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Research Article

IMAGE CLASSIFICATION TOOL FOR LAND USE / LAND COVER ANALYSIS: A COMPARATIVE STUDY OF MAXIMUM LIKELIHOOD AND MINIMUM DISTANCE METHOD

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ABSTRACT
Monitoring Land use / Land cover (LULC) changes and develop a model is utmost important for the developing cities to avoid its haphazard growth, especially in fringe areas. With the help of satellite imageries available for last few years or decades, with different spatial and spectral resolution, this task has become easier and reliable. But, to give the model solution for any real world problem there is a need to have reliable input data in appropriate format. Hence to provide solution for uncontrolled land use changing pattern, it is mandatory to perform image analysis on raw images.
This study aims to review different image classification methods and its utility for Land use / Land cover analysis. The paper includes demonstration of supervised image classification with both maximum likelihood and minimum distance method.

Key Words: *Supervised Image Classification, Land Use / Land Cover, Pune Municipal Corporation*

INTRODUCTION
Remote Sensing is an advanced tool for the inventory and analysis of Land use pattern and also for city planning at both small and large scales in undeveloped and developing parts of the world. Various types of remote sensing data, such as MSS, LISS, TM, SPOT, MODIS and AVHRR have been used for natural resources management and monitoring Land use pattern (Gregorio and Jansen, 1998 and Platt**,** 2004).
Image classification is one of the important phases of image analysis process (Anderson *et al.*, 1976; Adeniyi**,** 1985; Paul, 1991; Richards**,** 1993; Meyer, 1995 and Mather, 2004). The overall objective of image classification procedures is to automatically categorize all pixels in an image into land cover classes or themes. Normally multispectral data are used to perform the image classification and, the spectral pattern depicted by each pixel is used as the numerical basis for categorization (Jensen, 1996).
Image analysis is a sequential process which includes many phases like: Image import, Georeferencing, Image subsetting, Geometric correction, Image classification, design algorithm etc (Jensen, 2002; Lillesand and Kiefer, 2004 Thomas, 2001). Present research work focuses on Image classification phase of Image analysis process.

Types of Image Classification Process
Image classification process is divided into two: Hard and soft classification.

*Hard Classification***:**
In hard classification, each pixel represents a homogeneous area on the ground and shows only land cover type. Statistical methods are used to map each pixel by assigning it exclusively to one specific class. The spectrally similar data is described thematically in similar objects and is a dominant scene component for each pixel. Hard classification method is subdivided into three types, namely Unsupervised, Supervised and Expert knowledge based classification. Out of these three methods, two-classification methods i.e. unsupervised and supervised classifications are mostly used in many spatial problem solving techniques.

Supervised classification: In supervised classification, the image analyst supervises the pixel categorization process by specifying the computer algorithm and numerical descriptor representing various land cover types in a scene (ERDAS Field Guide, 1999).
Unsupervised classification: In unsupervised classification, the image analysts need not to have knowledge about the existing assignment or name of those classes. In short, image analysts do not supervise the pixel categorization process in unsupervised classification method.
*Expert knowledge based classification***:** Expert knowledge based classification is a hierarchy of rules, or a decision tree which describes the conditions under which a set of low level constituent information gets abstracted into a set of high level informational classes.

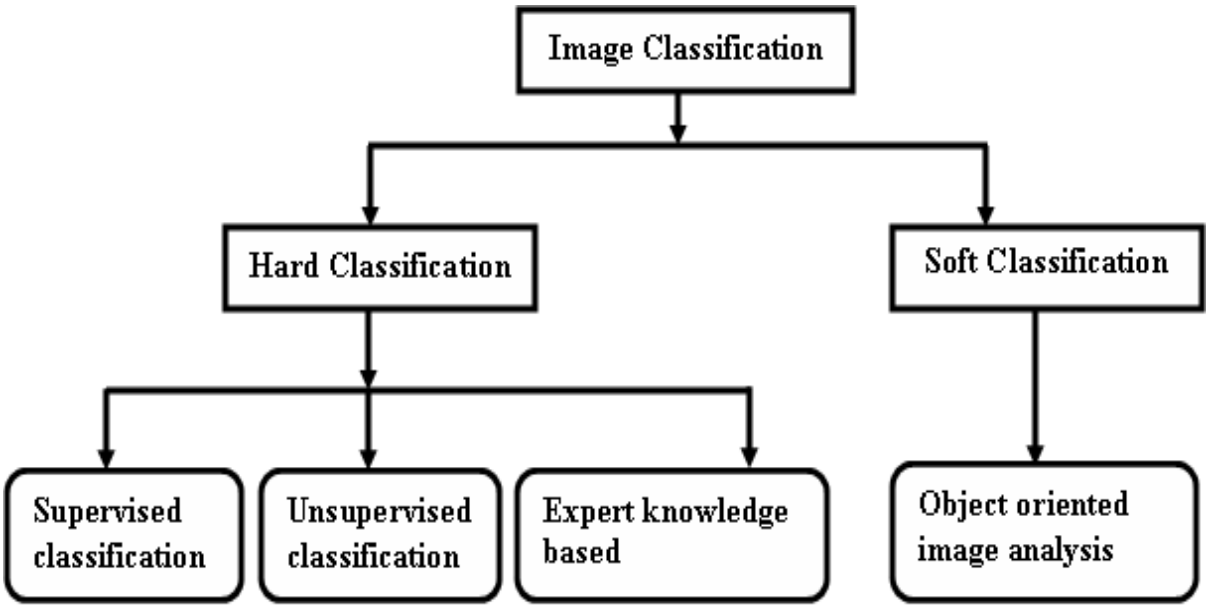


Figure 1: Image classification techniques

Soft Slassification
This classification method deals with mixed pixels problem by describing the spatially heterogeneous character of land cover in terms of continuous surfaces. This method provides the user with a measure of the degree (termed membership grade) to which the given pixel belongs to some or all of the candidate classes, and leaves on the investigator's decision as to which category the pixel could be attributed.
Object oriented image analysis classification: This classification technique is based on the object-based approach and it is called as soft classification method. In this method, image attribute information like location, shape, tone, texture, relational and contextual information is used during categorization.
Accuracy Assessment
The final stage of image classification process usually involves an accuracy assessment. Accuracy estimation is the quantification of mapping using remote sensing data to the group classification conditions. This is useful in evaluation of classification techniques, and determining the level of error that might be contributed by the image. Accuracy of each classification is expressed in the form of an error matrix (Congalton, 1991; Congalton and Green, 1998 and Smith *et al.,* 2003).
An error matrix is a square array of numbers in which the columns express the informational categories, and the rows show the classes in which those informational categories have been classified. The overall agreement of the classification is therefore expressed by the sum of main diagonal entries. An omission error happens when a test area is not classified into its informational category. On the other hand, the

commission occurs when a test area is classified in a class different from its true informational categories. Information about these types of error is given by the user's and producer's accuracies respectively. Test area of same size as the training areas were used to determine the classes in which a test area is classified. The agreement of the classification with ground truth was measured by means of the overall accuracy, and the Kappa Statistics.

Traditional accuracy assessment is done by generating random set of locations to visit the ground for verification of the true land cover type. A simple value file is then made to record the true land cover class (by integer index number) for each of these location. This value file is then used with the vector file of point locations to create raster image of true classes found at the location examined. The raster image is then compared to the classified map using error matrix. Error matrix tabulates the relationship between true land cover classes and the classes as mapped. It also tabulates error of omission and errors of commission as well as the overall proportional error. This information is used to assess the accuracy of the classification procedure that was under taken and is used for the results of all supervised classification.

MATERIALS AND METHODS

In unsupervised classification, there is a possibility that the maps and images that are produced through this method do not match the reality and therefore the accuracy of the resulting maps and images always need to be verified in the field before using them. Due to this known drawback of unsupervised classification method, Maximum Likelihood Classification (MLC) of supervised classification method is used for the present research work.

After this, another supervised classification was performed with Minimum Distance Classification (MDC) option to compare the results. LANDSAT image of the year 1999 is classified into 4 major classes: barren land, vegetation, water bodies, built-up area etc. The built up area is direct indicator of urban land which includes most of the dense built-up (Patil et al, 2012).

Pune Municipal Corporation (PMC) area is selected as a case study for this research work. Hence PMC boundary has been cropped from Survey of India Topographic sheet No. 47 F/10, 11, 14 and 15 and considered as a base map for the Land use Land cover (LULC) classification. Figure 2 shows Topographic sheet of Pune Municipal Corporation area.

Algorithm used for this present research work

Practical Demonstration

1. The digital remote sensing data of past decades has been procured.

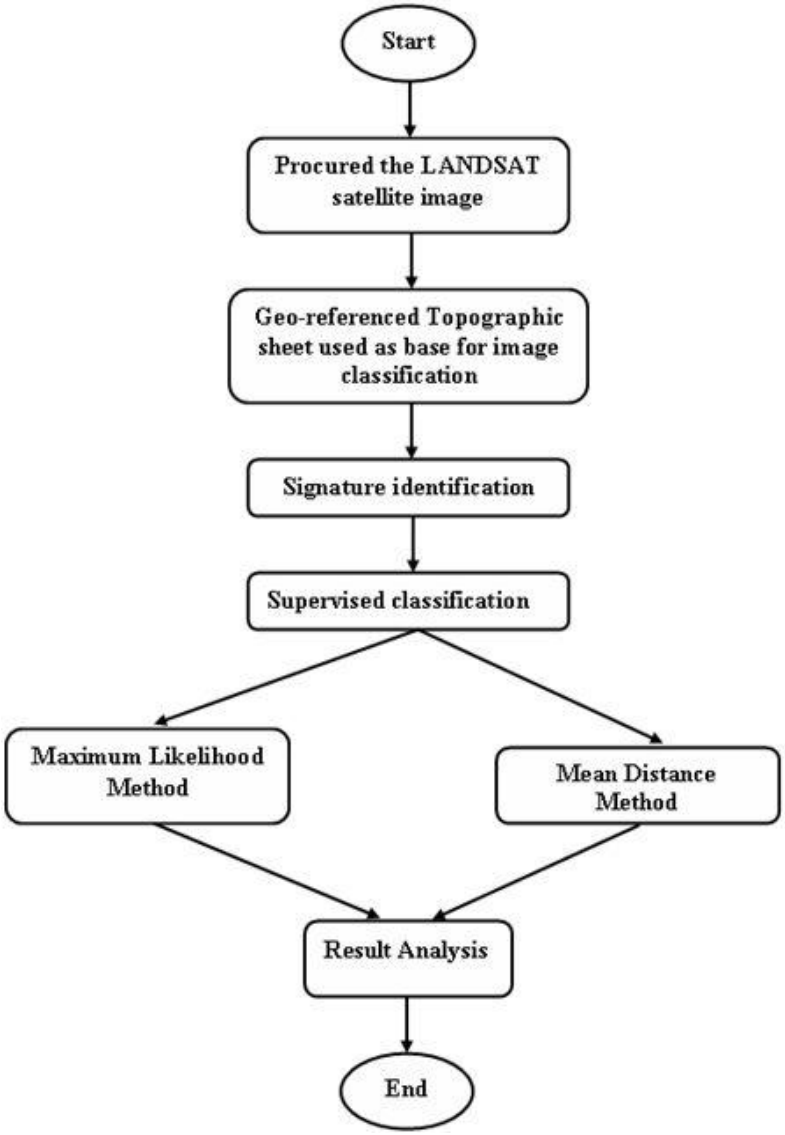
2. Topographic sheet of PMC area of year 1972 was scanned and geo referenced. This topographic map was further used as base map for the image registration.

3. The LANDSAT imagery for the year 1999 was imported, enhanced and geo referenced using ERDAS 9.2 software (Figure 3).

4. Using signature editor tool, various pixel colors were selected for different classes

5. The enhanced LANDSAT satellite image of the year 1999 was classified into different classes by using ERDAS imagine and compared with city land use maps.

6. Maximum Likelihood Classification (MLC) of supervised classification method was firstly used (Figure 5). After this, another supervised classification was performed with Minimum Distance Classification (MDC) option to compare the results / output of earlier option.



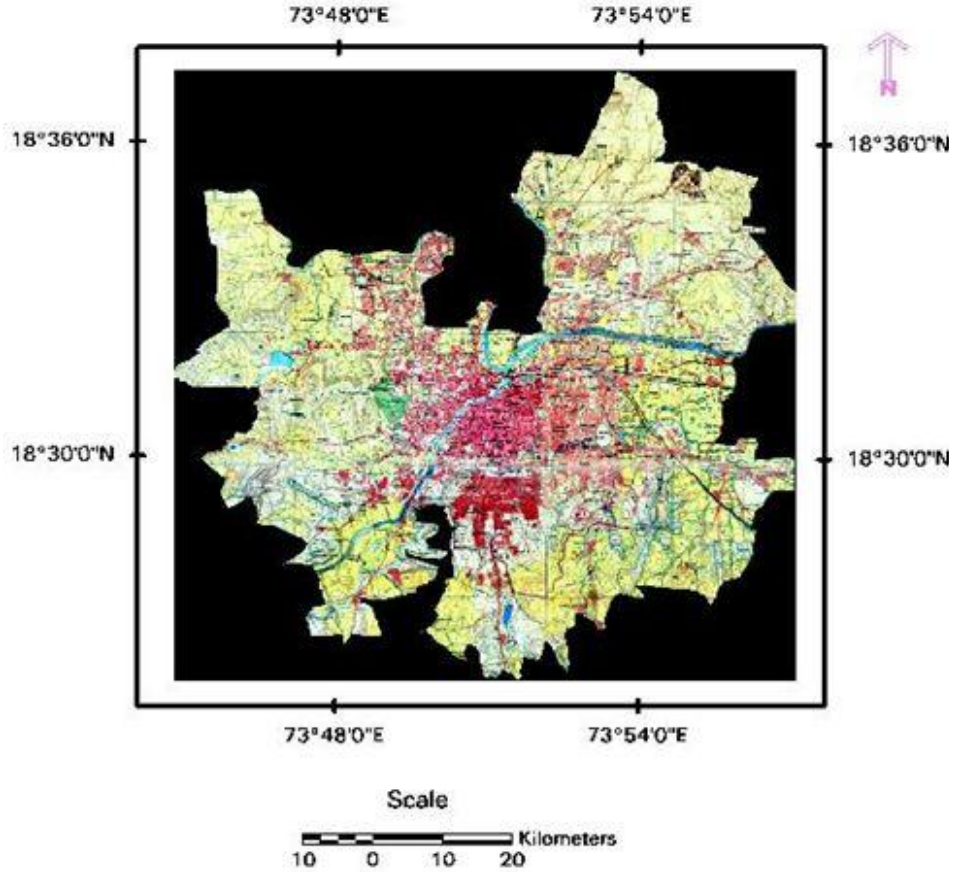


Figure 2: Topographic sheet of Pune Municipal Corporation area

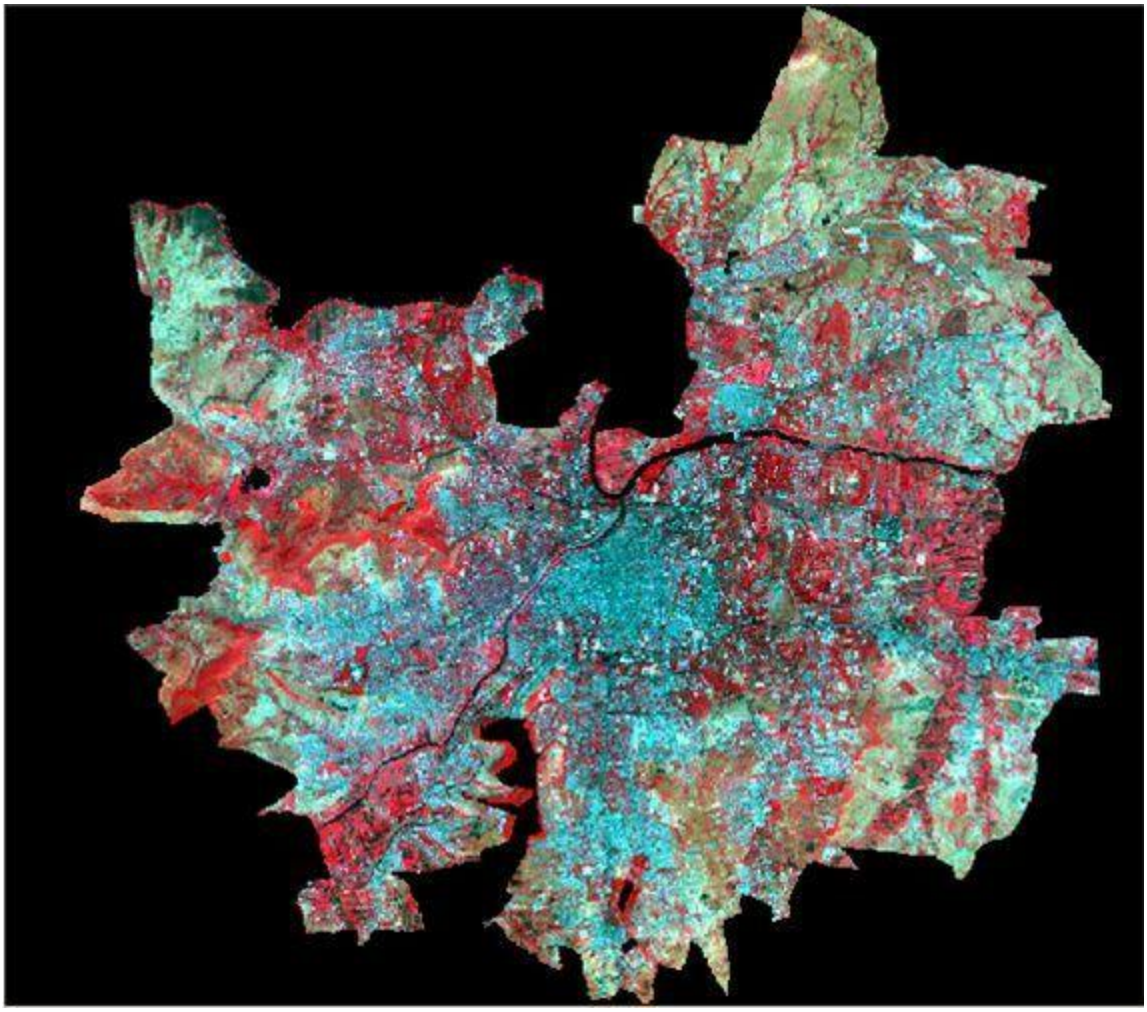


Figure 3: LANDSAT satellite imagery of Pune Municipal Corporation area

Class #	Signature Name	Color	Red	Green	Blue	Value	Order
1	builtup		1.000	0.000	0.000	1	1
2	barren		0.824	0.706	0.549	2	2
3	water		0.000	0.000	1.000	3	3
4	vegetation		0.000	0.392	0.000	4	4

Figure 4: Selected pixel colors for different classes using signature editor

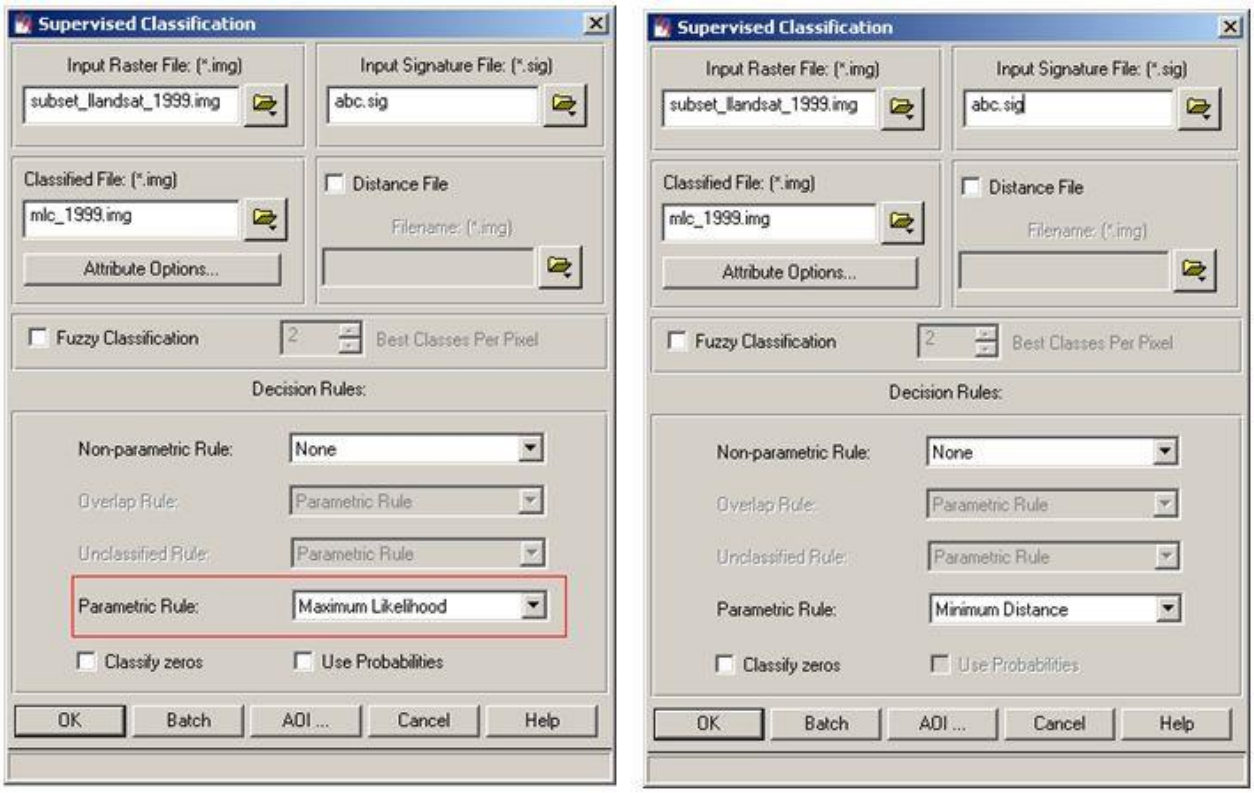


Figure 5: Maximum Likelihood and Minimum Distance options of supervised classification

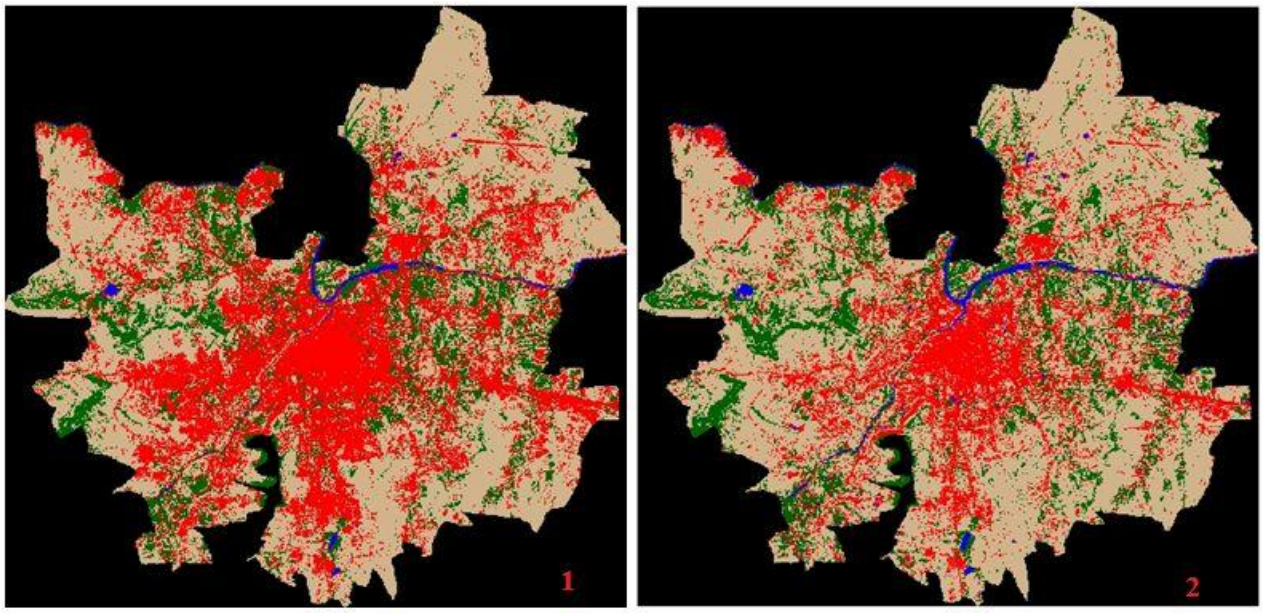


Figure 6: Output of MLC (1) and MDC (2) supervised classification

Evaluation of Classification Error Matrix

Table 1: shows the Error Matrix Resulting from Classifying Training Set Pixels using Maximum Likelihood method

Training Set Data					
	B	**W**	**V**	**Bu**	**Row Total**
B	126	0	5	0	131
W	0	52	0	10	62
V	0	16	100	0	116
Bu	0	0	38	480	518
Column Total	126	68	143	490	827

Table 1: Accuracy assessment Using MLC (126+52+100+480)/827 = 0.91%

Table 2 shows the Error Matrix Resulting from Classifying Training Set Pixels using Minimum Distance method

Training Set Data					
	B	**W**	**V**	**Bu**	**Row Total**
B	200	0	10	0	210
W	0	52	0	20	72
V	0	20	100	0	120
Bu	0	0	38	290	328
Column Total	200	72	148	310	730

Table 2: Accuracy assessment Using MDC (200+52+100+290)/730 = 0.87%

RESULT AND DISCUSSION

A variety of supervised classification methods has been applied and tested extensively for land use planning and management worldwide. But, for this research study, conducted on Pune Municipal Corporation area, a per-pixel maximum likelihood classification of LANDSAT-TM data offered the most satisfactory results. From the results, it has been confirmed that supervised classification using maximum likelihood method is most accurate as compared to minimum distance method.

Our goal was to compare the performance of MLC and MDC supervised classification algorithms in the benchmark task of Land use / Land cover categorization of Pune Municipal Corporation area. Maximum likelihood supervised classification method yielded higher accuracy in results of image classification even though it is computationally intensive and time consuming. Hence for present research work, MLC approach has been adopted for Land use / Land cover monitoring and analysis.

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