Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 12 ~ Issue 3 (March 2026) pp: 31-36
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Estimation of Land Use Land cover (LULC) Change Detection analysis using Sentinel 2a datasets of Maharajganj district for year 2017 and 2025 by Remote Sensing & GIS

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ABSTRACT
Land is a crucial natural asset that sustains human life, maintains ecological equilibrium, and fosters economic growth. Analyzing Land Use and Land Cover (LULC) offers vital understanding of the ways in which land resources are used and altered over time due to both natural and human-driven influences. The Maharajganj district, situated in the Tarai region of Uttar Pradesh, features mainly agricultural landscapes shaped by fertile soils, conducive climatic conditions, and rising population pressure. The regional distribution of land use and land cover patterns in the Maharajganj district are investigated in this study. The analysis is done through remote sensing based studies. Bare Ground, forests, range land, and built-up regions are other land use categories that have gradually changed as a result of infrastructure development, urban growth, and environmental shifts. Significant LULC changes have been seen during the past few decades, mostly due to human interventions, agricultural intensification, and population growth, which have an effect on the local environment and climate. The Sentinel-2a data is used in the study of 10m resolution (cell size). The data is used is of year 2017 and 2025. LULC change detection analysis is calculated and discussed in the following sections. The study emphasizes the necessity of sustainable land management techniques to strike a balance between environmental preservation and development. To maximize land use, protect natural resources, and guarantee the district's long-term ecological stability, effective planning and policy interventions are crucial.

Keywords: *LULC; Land Cover; Built-up; Land management.*

I. Introduction

As the basis for human activity, ecological processes, and economic development, land is one of the most important natural resources. Understanding how land resources are used and how they change over time due to both natural and human interventions is greatly aided by the study of land use and land cover (LULC). While land cover refers to the physical and biological cover of the earth's surface, including flora, water bodies, and populated areas, land use refers to how humans use land for purposes like agriculture, settlement, and industry. The rich Tarai region includes the Maharajganj district, which is situated along the Indo-Nepal border in northeastern Uttar Pradesh. The district is ideal for agricultural activities due to its low topography, alluvial soil, high groundwater availability, and humid subtropical climate. As a result, a significant section of the population depends on agriculture for their living, which dominates the region's land use pattern. Due to significant population increase, agricultural land expansion, urbanization, and infrastructure development, the district has seen discernible changes in land use and land cover in recent time. Soil degradation, deforestation, biodiversity loss, and altered hydrological patterns are some of the major effects of these changes on environmental sustainability. In order to comprehend spatial patterns, spot trends, and evaluate how human activity affects natural resources, it is crucial to analyze LULC dynamics.

It is now simpler to precisely and effectively monitor and analyze LULC changes thanks to developments in geospatial technology like remote sensing and geographic information systems (GIS). Better planning and decision-making are made possible by these technologies, which offer trustworthy data for mapping, classification, and change detection throughout time. The purpose of this study is to investigate the Maharajganj district's land use and land cover pattern, identify the main land use groups, and look at changes over time. It is

anticipated that the results of this analysis would help formulate policies for balanced regional growth and contribute to sustainable land resource management.

II. Methodology and Materials

2.1 Study Area

Maharajganj district is located in the northeastern part of Uttar Pradesh, along the Indo-Nepal border. It lies between approximately 26.5°N to 27.2°N latitude and 83.0°E to 83.8°E longitude. The district shares its northern boundary with Nepal and is bounded by Gorakhpur district and Kushinagar district to the south and east. The area has good soils and a flat topography, making it a component of the alluvial plains. There is a lot of monsoonal rainfall and a humid subtropical climate. Rivers such as the Rapti dominate the drainage system. The majority of the land is used for agriculture, and settlement areas are expanding. The district was chosen for this study because of its agricultural significance and dynamic changes in land usage.

Fig- Study Area

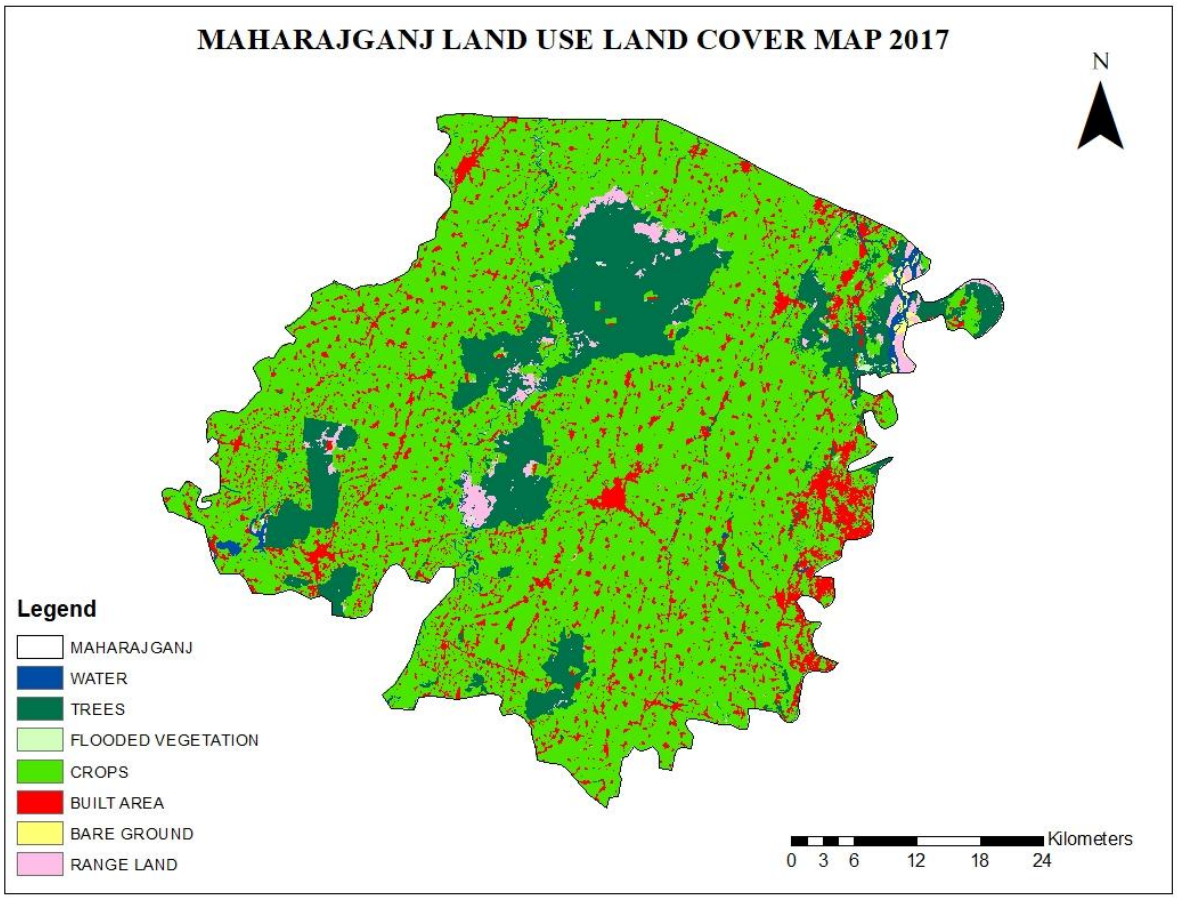
2.2 Data and Software used

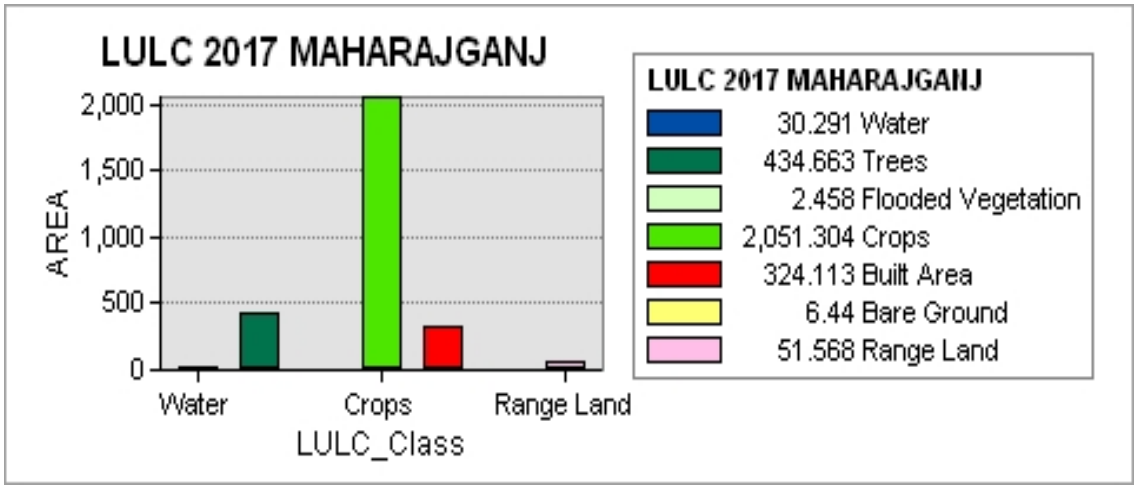
Satellite imagery from **Sentinel-2a** was used for LULC analysis. The data has a spatial resolution of 10 meters and was acquired for the year 2017 & 2025. The imagery was obtained from the **Copernicus Data Space Ecosystem** European Space Agency (ESA). Administrative boundary data for Maharajganj district was obtained from government sources. Topographic information was referenced from Survey of India maps. Ground truth data was collected through field surveys to validate land use classes. Spatial analysis, Image processing and classification and map preparation were carried out using ArcGIS software.

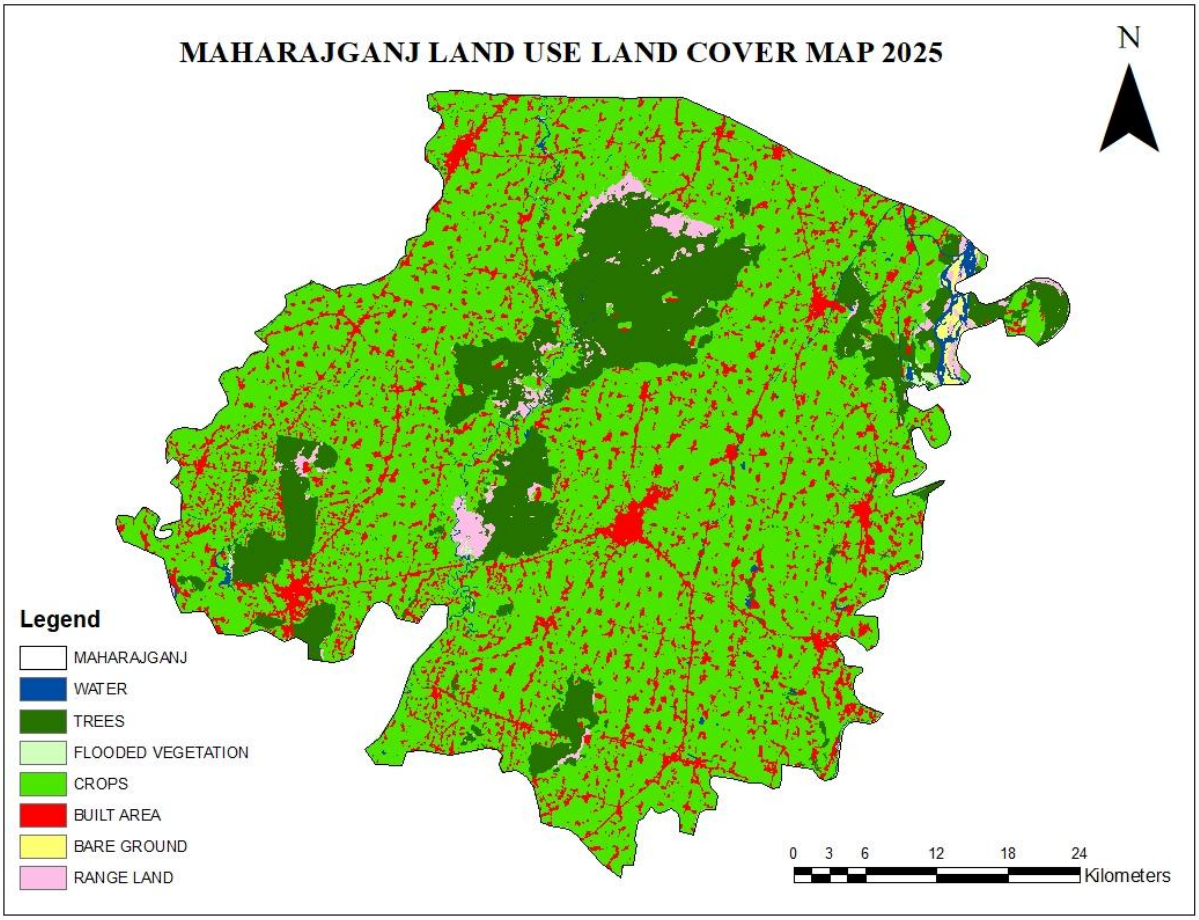
2.3 Methodology

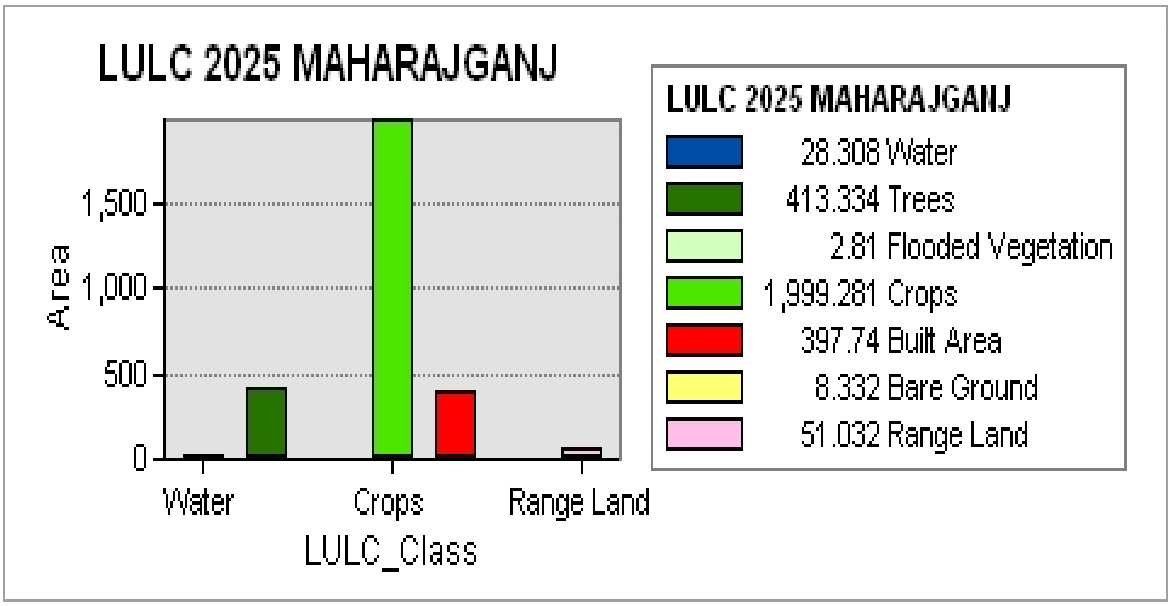
The study is done using Remote Sensing and GIS techniques to analyze land use and land cover of Maharajganj district, Uttar Pradesh. Satellite imagery from Sentinel-2a was obtained from the Copernicus Data Space Ecosystem European Space Agency (ESA) for the year 2017 & 2025. Administrative boundary data was also collected for the study area.

The acquired imagery was pre-processed using ArcGIS software. After band stacking to produce a multispectral image, the study area boundary was clipped. Extract by mask from Spatial analysist tool is used to perform classification to classify the image into different land use categories such as crop (agriculture), built-up land, water bodies, and vegetation, trees (forests), bare ground, range land, etc.


MAHARAJGANJ LAND USE LAND COVER MAP 2017
N
Legend
MAHARAJGANJ
WATER
TREES
FLOODED VEGETATION
CROPS
BUILT AREA
BARE GROUND
RANGE LAND
Kilometers
0 3 6 12 18 24


LULC 2017 MAHARAJGANJ
AREA
2,000
1,500
1,000
500
0
Water
Crops
Range Land
LULC_Class
LULC 2017 MAHARAJGANJ
30.291 Water
434.663 Trees
2.458 Flooded Vegetation
2,051.304 Crops
324.113 Built Area
6.44 Bare Ground
51.568 Range Land





III. Result and Discussion

Table showing the Area of LULC Class of 2017 Year

LULC CLASS	VALUE	AREA (sq.km)
Water	1	30.291
Trees	2	434.663
Flooded Vegetation	4	2.458

Crops	5	2051.304
Built Area	7	324.113
Bare Ground	8	6.44
Range Land	11	51.568

Table showing the Area of LULC Class of 2025 Year

LULC CLASS	VALUE	AREA (sq.km)
Water	1	28.308
Trees	2	413.334
Flooded Vegetation	4	2.81
Crops	5	1999.281
Built Area	7	397.74
Bare Ground	8	8.332
Range Land	11	51.032

Cropland dominates the landscape in both years, according to the Maharajganj district's LULC research. Crops spanned 2051.30 square kilometers in 2017; by 2025, that number had somewhat dropped to 1999.28 square kilometers. This shows that during the study period, there was a net loss of agricultural land **52 sq. km**. Forest/tree cover also declined from 434.66 sq. km (2017) to 413.33 sq. km (2025), suggesting a reduction of about **21 sq. km**. Water bodies showed a minor decrease from 30.29 sq. km to 28.31 sq. km a reduction of about **1.98 sq. km**, indicating possible seasonal variation or encroachment. On the other hand, built-up area increased significantly, from 324.11 sq. km in 2017 to 397.74 sq. km in 2025, representing an expansion of about **73.6 sq. km**. This reflects rapid urbanization and infrastructure development in the district. Other classes such as flooded vegetation and bare ground showed slight increases, while rangeland remained relatively stable with only a marginal decrease.

Table showing Change Detection Analysis (The comparison between 2017 and 2025)

LULC CLASS	Increase/ Decrease	AREA (sq.km)
Water	Slight Reduction	-1.98
Trees	Decrease	-21.33
Flooded Vegetation	Small Increases	+0.35
Crops	Decrease	-52.02
Built Area	Increase	+73.63
Bare Ground	Small Increases	+1.89
Range Land	Nearly Unchanged	-0.54

The Maharajganj district's observed alterations are indicative of common land transformation trends in quickly emerging areas. Urban sprawl and infrastructural growth are indicated by the notable rise in built-up area at the expense of crops and vegetation. Because it may have an impact on rural lives and food security, the loss of agricultural land is especially significant. In a similar vein, decreased tree cover may result in changing microclimates, increased soil erosion, and biodiversity loss. Concerns regarding the sustainability of water resources are raised by the minor decline of water bodies, particularly in light of climate variability and rising demand. Overall, the findings point to human activity as the district's main cause of LULC change. Long-term environmental effects like decreased ecological balance, elevated flood risk, and land degradation could result if current trends continue.

IV. Conclusion

The Maharajganj district's LULC analysis shows that between 2017 and 2025, built-up areas replaced natural and agricultural landscapes. To strike a balance between development and environmental preservation, sustainable land management techniques and appropriate urban planning are required.

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