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Temporal Assessment of Surface Land Transformations Using Landsat-8 Imagery and GIS

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Abstract: ***Land use and land cover change is a key indicator of human and environmental interaction, reflecting the impact of urbanization, agriculture, and climate variability on natural resources. This study focuses on the spatio-temporal assessment of LULC transformations in Jogulamba Gadwal District, Telangana, for the period 2015 to 2024, using Landsat-8 satellite imagery and Geographic Information System (GIS) techniques. Multi-temporal images were processed through layer stacking, band composition, and supervised classification to identify five major land-cover categories: vegetation, agricultural land, built-up area, barren land, and water bodies. Accuracy assessment was performed using ground-truth data and confusion-matrix validation. The results revealed a notable increase in vegetation and barren land, primarily due to rapid urban expansion and agricultural conversion. Water bodies showed slight temporal fluctuations linked to rainfall variation. The analysis demonstrates the value of integrating satellite imagery and GIS for monitoring land-use dynamics and supports sustainable resource-management planning in semi-arid regions of Telangana.***

Keywords: Land Use, Land Cover, Landsat-8, Remote Sensing, GIS, Spatio-Temporal Analysis, Jogulamba Gadwal District

I. INTRODUCTION

Land use and land cover (LULC) are essential parameters for understanding the interaction between human activity and the natural environment. Monitoring LULC variations provides critical insights into how land resources are utilized and transformed over time due to agricultural intensification, urban expansion, and population growth. These transformations directly influence hydrological balance, ecosystem stability, and the overall sustainability of regional development. In recent decades, semi-arid regions such as Telangana have experienced rapid land-use changes driven by increasing population pressure, infrastructure development, and changing agricultural practices. These changes often result in the conversion of fertile agricultural areas and vegetated land into built-up or barren surfaces, leading to reduced infiltration, higher surface runoff, and local climatic alterations. Assessing such spatial and temporal variations helps decision-makers to evaluate the long-term implications of land-use conversion and to design sustainable land and water-management strategies.

Remote Sensing (RS) and Geographic Information System (GIS) technologies have emerged as powerful tools for identifying, quantifying, and mapping LULC changes at various spatial and temporal scales. Satellite imagery, particularly from Landsat missions, provides consistent, multi-temporal data suitable for environmental monitoring. Through digital image processing techniques—such as layer stacking, band composition, and supervised classification—LULC categories can be accurately delineated and compared across different time periods.

This study aims to analyse the spatio-temporal transformations of LULC in Jogulamba Gadwal District, Telangana, during the period 2015–2024. The analysis utilizes multi-temporal Landsat-8 imagery integrated within a GIS environment to identify key land-cover classes, including vegetation, agricultural land, built-up area, barren land, and water bodies. By comparing classified images from different years, the study evaluates the magnitude and direction of land-cover transitions. The findings are expected to support sustainable urban and agricultural planning by providing a scientific basis for understanding ongoing landscape dynamics in one of Telangana's semi-arid districts.

II. OBJECTIVES OF THE STUDY

To classify and map the Land Use and Land Cover (LULC) of Jogulamba Gadwal District for the years 2015 and 2024 using multi-temporal Landsat-8 data and GIS tools.

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III. STUDY AREA

The study was conducted in Jogulamba Gadwal District, located in the southern part of Telangana State, between 15°50′ N to 16°21′ N latitude and 77°29′ E to 78°15′ E longitude, covering an area of about 2,575.5 km². The district shares boundaries with Kurnool to the south, Narayanpet to the west, Wanaparthy to the east, and Raichur to the north. It experiences a semi-arid climate with an average annual rainfall ranging from 600 to 800 mm, mostly received during the southwest monsoon. The terrain is generally undulating with red sandy loam and black cotton soils, supporting agricultural activities as the main livelihood. In recent years, rapid urban expansion, agricultural intensification, and infrastructure development have resulted in significant land-use changes, making Jogulamba Gadwal District an ideal region for spatio-temporal analysis of Land Use and Land Cover using Landsat-8 imagery and GIS techniques.

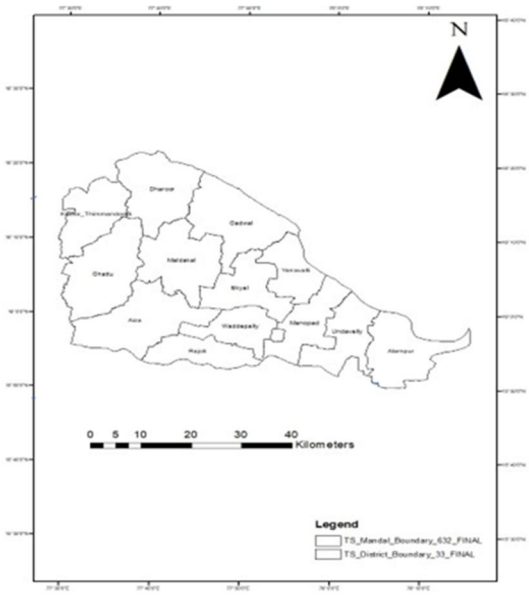

Fig.1 Location map of the study area

IV. METHODOLOGY

A. Data Collection

Landsat-8 Operational Land Imager (OLI) satellite data for the years 2015 and 2024 were obtained from the United States Geological Survey (USGS) Earth Explorer. The images selected had a 30-meter spatial resolution and less than 10% cloud cover to ensure high-quality analysis.

B. Image Pre-Processing

All satellite images were processed entirely in ArcGIS 10.8. The preprocessing steps included layer stacking, atmospheric correction, and sub-setting to extract the study area. A False Color Composite (FCC) was created using bands 5 (Near Infrared), 4 (Red), and 3 (Green) to enhance the visualization of vegetation, water bodies, and built-up areas.

C. Land Use and Land Cover Classification

Supervised classification was performed in ArcGIS using the Maximum Likelihood Classification (MLC) algorithm. The study area was categorized into five major LULC classes: agricultural land, vegetation, built-up area, barren land, and water bodies.

D. Map Preparation and Analysis

The final classified images were symbolized, labelled, and converted into thematic LULC maps within ArcGIS. Area statistics for each category were computed using spatial analysis tools to determine the extent of each land-cover type. The prepared maps visually depict the spatial distribution of land-cover features within the study area, providing a clear understanding of the region's land-use pattern for the selected years.

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V. RESULTS AND DISCUSSION

Fig 2 represents the Land Use and Land Cover (LULC) map of the study area for the year 2015, derived from Landsat-8 imagery using ArcGIS.

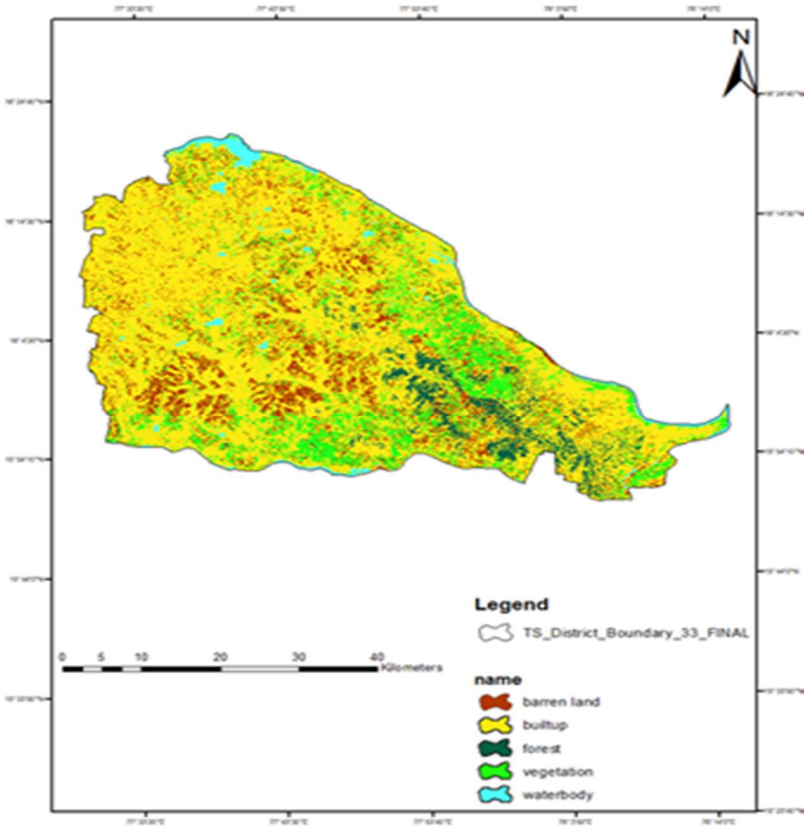

Fig: 2 Landuse landcover Map during the year 2015

The analysis shows that built-up areas covered the largest portion of the district, accounting for about 1,764.34 km², indicating that most of the land was under settlement and agricultural use mixed with habitation. Vegetation occupied around 320.98 km², mainly concentrated in the southern and central parts, supported by seasonal rainfall and favourable soil conditions. Barren land extended to 317.58 km², primarily in the western and upland regions characterized by rocky terrain and limited cultivation. Forest area occupied about 110.33 km², located mostly along hill slopes and stream corridors, while water bodies accounted for around 58.93 km², appearing as small tanks, ponds and reservoirs scattered throughout the district. The overall landuse landcover pattern indicates that the study area is predominantly an agricultural and vegetative landscape, with moderate built-up development and small proportions of forest and water resources.

Figure 3 displays the Land Use and Land Cover (LULC) map of the study area for the year 2024, prepared using Landsat-8 imagery processed in ArcGIS. The results indicate significant modifications in the district's surface features over the study period. The barren land increased to approximately 696.17 km², primarily in the western and northern regions, suggesting reduced soil fertility and expansion of non-productive areas. The built-up area measured around 1,090.15 km², indicating stable urban development concentrated in and around major settlements such as Gadwal and Alampur mandals. Vegetation declined to about 527.58 km², reflecting the effects of land conversion for settlements and agricultural reduction. The forest cover recorded a slight improvement of 113.29 km², particularly along hill slopes and riverine areas, indicating some conservation and regrowth. Meanwhile, water bodies expanded to 144.98 km², which may be attributed to better rainfall distribution and water-storage measures implemented in recent years.

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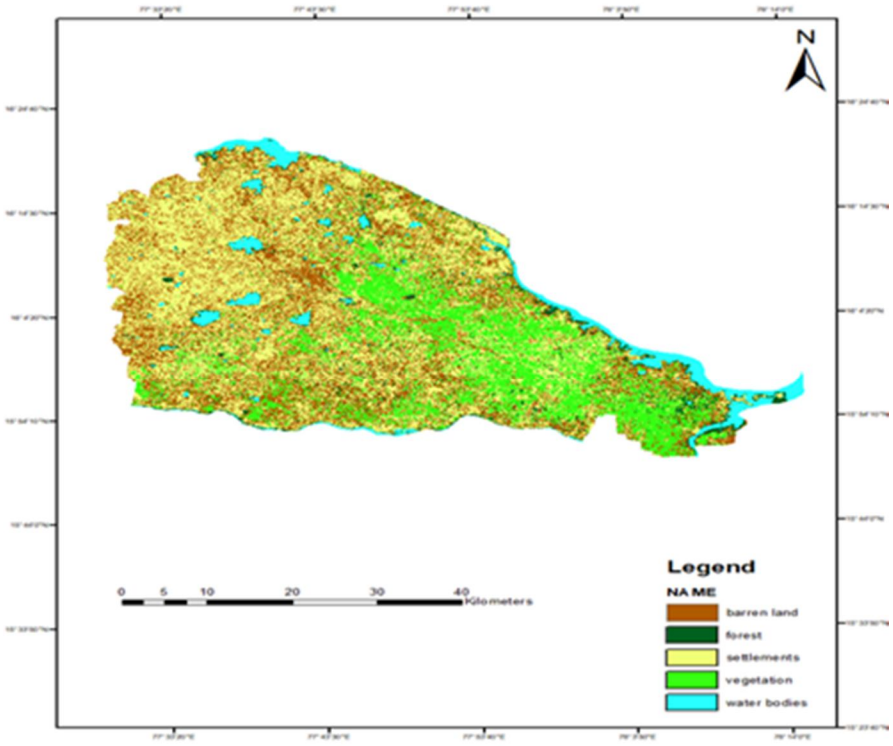

Fig. 3 Landuse landcover Map during the year 2024

The landuse landcover scenario highlights a progressive rise in barren and waterbody areas accompanied by a decline in vegetation, illustrating the ongoing transformation of land resources influenced by urban growth and climatic factors.
The quantitative summary of Land Use and Land Cover categories for the years 2015 and 2024 are represented in Table 1, which depicts their spatial distribution across the study area.

Table:1 Landuse landcover categories in the study area

Landuse landcover Classification in (km^2)	Year 2015	Year 2024
Barren land Area	317.58	696.17
Built up Area	1764.34	1090.15
Forest Area	110.33	113.29
Vegetation Area	320.98	527.58
Waterbodies	58.93	144.98
Grand total	2572.17	2572.17

The analysis reveal continuous variation in each land-cover type over the study period. In the year 2015, the study area is dominated by built-up and agricultural areas, with 1,764.34 km² of built-up land and 320.98 km² of vegetation, leaving 317.58 km² of barren surfaces. Whereas, in the year 2024, barren land increased to 696.17 km², vegetation increased to 527.58 km², and built-up area decreased to 1,090.15 km². The forest cover fluctuated between 110.33 km² to 113.29 km², while water bodies steadily increased to 144.98 km² by 2024. Overall, the tabulated data and maps together demonstrate that the study area experienced a progressive increase in barren land, waterbodies and also increase in vegetation and agricultural zones while the built up area decreased by 26% over a period of 10 years.

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VI. CONCLUSION

The analysis of landuse and landcover between 2015 to 2024 using Landsat-8 imagery and GIS revealed distinct changes in the surface features of within the study area. The district experienced a steady increase in barren land from 317.58 km² to 696.17 km² and a rise in water bodies extent from 58.93 km² to 144.98 km², indicating both land degradation and improved surface-water storage. Vegetation also increased from 320.98 km² to 527.58 km², reflecting the increase in the agricultural activities in the study area. Built-up area declined from 1764.34 km² to 1,090.15 km², representing phases of rapid development followed by saturation. Forest cover almost remained the same throughout the study area.

Overall, the district's land transformation trends suggest that urban growth, agricultural conversion and climatic variability are the major factors influencing surface-land changes. The increase in barren areas highlights the need for integrated land-use planning, afforestation and soil water conservation initiatives. The study confirms that Landsat-8 imagery integrated with GIS provides an effective and economical approach for continuous monitoring of regional land-use dynamics and supports future decision-making for sustainable land resource management in semi-arid regions of Telangana.

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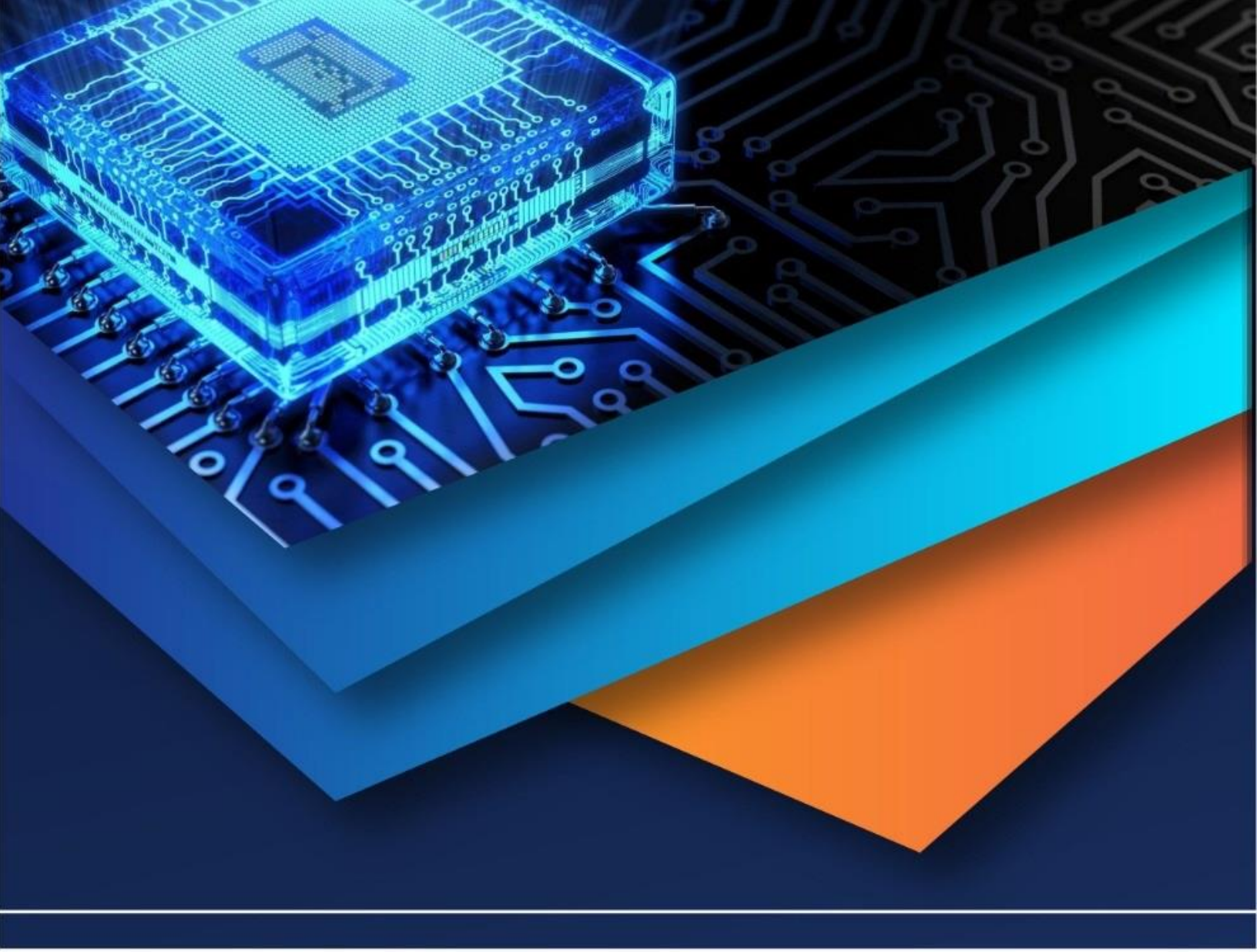

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