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GEOSPATIAL ASSESSMENT OF LAND USE AND LAND COVER IN KURUKSHETRA DISTRICT, HARYANA, 2024

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ABSTRACT

The interplay between agricultural landscapes, settlement patterns and environmental resources is crucial. This study examines the current Land Use Land Cover (LULC) distribution in Kurukshetra District, Haryana, India, as of 2024. We utilized Landsat 8 Operational Land Imager (OLI) Collection 2 Level-2 Surface Reflectance data, processed using Geographic Information System techniques. Image processing and classification were performed in QGIS 3.40.9, employing the Semi-Automatic Classification Plugin 8.5.0. Six reflective spectral bands allowed for supervised Maximum Likelihood Classification into five distinct categories: Built-up Area, Cropland, Vegetation and Tree Cover, Water Bodies and Bare Land. The finalized classified raster comprised 1,862,375 valid 30 m pixels, representing 1,676.14 km2

Cropland emerged as the most widespread category, occupying 1,072.0 km2 (63.96 percent), Following closely was Bare Land at 417.66 km2 (24.92 percent). Built-up Area accounted for 129.56 km2 (7.73 percent). Vegetation and Tree Cover covered 51.19 km2 (3.05 percent) and Water Bodies made up the smallest portion with 5.69 km2 (0.34 percent)

An accuracy assessment, using 5,381 validation pixels, yielded an Overall Accuracy of 96.88 percent and a Kappa coefficient of 0.9406. The primary remaining confusion in the classification was observed between Built-up Area and Bare Land. These results indicate that while Kurukshetra remains largely agricultural, it also possesses significant built-up zones and exposed land surfaces. The generated database serves as a valuable contemporary benchmark for managing agricultural lands, planning urban development and observing future LULC changes.

Keywords: Land Use and Land Cover, Kurukshetra, Landsat 8 OLI, Remote Sensing, GIS, Maximum Likelihood Classification

1. INTRODUCTION

Land is a finite geographical resource which facilitates agriculture, housing and infrastructure networks and supports ecosystems and water-resource systems. Land use reflects the function for which the land is utilised whilst land cover provides a description of the visible surface, such as vegetation, trees, water, bare soil or artificial surfaces Anderson et al. (1976). Obtaining accurate information of land use/land cover (LULC) is essential for regional planning, agricultural management and environmental assessment.

Remote sensing (RS) and geographic information systems (GIS) have revolutionised land use and land cover (LULC) mapping. The availability of spatially continuous, repeated observations and techniques that provide efficient tools for

identification, measurement and classification of LULC has enhanced our knowledge and analysis of this Jensen (2015), Lillesand et al. (2015). Among others, the Landsat programme provides an appropriate platform for regional and district-level mapping, with data at 30 m spatial resolution with multispectral bands that allow large-scale classification of various land use and land cover types including crops, settlements, vegetation, water and other types of exposed land.

Multispectral data is used successfully for the identification of these classes with supervised image classification. MLC is advantageous in that it is based on a statistical approach with a clear methodology. The accuracy of classification will be influenced by factors such as mixed pixels, spectral overlap and the representativeness of training samples Richards (2013). Therefore, accuracy assessment is indispensable. Congalton (1991), Foody (2002) et al. (2014) have all stressed the importance of using independent reference information and using assessment through the confusion-matrix approach.

Kumar et al. (2021) examined the Satellite-based analysis of land use and land cover pattern in District Kurukshetra keeping in view the trends and patterns of the LULC in the flat rolling plains of the Kurukshetra district, Haryana sourced from Landsat 8 imagery for February 2020.

Kurukshetra District has been taken to perform analysis of present day LULC, as it comprises both high agricultural and growing urban areas, road networks, educational and spiritual centres with the land getting more competitive day by day. The district is situated in the fertile Indo-Gangetic alluvial plain with its area being more flat land conducive to farming.

Satellite studies have already proved the agricultural nature of Kurukshetra. A district-level study of Landsat in February 2020 indicated Cropland 58.89percent, Bare Land 34.54percent, Built-up Area 3.64percent, Vegetation 2.22 percent and Water Bodies 0.70 percent. It must be pointed out here that most of the land classified as Bare, is actually used for ploughed / harvested agricultural fields and not permanently barren terrain. Also, the studies carried out for Shahabad, Thanesar and Pehowa showed the land to be diverse within districts, with the season (agricultural seasonality) playing a big role in its spectral character.

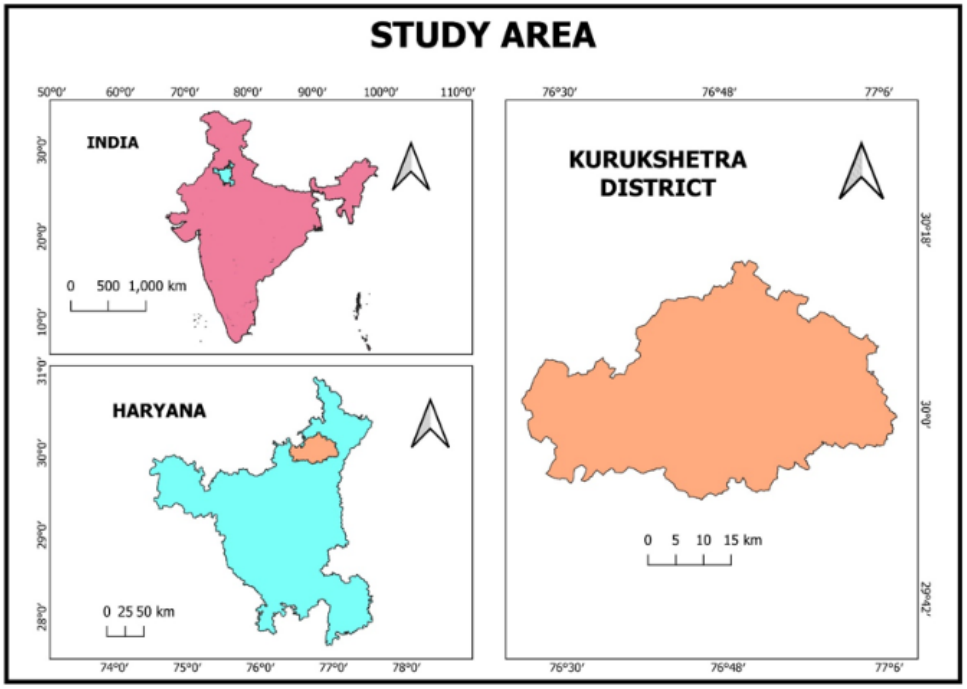
In this present study the LULC pattern of Kurukshetra district of 2024 is being mapped and assessed. The main LULC classes will be determined along with the spatial coverage and percentage share. The classification technique used will be tested for its validity and the landscape at the present time will be interpreted as it applies to land use practices in this region, agricultural activity, settlement and its application on resource management.

2. STUDY AREA

Kurukshetra District is in the north-east of Haryana in the Indo-Gangetic alluvial plain. Its reported geographical area is about 1,676 km2 while the rasterised analytical area employed in the current study is 1,676.1375 km2 The largely flat land, fertility of the alluvial soils and the good irrigation, has led to intensive agriculture, with wheat and paddy forming the main aspects of the cropping system; groundwater a significant source of irrigation.

The main built-up area is represented by the Kurukshetra-Thanesar urban complex, with Shahabad, Pehowa, Ladwa and a whole series of villages as part of the wider settlement system. The area has significant religious, cultural, administrative and educational roles. The natural factors are mainly plantations, orchards, roadside

and canal-side trees, institutional greenery, field-boundary vegetation and surface-water features represented by ponds, canals and small standing-water bodies.



3. MATERIALS AND METHODS

3.1. SATELLITE DATA AND IMAGE PROCESSING

Landsat 8 OLI Collection 2 Level-2 Surface Reflectance data for 2024 were used. Details relating to the collection date and the ID of the Landsat product should be inserted prior to submission to the journal from the associated MTL metadata.

Six reflective bands are used, as shown below; blue (Band 2), green (Band 3), red (Band 4), Near Infrared (Band 5), SWIR-1 (Band 6) and SWIR-2 (Band 7). Thermal bands were not used in this project as the goal here was spectral classification of LULC.

The image processing was done in the software QGIS Desktop 3.40.9 using the plug-in Semi-Automatic Classification Plugin 8.5.0. Landsat imagery was clipped using the district boundary. All spatial data was in the projection WGS 84 / UTM Zone 43N (EPSG:32643).

False-colour and SWIR-sensitive composites were analysed to enhance discrimination between Cropland, Vegetation, Built-up Area and exposed soil.

3.2. CLASSIFICATION SCHEME

Five LULC categories were used.

In the case of Bare Land, special care was given in interpreting as it may look similar to bare soil such as arable fields under harvest, ploughing or in short-term fallow periods.

A few representative sample training areas were prepared for each category. The image was classified by supervised Maximum Likelihood Classification. The output was evaluated and validated against Landsat composites, and any obvious mistakes were rectified.

The 2024 satellite image, on the contrary, did not need any additional processing by means of MNDWI-based water extraction (after the standard classification and refinement) as was done in this work with 2014.

Class	LULC category	General description
1	Built-up Area	Buildings, settlements, roads and constructed surfaces
2	Cropland	Agricultural fields with identifiable cultivated cover
3	Vegetation and Tree Cover	Plantations, orchards and other non-crop tree cover
4	Water Bodies	Ponds, canals and identifiable open water
5	Bare Land	Harvested/fallow fields, exposed soil and vacant/open surfaces

3.3. THE ESTIMATION AND MEASUREMENT OF ACCURACY

For every Class area of 30 × 30 m, 900 m^2, or 0.0009 km^2 in the Landsat pixels, the following has been calculated. Where is the number of pixels of class.

A set of independent validation ROIs (not used in the training samples) were used as a measure of accuracy. These consisted of 5,381 validation pixels, where the accuracy and the precision (user's accuracy), overall accuracy and Kappa coefficients were computed by a confusion matrix.

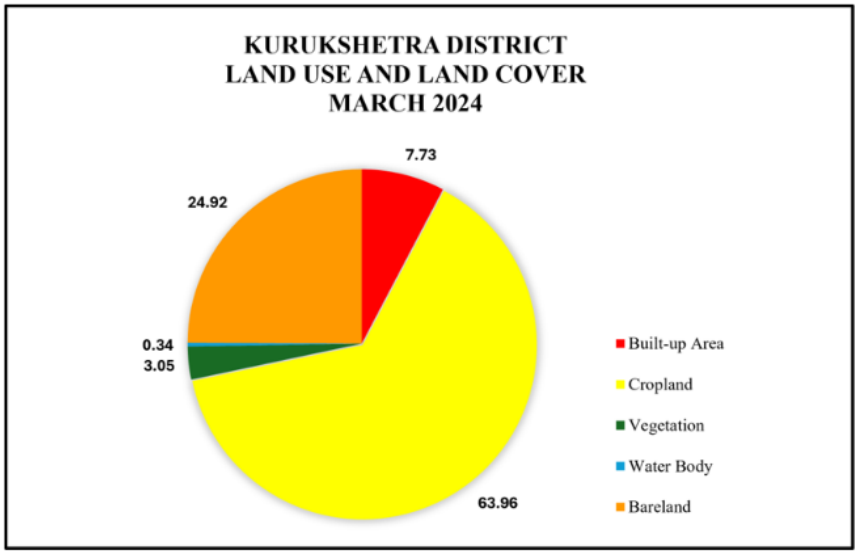
4. RESULTS

This last and final category includes 1,862,375 valid pixels and covers 1,676.1375 km2.

Table 1

Table 1 LULC distribution in Kurukshetra District, 2024

LULC category	Pixel count	Area (km^2)	Percentage
Built-up Area	1,43,947	129.5523	7.73
Cropland	11,91,170	1,072.05	63.96
Vegetation and Tree Cover	56,871	51.1839	3.05
Water Bodies	6,323	5.6907	0.34
Bare Land	4,64,064	417.6576	24.92
Total	**18,62,375**	**1,676.14**	**100**



4.1. CROPLAND

Cropland is the most prominent LULC category of the area (1,072.05 km2 or 63.96 percent), it spreads widely in the district because it is suitable for cultivation due to its flat fertile nature. It extends over a wide stretch of the study area, except along the villages and also along the areas with water bodies.

4.2. BARE LAND

Second on the scale was Bare Land at 417.66 km2 and makes 24.92percent. It must not be taken to mean that this percentage is permanently bare land. It may be that in an intensively cultivated area, harvested fields, temporary fallow, newly ploughed areas and so on, also feature in the Bare Land category.

As with previous work relating to Kurukshetra, the study illustrates the important impact a harvesting period has on the proportion of land (especially for post harvested sugarcane crops) that would be classified as 'bare' in terms of spectral data.

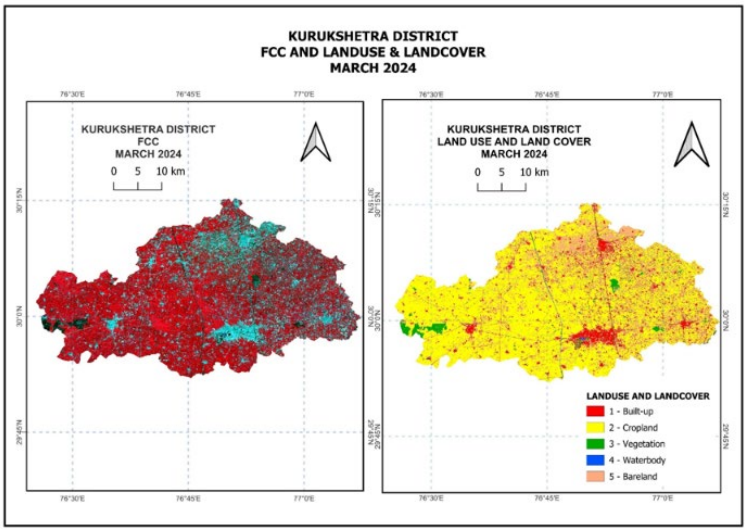
4.3. BUILT-UP AREA

This 'Built-up Area takes up 7.73 percent or 129.55 km2. Most of this is found in the townships of Kurukshetra-Thanesar, but smaller built-up areas also exist elsewhere like Shahabad, Pehowa, Ladwa and in the villages. This category includes built-up and rural construction so can be best described as Built-up or constructed surfaces.

4.4. VEGETATION AND WATER BODIES

Vegetation and Tree Cover was the land use category that accounted for 51.18 km2 or 3.05percent of land use was recorded as which includes plantations, orchards, agroforestry, roadside vegetation and institutional greenery as well as other recognisable but non-crop vegetation, it is not just natural forest.

The smallest class, which accounted for 0.34 percent that is Water Bodies occupied only 5.69 km2 of the area consisted of ponds and canals and other spectrally identifiable standing-water surfaces.



Kurukshetra District Land Use and Land Cover Map 2024

5. ACCURACY ASSESSMENT

The last one in 2024 has an Overall Accuracy of 96.88 percent and has a Kappa coefficient of 0.9406.

Table 2

Table 2 Class-wise classification accuracy

LULC category	Producer's Accuracy (percent)	User's Accuracy (percent)
Built-up Area	74.09	99.77
Cropland	99.48	99.97
Vegetation	99.28	99.89
Water Bodies	87.59	100
Bare Land	99.92	87.64

The classes Cropland and Vegetation show a good accuracy. For Water Bodies also a User's Accuracy of 100 percent was obtained, which means that the water pixels are well defined.

Built-up Area also has high User's Accuracy with a significant decrease in Producer's Accuracy. This occurred in the instance of 56 reference Built-up pixels classified as Bare Land. This is due to the spectral similarity between low-density settlements and exposed soil, especially as individual Landsat pixels contain buildings, courtyards, roads, vegetation and vacant land.

Conversely the Bare Land class had a high Producer's Accuracy but a relatively low User's Accuracy because some Built-up pixels were also classified as Bare Land.

6. DISCUSSION

The 2024 classification clearly confirms that Kurukshetra remains predominantly agricultural. Cropland alone accounted for almost two-thirds of the district. When the substantial Bare Land component is also considered, agricultural and exposed surfaces dominate the contemporary landscape.

However, it should be noted that interpretation of the relationship between Cropland and Bare Land should not be taken as a simple land conversion. Earlier study on Kurukshetra had observed 58.89 percent Cropland and 34.54 percent Bare Land in February 2020 which was compared to 63.96 percent Cropland and 24.92 percent Bare Land, in the current 2024 classification. This should not be interpreted literally as simple land conversion, as satellite acquisition conditions and crop phenology can affect the spectral appearance of agricultural fields.

It can be classified as either Cropland or Bare Land according to whether or not the land is under growth of vegetation, an issue of particular significance in intensively cultivated districts. (land cover vs land use)

The Built-up share of 7.73 percent has significant geographical implications too. Built-up surfaces in the Kurukshetra-Thanesar urban complex and all over the towns, villages, other institutions and areas developing along transport routes, may lead to the fragmentation of agricultural ecosystems.

The class statistics also show the low percentages for Non-crop Vegetation and open Water Bodies. Vegetation constitutes 3.05percent of the whole area, but tree cover has a role in agroforestry, shade and ecological connectivity, as well as helping improve landscape quality. Water Bodies represent 0.34 percent of the area, but

village ponds and canals do provide functions like drainage and irrigation, as well as other environmental functions in their own right.

The high Overall Accuracy is a good indicator of the reliability of the results for district level mapping. However, Landsat's 30 m resolution does restrict the accuracy of mapping in certain instances roads too narrow, small ponds, trees individually spaced, and houses. The high level of error between Built-up and Bare Land shows the benefit of higher-resolution imagery for detailed settlement mapping.

The implications here that affect planning, are the following such as productive agricultural land should continue to be the focus of land-management policy as most the land area is used for Cropland (i.e. productive farming). This suggests that Bare Land should not be assumed to be vacant land waiting for development as parts of an area may continue to support farming. Lastly, it implies that areas earmarked for development should be considered for spatial efficiency to avoid unnecessary fragmentation of the land.

So, the map for 2024 is not only a land-cover inventory, but also a modern baseline for future LULC changes.

7. CONCLUSION

The current LULC pattern of Kurukshetra District was mapped on using Landsat-8 (OLI) imagery and GIS techniques for the year -2024. Five major classes were identified in the study area which was 1,676.14 km2.

The major land use/cover in the study area is Cropland (63.96 percent) followed by Bare Land (24.92 percent), Built-up Area (7.73 percent), Vegetation and Tree Cover (3.05 percent), and Water Bodies (0.34 percent).

The classification produced an Overall Accuracy of 96.88 percent and a Kappa coefficient of 0.9406, both showing that the results for analysis on a district scale are reliable (the main classification problem remaining is between Built-up Area and Bare Land).

The results show that Kurukshetra has a mainly agrarian essence, including a significant built-up element which varies in space; however, the Bare Land category must be interpreted with caution, as it includes large areas of harvested and fallow farmland.

The research supplies an accurate geospatial analysis for 2024 about Agricultural Land, Vegetation, Water Bodies and Settlement growth that can be compared to. For the future, using other seasons of Sentinel-2 imagery alongside a higher-resolution dataset would make even finer distinctions possible e.g. vacant land, plantations, Built-up functions and crop conditions.

CONFLICT OF INTERESTS

None .

ACKNOWLEDGMENTS

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