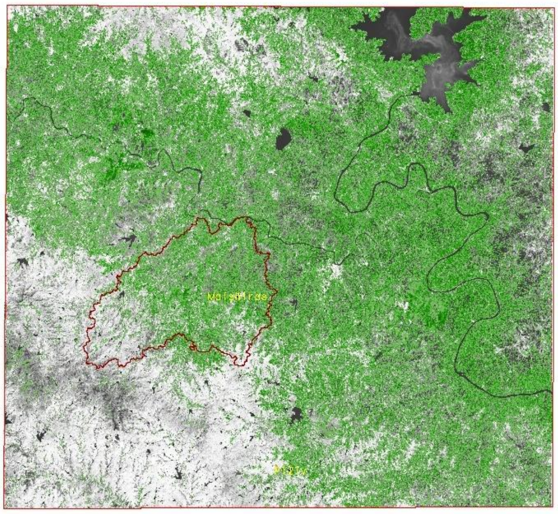
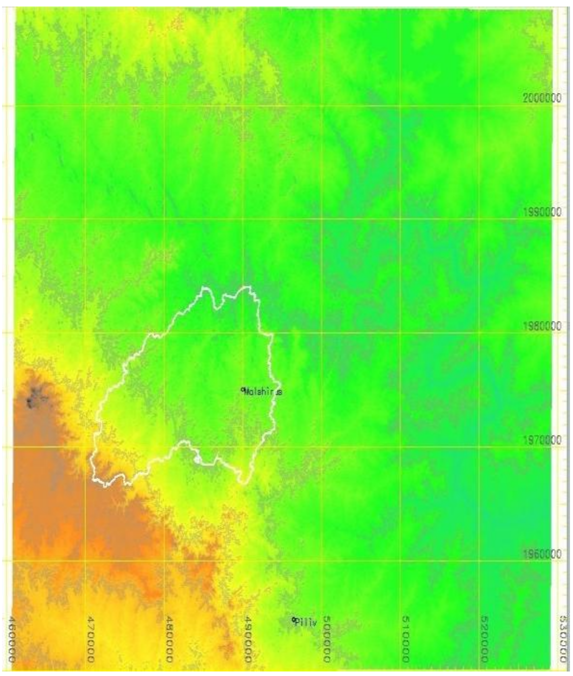


Figure 9: Normalized Differential Vegetation Index (NDVI) of the study area.

V. CONCLUSIONS

In this paper, MACO classification algorithm has been proposed based on the ACO with modified features for clustering for LULC. In order to improve the overall classification accuracy of the proposed MACO algorithm spectral, spatial and texture features have been combined together for the clustering and classification. The overall classification accuracy of the proposed (MACO) algorithm has been improved by 13.93 % for the agricultural land class, 13.14 % for hills and waste land, 11.55 % for water bodies, 12.29 % for settlements and 18.89 % for the open space land as compared to k-means algorithm. NDVI determines the vegetative cover by visual as well as computational means. DEM analysis helps in delineating the hills and plain areas which also helps in identifying the terrains with variable heights. The classification accuracy can be improved with supervised classification techniques which require exact training samples of the study area.



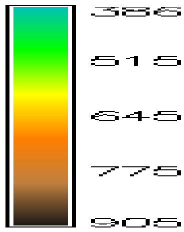


Figure 10. Digital Elevation Model of the geographical study area

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