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Land use and land cover classification of Jabalpur district using minimum distance classifier

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Abstract
Land use and Land cover (LULC) classification of satellite imagery is an essential research field and analyzed extensively in remote sensing. Although, precise and accurate land use land cover detection is still a challenge. This paper represents LULC classification of Sentinel 2 imagery using Minimum distance classifier. The study area for the present work is Jabalpur District of Madhya Pradesh, India. The Minimum distance classifier was applied to classify the image into five LULC classes *viz.* agriculture, vegetation, open/fallow/barren land, water body and habitation. It was found that agriculture covers 48.78%, 13.21% is occupied by vegetation, open/fallow land comprises of 34.04% area, 2.20% is covered by water body while habitation occupies 1.76% of the total area. The classification accuracy for multispectral image was found to be 87.75%.

Keywords: LULC, sentinel 2, minimum distance classifier, kappa coefficient

Introduction
LULC classification plays a significant role in evolution of region and nation. Precise and relevant details of LULC is immensely essential for examining numerous socio-ecological concerns. This information is crucial in diverse implementations involving agriculture, rural management, urban land planning and sustainable development. Remote sensing technology is tremendously applied to study the evaluation of LULC changes. Remote sensing data obtained from many satellites have been broadly used to retrieve LULC information (Babykalpana *et al*., 2010; Saadat *et al.*, 2011) [1, 2]. A variety of methods have been introduced for LULC classification with the development and advances in remote sensing technology and satellites (Sekertekin *et al*., 2017; Mishra *et al*., 2014) [3, 5]. The study employed multispectral data from Sentinel-2. Sentinel-2 is an Earth observation mission under the Copernicus Programme, it systematically obtains optical imagery at high spatial resolution (10 m to 60 m) over land and coastal water bodies. Sentinel-2 serves a wide range of applications including agricultural and forestry practices.

When training samples for classes are limited then an algorithm is needed to use only mean value for the classes. MDC or minimum distance classifier is an approach where class mean is evaluated by using training samples and then consign pixels to the class of nearest mean (Lillesand *et al*., 2004) [4]. Thus, the basic aim of this paper is to apply Minimum Distance supervised classification technique to generate LULC image of Jabalpur district of Madhya Pradesh.

Study Area
Jabalpur district is situated on the banks of Narmada River in the state of Madhya Pradesh in Central India. It is spread over 22° 49' 42" N to 23° 37' 5" N and 79° 20' 56" E to 80° 35' 10" E. The district is expanded over 5198 km². It consists of a long narrow plain running north-east and south-west and shut in on all sides by highlands. The plain forming an offshoot from the Narmada valley, is shielded in its western and southern segment by a rich alluvial deposit of black cotton soil. At Jabalpur city, the soil is black cotton soil, and water plentiful near the surface. The district of Jabalpur comprises of 1457 villages divided into seven blocks *i.e.*, Jabalpur, Sihora, Majholi, Patan, Shahpura, Panagar and Kundam.

Sentinel-2 consists of single multispectral instrument with 13 spectral channels in visible, near infrared and short wave infrared spectral range. The present study utilized Sentinel-2 satellite images of February 2020. The satellite image of this month produces highly clear imagery of agricultural areas of Jabalpur district because it depicts clearly distinguishable cropped agricultural land and fallow agricultural land. Fig. 1. Represents the study area.

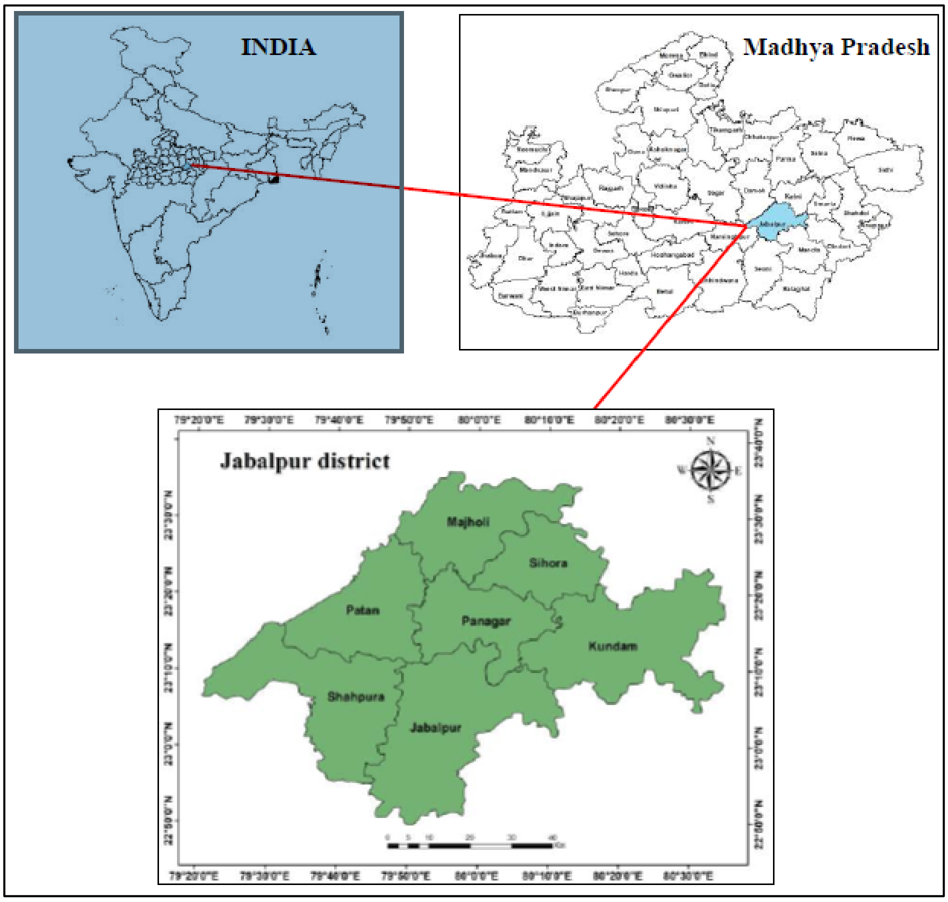

Fig 1: The study area (Jabalpur district of Madhya Pradesh)

Methodology

Before classifying, the image was pre-processed using ERDAS IMAGINE® 2020 software.

Minimum Distance Classifier

There are several methods to perform supervised classification such as Maximum likelihood classifier, neural network, Mahalanobis distance, Support vector machine, Minimum Distance classifier etc. Minimum Distance Classification (MDC) is used to classify unknown image data to classes which minimize the distance between the image data and class in multi-feature space. The distance is defined as an index of similarity so that the minimum distance is identical to the maximum similarity. In this technique the mean point in digital parameter space is calculated for pixels of known classes, and unknown pixels are then assigned to the class which is arithmetically closest when digital number values of the different bands are plotted. To classify the study area, ROI for five major classes were prepared which comprises of Agriculture, Vegetation, Water body, Habitation, and Fallow/Open/ Barren land.

Accuracy Assessment

The accuracy assessment techniques are applied to establish statistical results that are used to verify the classification outcome's precision. It is an essential procedure as it aids in the error analysis of every class for assessment of the ultimate reliability of classified map. A confusion matrix (also known as an error matrix) forms the basis of accuracy assessment, it compares the classified image with known reference data that is considered to be accurate. It is predicted by evaluating overall accuracy along with kappa coefficient. These values are calculated by using confusion matrix (Lillesand *et al*., 2004) [4]. The kappa coefficient can be estimated by using an equation defined below,

$$\widehat{K} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$

r = number of rows in the error matrix
x_{ii} = number of observations in row I and column I (on the major diagonal)
x_{i+} = total number of observations in rows I (shown as marginal total to right of the matrix)
x_{+I} = total number of observations in column I (shown as marginal total at bottom of the matrix)
N = total number of observations included in matrix

Result

Land Use and Land Cover classification of Jabalpur district has been performed by Minimum Distance Classification technique of supervised classification. Satellite image of Jabalpur district was categorized into 5 major classes namely Agriculture, Vegetation, Open/Fallow/Barren land, Water body, and Habitation. The outcomes of classified LULC map depicted that Agriculture occupies almost half of the area of Jabalpur district with an acreage of 246519 ha followed by Open/Fallow/Barren land (172053 ha), Vegetation (66767 ha), Water body (11126 ha), and Habitation (8899 ha). Table 1 represents area of different LULC classes. The classification accuracy is estimated for classified image and was found to be 87.75% with the kappa coefficient 0.820025. Error matrix of classified LULC map of Jabalpur district is depicted in table 2. Fig 2 represents the LULC classified map of Jabalpur district.

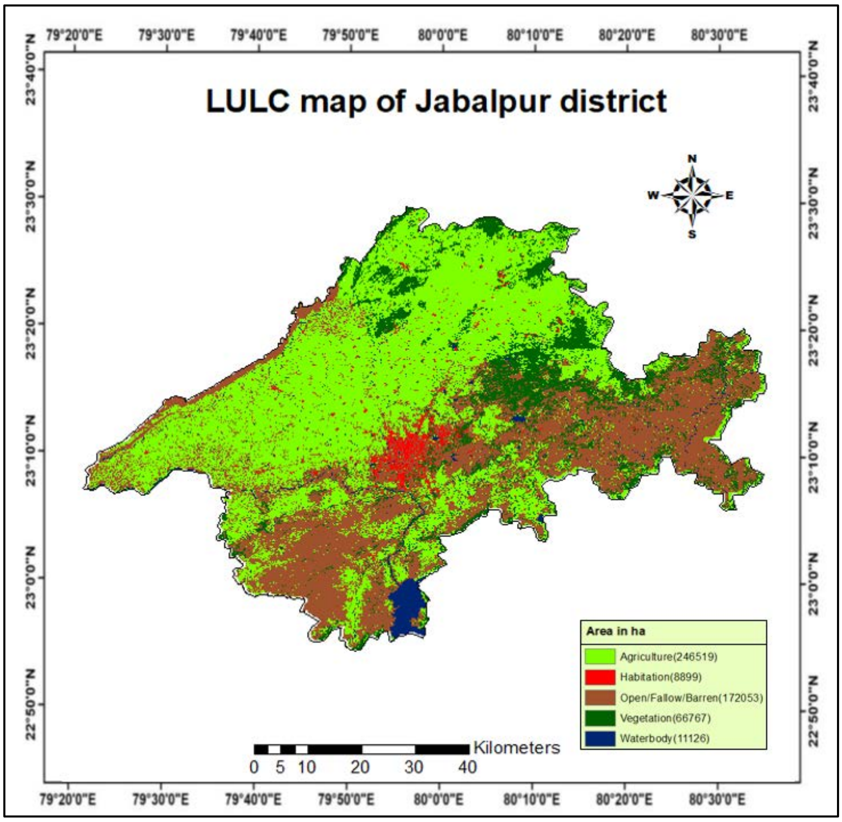

Fig 2: Land Use Land Cover map of Jabalpur district

Table 1: Area of different LULC classes

Class	Area in ha	Area in %
Agriculture	246519	48.78
Vegetation	66767	13.21
Open/fallow/barren land	172053	34.04
Habitation	8899	1.76
Water body	11126	2.20

Table 2: Error matrix of classified LULC map of Jabalpur district

Class	Agriculture	Vegetation	Waterbody	Open/ fallow/ barren	Habitation	Total	User's accuracy	Kappa coefficient
Agriculture	97	15	0	2	0	114	0.850877	0
Vegetation	1	27	0	3	0	31	0.870968	0
Waterbody	0	0	10	0	0	10	1	0
Open/ fallow/ barren	0	8	0	72	0	80	0.9	0
Habitation	1	0	0	0	9	10	0.9	0
Total	99	50	10	77	9	245	0	0
Producer's accuracy	0.979798	0.54	1	0.935065	1	0	0.877551	0
Kappa coefficient	0	0	0	0	0	0	0	0.820025

Conclusion

Remote sensing approach for land use land cover classification was studied in this paper. Minimum Distance Classification was adopted as a method of supervised classification to analyze the land use land cover classes in the study area. The results show that the classification accuracy was found to be quite satisfactory, therefore, it is concluded that remote sensing and GIS is an efficient tool to perform land use land cover classification.

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