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Urban Area Classification Using High Resolution Remote Sensing Data: A Hybrid Classification Approach

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Abstract: ***Increasing urbanization has resulted in reduction of agricultural land. There is immense requirement of keeping track urban development's to avoid depletion of agricultural land. This paper explains urban area classification using remote sensing and GIS Mapping of classification is done with help of top sheet E43D/5, with scale 1:50, 0000 and IRS-P6 LISS-IV image of Feb. 2014 having resolution of 5.8 m and GPS receiver My GPS coordinates is used. Classification methods like supervised and unsupervised both are used and detailed results analysis is done. For doing this the acquired image went through the series of process namely Preprocessing, Classification and Result analysis. Some image enhancement techniques were also performed to improve the satellite imagery for better visual interpretation. ENVI 4.4 image analysis tool were used for data processing and analysis. Maximum Likelihood, Mahalanobis distance, and Isodata classifiers were performed for urban classification in this study. Seven urban classes have been identified from the satellite image classification processes. It is observed that area is covered by barren land, agricultural area (with crops and without crops), hilly area, buildings and water bodies and play ground etc. The experimental results were compared with different supervised and unsupervised classifiers, such as Mahalanobis distance, and Maximum Likelihood and Isodata classifiers respectively. The performances of the classifiers were evaluated in terms of the classification accuracy with respect to the ground truth. The result of the classifications suggests that, each used and covered type were best classified by the Hybrid classification technique. Hybrid classification is done by first applying unsupervised classification like ISODATA classification, followed by various supervised classification techniques like Maximum likelihood, Mahalanobis classification. Hybrid classifier is best classifier of all. Combination of Supervised and Unsupervised classifier results in better accuracy as compared to supervised classification alone.***

Keywords: ***Supervised classification, Unsupervised classification, Hybrid classification, Multispectral, confusion matrix***

1. Introduction:

Urbanization is a process characterized by more and more people living in urban area. This is one of most important transformation world has witness in recent decayed. India is an integral part of this process. It is predicted that by 2050 just half of all countries are expected to have fewer than 5 million urban dwellers and will account for 1.7 per cent of the world urban population [1].Increasing urbanization has resulted in decrease in agricultural land. Most of agricultural land is changing to residential or commercial land .In addition to that unplanned industrialization and urbanization has adverse effect on ecosystem. Aurangabad is one of the rapidest developing cities in India. In response to increasing land prices and growing demand for housing, agricultural areas is becoming built-up by the individual and property developer. As the result, urbanization, industrialization, population growth and other economic activities have also impacted the agricultural production, and thus resulted in serious cultivated land instability which leads to cultivated land loss and food security problems. Again field survey of urbanized area like Aurangabad city is time tedious and time consuming. So, to overcome all this problems proper classification of urban and industrial area is necessary. Urban area is consisting of high frequency details like buildings tress etc. To identify these details remote sensing data of very high resolution (≤5m) are required [2].There are many problems related to updation of survey maps. These maps are separately designed for rural and urban areas. It is very tedious and time consuming task to update these data synchronously[3].so to overcome this problem related to cadastral map and also to reduce the compilation time of land classification proposed system is used. Also land survey map are time consuming and requires lots of manpower .Classification of land use and land cover based on satellite imagery is easy and requires lesser time and man power.

2. Study Area

Aurangabad municipal corporation area lies between 19° 48' 1"N to 19° 56' 47"N latitude and 75° 14' 40"E to 75° 26' 24"E longitude. The satellite data comes from bands (0.52 – 0.59 um), (0.62 – 0.68 um), (0.77 – 0.86 um) of RESOURCESAT-1 also known as IRS – P6, LISS-IV dated 4th February 2014. The Data required for the study is obtained from NRSC Balanagar, Hyderabad. The Survey of India Top sheet E43D05 at 1:50,000 scale is used. The geometrically corrected IRS-P6 Resourcesat-I LISS-IV satellite single date multispectral imagery was used for the preparation of Land use Land cover map. The IRS-P6 Resourscesat-1 LISS-IV satellite imagery has three bands i.e. Band 2 - Green, band 3 - Red, band 4 - NIR. Figure 2 shows the Original Satellite Image and Figure 3 shows the methodology used in experimentation.

Table-1: Used Data

Sr.No.	Used Data	Resolution	Data source
01	IRS-P6, LISS IV	5.8m	NRSC, Hyderabad.
02	Toposheet :E43D/5	1:50,000	Survey Of India (SOI)

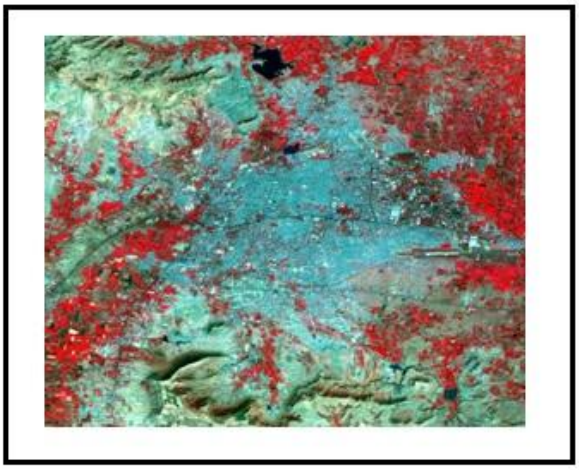

Fig-1: LISS-IV Satellite Image showing study area

3. Related Work

The existing system consists supervised and unsupervised classification techniques. Remote sensing images are analyzed by both supervised and unsupervised techniques. Supervised methods such as Machine learning are mostly used .Pixel-based supervised classification of very high spatial resolution images is used for urban classification [4].Bayesian methods on sparse representation of spectral information [5] are also used in classification. Unsupervised classification methods such as ISODATA and K-means are commonly used. Fuzzy classification and hierarchical fuzzy classification method produces increase in classification accuracy of urban classification[6].Different methods such as BPNN,MLC based on maximization of training and SVM are used in classification[7].Robust object based image analysis method is used for urban land cover classification[8].Recently supervised algorithm combining MLR with space projection methods are used. These methods results in higher accuracy as compared with traditional methods [9]. Neural network based classification methods [10], Fusion methods are used for classification, fuzzy combination rule is one of them. This method is combination of accuracies based on prior knowledge and automatically determined point wise result of each classifier[11].Compression based classification methods[12], Semi supervised methods using spectral unmixing concept is used for classification[13].

4. METHODOLOGY

The proposed method consists of combination of supervised and unsupervised classification technique, together called Hybrid classification. In Hybrid classification we have used both the supervised and unsupervised algorithms where the effective use of these algorithms is done. Classification algorithms based on single-pixel analysis often do not give the desired result when applied to high-spatial resolution remote-sensing data. In such cases, classification algorithms based on object-oriented image segmentation are needed. There are many segmentation algorithms in the literature, but few have been applied in urban studies to classify a high spatial-resolution remote-sensing image.

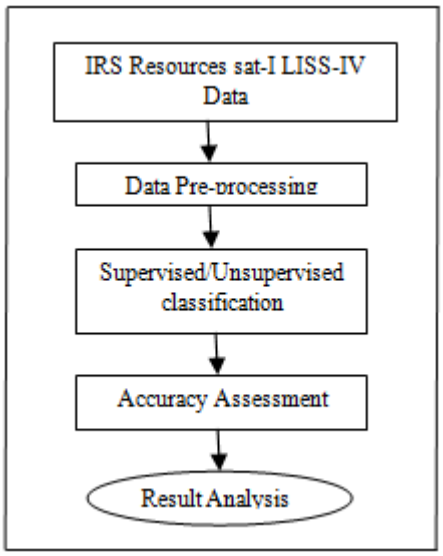

Fig-2: shows the methodology used in experimentation

3.1 Date Pre-processing

Image enhancement and filtering techniques used are linear contrast stretch, median/sharpen filter respectively. Linear 0-255 stretch was performed on satellite image. This stretch sets data value of 255 to screen value of 255 and also data value of 0 to a screen value of 0.This means all data values are linearly set between 0 and 255[14].Filtering technique and high pass filtering technique such as Median filter, High pass filter respectively are used on satellite image. Pulse or spike is removed by median filter and finer details are more visible using high pass filter[15].

3.2 Classification

Different classification methods such as supervised and unsupervised are used and a hybrid classification technique which is combination of both is used in order to increase accuracy of image.

3.2.1Unsupervised classification

First unsupervised classification method is applied on satellite image. Unsupervised classification is basically clustering of pixels grouped in different categories. Here grouping of pixels is based on similarity of their spectral values. ISODATA

clustering is iterative self-organizing data analysis techniques method of unsupervised classification [16].In this deletion, splitting and at last merging is performed. In this work Image undergoes through Isodata clustering first.

3.2.2Supervised classification

Supervised classification is based on training samples, based on this classification is performed. Prior knowledge of image which is classified must be known. These methods include Maximum Likelihood, Mahalanobis distance; Minimum distance and Parallelepiped classification algorithm are implemented. Proper selection of number of spectral band is done; bands containing more information are selected. Training or training samples are needed to be calculated are selected for each of classes defined in classification scheme. Quality training sites[17].
IMAGES] are required for better classification also it requires knowledge and understanding of the properties of different ground features in the satellite image.

3.2.2.1Mahalanobis distance Classifier

Mahalanobis distance classification assumes normal distribution of histogram bands and covariance matrix is used[18]

3.2.2.2 Maximum likelihood classifier

Maximum likelihood classifier is based on Bayesian probability concept. This classifier relies on second order statistics of Gaussian probability density function model for each class This is one of most widely used classification algorithm. The maximum likelihood method takes advantage of the probability of the pixel being a member of an information class in its decision making. This classifier relies on the second-order statistics of the Gaussian probability density function model for each class.
The basic discriminant function for pixel X is,

X€Cj if (Cj/X)=max[p(C1/X),p(C2/X),p(Cm/X)]……1
Where, max [p(C1/X),p(C2/X),p(Cm/X)] is a function that returns the largest probability among those inside the bracket
The information class corresponding to this probability is used as the identity for pixel X. p(Ci / X) denotes the conditional probability of pixel X being a member of class Cj. It is solved using the Bayes's theorem:
P(Cj/X)=p(X/Cj)*p(Cj)/p(X)……..……2
Where,p(X/Cj) , represents the conditional probability of encountering pixel X in class Cj. Also called s priori probability,p(Cj) , stands for the occurrence probability of class Cj in the input image; P(X), denotes the probability of pixel X occurring in the input image. It is obtained from the training samples by summing up the probability of finding it in every information class multiplied by the proportion of the respective class[19]

4. Results & Analysis

The major target of the classification is to differentiate the study area into different thematic classes. The results obtained from this study shows that IRS-P6 Resourcesat-Is LISS-IV to be reliable data source for urban classification. The final result shows that, seven different classes open space, water ,buildup, hill area, barren land, agricultural crop area, agricultural land without crop were obtained through image classification

The ISODATA classifier results shows Open space 2372.58 hectares, water body 2526.14 hectares, buildings 4037.57 hectares, hill area 4669.39 hectare, Barren land 3880.47 hectares, Agricultural land without crop 2569.19 hectares and Agricultural land with crop 2444.66 hectares.

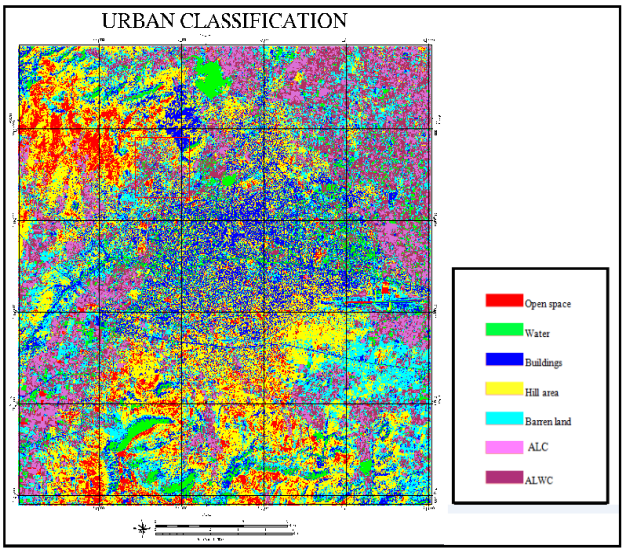

Fig-3:Urban classified map using ISODATA classifier

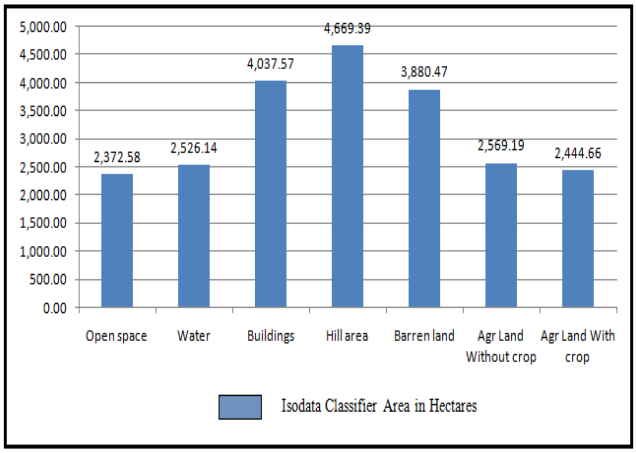

Fig-4: Area of urban land covers in hectares using ISODATA classifier

The Maximum Likelihood classifier(supervised method) results shows Open space 1312.77 hectares, water body 82.5325 hectares, buildings 3795.97 hectares, hill area5234.82 hectare, Barren land 6416.35 hectares, Agricultural land without crop 1157.90 hectares and Agricultural land with crop 4499.65 hectares.

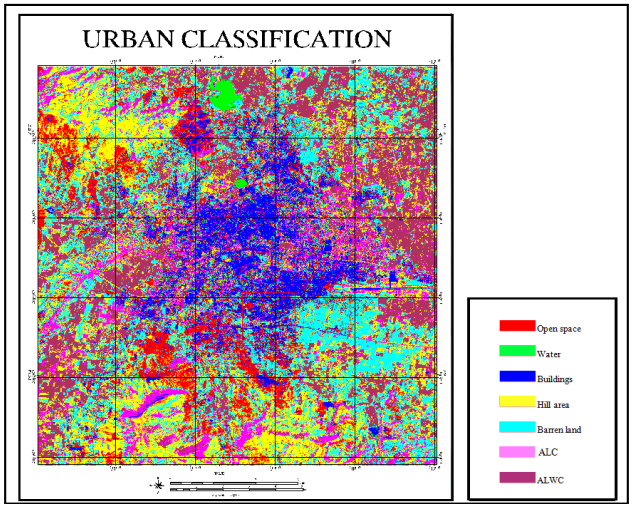

Fig-5: Urban classified map using supervised Maximium likelihood classifier

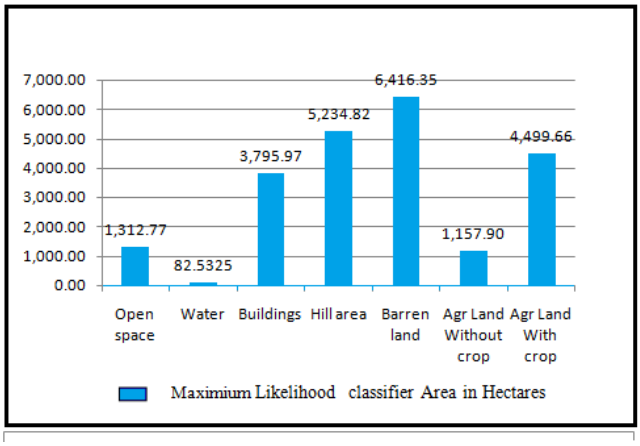

Fig-6:Area of urban land cover in hectares using Maximium Likelihood classifier(Supervised Method)

The Mahalanobis classifier(Supervised Method) shows Open space 1127.73 hectares, water body 282 hectares, buildings 3002.78 hectares, hill area 4365.5575 hectare, Barren land 3750.9425 hectares, Agricultural land without crop 6606.445 hectares and Agricultural land with crop 3363.86 hectares.

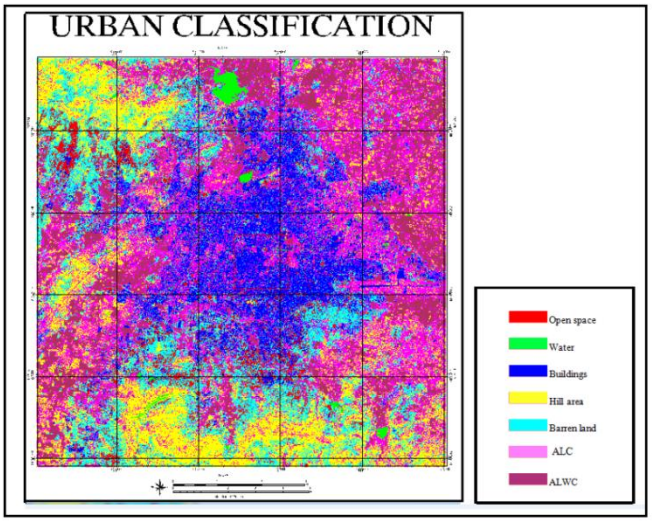

Fig-7:Urban classified map using supervised Mahalanobis classifier

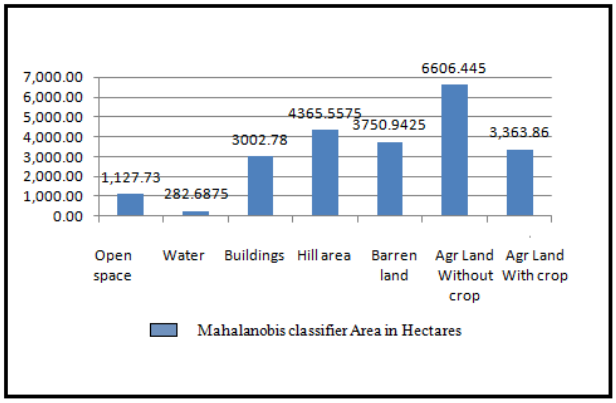

Fig-8: Area of urban land cover in hectares supervised Mahalanobis classifier

The Maximium Likelihood classifier(Hybrid method)shows Open space 2796.57 hectares, water body 455.275 hectares, buildings 2208.37hectares, hill area 4974.32 hectare, Barren land 4979.03 hectares, Agricultural land without crop 2617.27 hectares and Agricultural land with crop 4469.17 hectares.

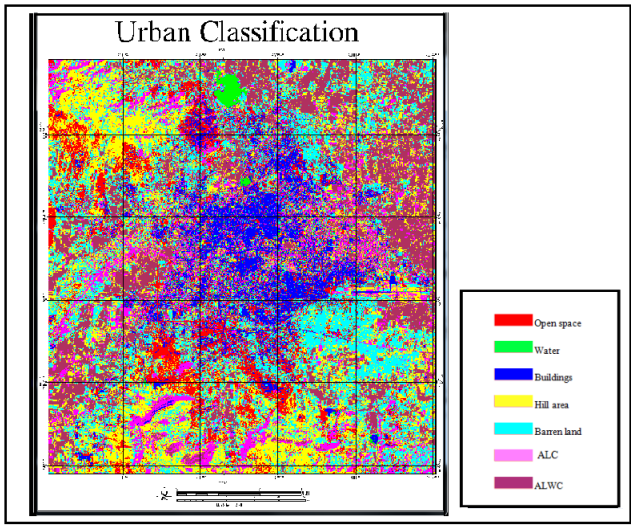

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Fig-9: Urban classified map using Hybrid Maximium likelihood classifier

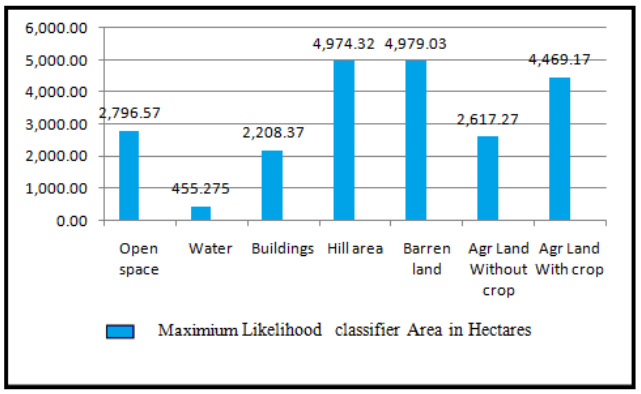

Fig-10: Area of urban land cover in hectares using Maximium Likelihood classifier(Hybrid Method)

The Mahalanobis classifier(Hybrid method) shows Open space 1825.98 hectares, water body 256.1625 hectares, buildings 3657.13hectares, hill area 1960.05 hectare, Barren land 7705.65 hectares, Agricultural land without crop 4848.58 hectares and Agricultural land with crop 2246.45 hectares.

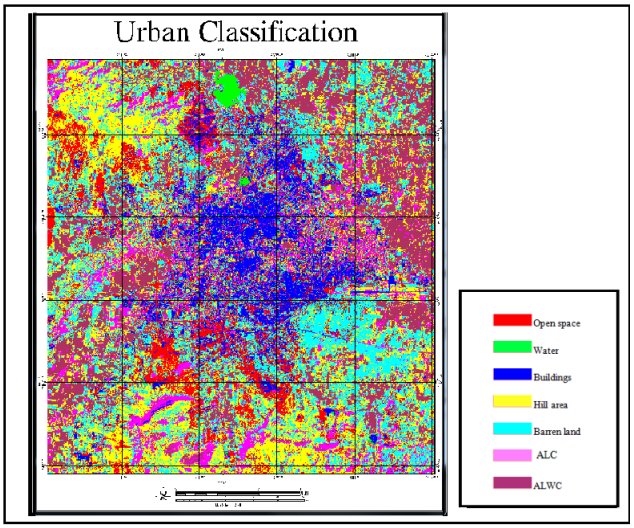

Fig-11: Urban classified map using Hybrid Mahalanobis classifier

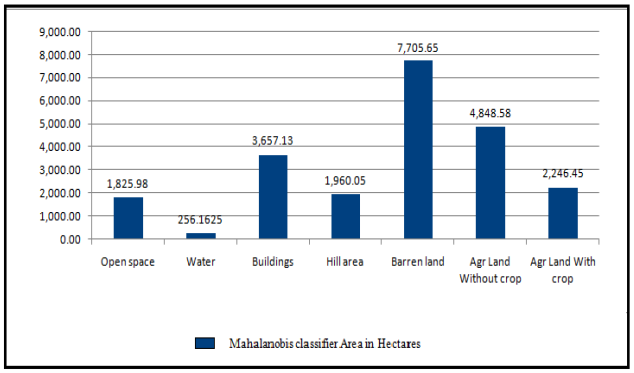

Fig-12:Area of urban land cover in hectares using Mahalanobis classifier(Hybrid Method)

4.5Classification accuracy assessment

Table -2: Error matrix for ISODATA classifier using Ground truth pixels

CLASSES	OS	WB	BD	HA	BL	ALWC	ALC	TOTAL
UNCLASSIFIED	0	0	0	0	0	0	0	0
OPEN SPACE	0	0	5	1	0	0	0	6

CLASSES	OS	WB	BD	HA	BL	ALWC	ALC	TOTAL
UNCLASSIFIED	0	0	0	0	0	0	0	0
OPEN SPACE	0	0	0	0	0	0	9	9
WATER	0	0	0	0	1	10	0	11
BUILDINGS	2	1	11	1	0	0	0	15
HILL AREA	0	0	0	0	7	0	1	8
BARREN LAND	8	0	0	3	0	0	0	11
AGRICULTURAL LAND WITHOUT CROP	3	0	0	6	0	0	0	9
AGRICULTURAL LAND WITH CROP	0	8	0	0	0	0	0	8
TOTAL	13	9	11	10	8	10	10	71

WATER	0	0	0	0	4	0	0	4
BUILDINGS	1	0	0	0	0	0	8	9
HILL AREA	4	0	1	5	0	0	0	10
BARREN LAND	0	9	1	0	0	10	0	20
AGRICULTURAL LAND WITHOUT CROP	0	0	0	0	4	0	2	6
AGRICULTURAL LAND WITH CROP	8	0	4	4	0	0	0	16
TOTAL	13	9	11	10	8	10	10	71

Table -3: Error matrix for Supervised Maximium Likelihood classifier using Ground truth pixels

CLASSES	OS	WB	BD	HA	BL	ALWC	ALC	TOTAL
UNCLASSIFIED	0	0	0	0	0	0	0	0
OPEN SPACE	1	0	0	0	0	0	10	11
WATER	0	0	0	0	7	1	0	8
BUILDINGS	0	0	10	1	0	0	0	11
HILL AREA	6	0	0	3	0	0	0	9
BARREN LAND	5	0	1	1	0	0	0	7
AGRICULTURAL LAND WITHOUT CROP	1	0	0	5	1	9	0	16
AGRICULTURAL LAND WITH CROP	0	9	0	0	0	0	0	9
TOTAL	13	9	11	10	8	10	10	71

Table -4: Error matrix for Supervised Mahalanobis classifier using Ground truth pixels

Table -5:Error matrix for Hybrid Maximium Likelihood classifier using Ground truth pixels

CLASSES	OS	WB	BD	HA	BL	ALWC	ALC	TOTAL
UNCLASSIFIED	0	0	0	0	0	0	0	0
OPEN SPACE	1	0	0	0	0	0	10	11
WATER	0	0	0	0	0	10	0	10
BUILDINGS	2	1	8	0	0	0	0	11
HILL AREA	0	0	2	0	8	0	0	13
BARREN LAND	10	0	0	3	0	0	0	7
AGRICULTURAL LAND WITHOUT CROP	0	0	0	7	0	0	0	9
AGRICULTURAL LAND WITH CROP	0	8	1	0	0	0	0	S
TOTAL	13	9	11	10	8	10	10	71

Table -6: Error matrix for Hybrid Mahalanobis classifier

CLASSES	OS	WB	BD	HA	BL	ALWC	ALC	TOTAL
UNCLASSIFIED	0	0	0	0	0	0	0	0
OPEN SPACE	1	0	0	0	0	0	10	11
WATER	0	0	0	0	0	10	0	10
BUILDINGS	2	1	8	0	0	0	0	11
HILL AREA	0	0	2	0	8	0	0	13
BARREN LAND	10	0	0	3	0	0	0	7
AGRICULTURAL LAND WITHOUT CROP	0	0	0	7	0	0	0	9
AGRICULTURAL LAND WITH CROP	0	8	1	0	0	0	0	S
TOTAL	13	9	11	10	8	10	10	71

OS- OPEN SPACE ,WB –Water Body,BD-Buildings,HA-Hill Area,BL-Barren Land,ALWC-Agricultural Land Without Crop,ALC-Agricultural Land With Crop,

5. Conclusion:

First ISODATA unsupervised classification was applied to classify image. Based on results of unsupervised classification again supervised classification was performed. With used classifier results were considerably improved in comparison to the results obtained by supervised classification alone. Hybrid classification using combination of Isodata and Maximum likelihood improved the accuracy of high resolution satellite data. Maximum likelihood classifier (Supervised) overall accuracy was 69% and kappa coefficient of 0.6365 ,whereas Maximum likelihood classifier (Hybrid) overall accuracy was 85% and kappa coefficient of 0.8353.Mahalanobis classifier (Supervised) overall accuracy was 56% and kappa coefficient of 0.4912 ,whereas Mahalanobis classifier (Hybrid) overall accuracy was 83% and kappa coefficient of 0.8022.Also results shows that Hybrid classification gives more accurate results as compared to supervised classification technique alone. Also hybrid classification results provide more accuracy in case of Maximum likelihood classification as compared to Mahalanobis classification.

Based on results, the following recommendations can be made. Maximum classifier results more accurate results whether used alone (Supervised Classification) or with combination of Isodata classifier (Hybrid classification).

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