
SPATIO-TEMPORAL ANALYSIS OF LAND USE-LAND COVER AND NDVI CHANGES IN KURNOOL DISTRICT, ANDHRA PRADESH: USING GEOSPATIAL TECHNIQUES

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ABSTRACT

The study spatio-temporal dynamics of land use and land cover changes in Kurnool district, Andhra Pradesh, with a particular focus on the variations in the Normalized Difference Vegetation Index over time. Utilizing multi-temporal satellite imagery from Landsat 8-9 and Sentinel-2 missions the analysed LULC changes across two distinct periods 2017 and 2024. The analysis employed advanced Remote sensing techniques, including supervised classification and NDVI calculations to quantify changes in vegetation cover, agricultural land, urban expansion and other land use categories. The findings reveal significant transformations in the landscape of Kurnool district characterized by a marked increase in urban areas and a corresponding decline in agricultural land and forest cover. The NDVI analysis indicates a decrease in vegetation health and density particularly in regions experiencing rapid urbanization. This decline in NDVI values correlates with the expansion of built-up areas and the conversion of agricultural land to non-agricultural uses highlighting the pressures of urban sprawl on natural resources. The study identifies critical areas where land degradation is most prominent, providing insights into the socio-economic factors driving these changes. The results underscore the importance of sustainable land management practices to mitigate the adverse effects of LULC changes on the environment and local communities. By integrating remote sensing data with socio-economic analysis, this research contributes to a deeper understanding of the interplay between human activities and

environmental changes in Kurnool District. The outcomes of this study are essential for policymakers and urban planners aiming to develop strategies for sustainable land use that balance development needs with environmental conservation.

KEYWORDS: LULC, RS, GIS & NDVI.

INTRODUCTION

The rapid transformation of land use and land cover patterns, driven by urbanization, agricultural expansion, and environmental changes, has significant implications for ecological balance and sustainable development. In Kurnool district, Andhra Pradesh, these changes are particularly pronounced due to its unique geographical and climatic conditions. The integration of geo-informatics, including remote sensing and Geographic Information Systems, provides a powerful framework for analysing these spatio-temporal dynamics. By employing advanced analytical techniques, researchers can effectively monitor and assess the alterations in land cover types, which are crucial for informed decision-making in land management and environmental conservation.

The Normalized Difference Vegetation Index serves as a vital indicator for evaluating vegetation health and land cover changes over time. By analyzing NDVI trends alongside LULC changes, this study aims to uncover the relationships between human activities and ecological responses in Kurnool district. Understanding these interactions is essential for developing strategies that promote sustainable land use practices and mitigate adverse environmental impacts. This research not only contributes to the existing body of knowledge on land cover dynamics but also provides valuable insights for policymakers and stakeholders involved in land resource management in the region.

Study area



The present study is carried out in the newly constituted Kurnool district of Andhra Pradesh, India, formed after the district reorganization in 2022. The district lies in the Rayalaseema region and extends between approximately 14°54' to 16°18' N latitudes and 77°09' to 78°30' E longitudes and the total geographical area of the district is 7,980 sq. km. Kurnool district is bounded by Nandyal district to the east, Anantapur district to the south, Telangana state to the west, and Karnataka state to the north. The region is characterized by a semi-arid climate, with hot summers and moderate rainfall mainly received during the southwest monsoon. The physiographic is dominated by undulating plains, rocky terrain, and isolated hill ranges, while the Tungabhadra and Hundri rivers form the major drainage systems. Agriculture is the primary livelihood, largely dependent on rainfall and limited irrigation, making the district highly sensitive to land use and land cover changes and vegetation dynamics, which are effectively analysed using remote sensing and GIS techniques (fig.1).

Objectives

- To study land use and land cover utilization from 2017 to 2024 using Sentinel -2 data
- To analysis healthy vegetation using NDVI from 2017 to 2024 with Landsat 8-9 data

METHODOLOGY

The research employs a methodical strategy for gathering and preparing satellite imagery data. Initially, Sentinel-2 data will be sourced for the study area, covering the years 2017 to 2024, available through the Copernicus Open Access Hub or other satellite data sources. It is essential to choose cloud-free images that correspond to the same seasons to maintain consistency in the analysis. Likewise, Landsat 8-9 imagery will be collected for the same period from platforms such as the USGS Earth Explorer, with an emphasis on acquiring cloud-free images. After data collection, the pre-processing stage will involve atmospheric correction using algorithms specific to Sentinel-2 and Landsat 8-9, aimed at eliminating atmospheric influences and improving image quality. Furthermore, geometric correction will be conducted to ensure that all images are accurately aligned to a unified coordinate system, enabling dependable analysis.

Software used: ArcGIS 10.3 and M.S. office

RESULT AND DISCUSSION

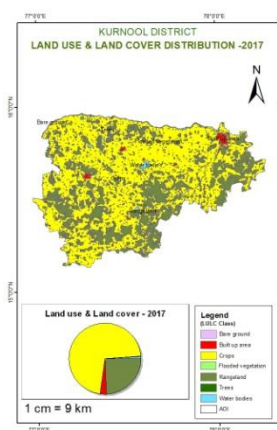


Fig: 2

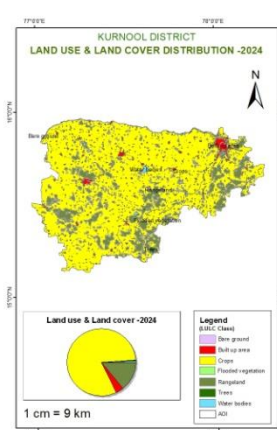


Fig:3

Table: 1

Land use & Land cover Distribution – 2017.

Sl.No	Name of the Class	Area sq km	Percentage (%)
1	Water bodies	75.43	0.95
2	Trees	27.47	0.35
3	Flooded vegetation	1.52	0.02
4	Crops	5677.33	71.37
5	Built up area	217.74	2.74
6	Bare ground	5.65	0.07
7	Rangeland	1949.9	24.51

The table.1 & fig.2, presents a detailed distribution of land use and land cover for the year 2017, highlighting the various classes of land and their corresponding areas in square kilometres, as well as their percentage contributions to the total land cover. The data reveals that the predominant land use category is crops, which occupies a substantial area of 5,677.33 square kilometres, accounting for 71.37% of the total land cover. This significant proportion underscores the importance of agricultural activities in the region, indicating a landscape heavily influenced by farming practices.

In contrast, the area designated as rangeland covers 1,949.9 square kilometres, representing 24.51% of the total land cover. This suggests a considerable presence of natural grazing lands, which may play a crucial role in supporting livestock and maintaining biodiversity. The built-up area, which includes urban and developed spaces, spans 217.74 square kilometres, making up 2.74% of the total land cover. This relatively small percentage indicates that urbanization is limited in comparison to agricultural and natural land uses.

Other land cover classes include water bodies, which cover 75.43 square kilometres (0.95%), trees at 27.47 square kilometres (0.35%), flooded vegetation at 1.52 square kilometres (0.02%), and bare ground at 5.65 square kilometres (0.07%). These figures reflect the minimal extent of these land cover types, suggesting that water bodies and forested areas are not predominant features in the landscape. The low percentages of flooded vegetation and bare ground further emphasize the dominance of agricultural land use in the region.

The data presented in table.1 and fig.2 illustrates a landscape primarily characterized by agricultural land, with limited urban development and minimal representation of natural features. This distribution has significant implications for land management, environmental conservation, and agricultural policy in the region.

Table: 2

Land use & Land cover Distribution – 2024.

s.no	Name of the Class	Area sq km	Percentage (%)
1	Water bodies	65.86	0.83
2	Trees	27.49	0.35
3	Flooded vegetation	0.65	0.01
4	Crops	6423.71	80.87
5	Built up area	295.43	3.72
6	Bare ground	1.91	0.02
7	Rangeland	1128.21	14.2

The table.2 & fig. 3, presents a detailed breakdown of various land use categories within a specified area, highlighting both the total area occupied by each class and their respective percentages. The data reveals that the predominant land use type is agricultural crops, which occupy a substantial area of 6,423.71 square kilometres, accounting for approximately 80.87% of the total land cover. This significant proportion underscores the importance of agriculture in the region, suggesting that the landscape is primarily utilized for food production.

In contrast, water bodies, which include lakes, rivers, and other aquatic environments, cover an area of 65.86 square kilometres, representing only 0.83% of the total land use. This relatively small percentage may indicate limited freshwater resources or a landscape that is predominantly terrestrial. The presence of trees is minimal, with only 27.49 square kilometres (0.35%), suggesting that forested areas are scarce in this region, which could have implications for biodiversity and ecosystem services.

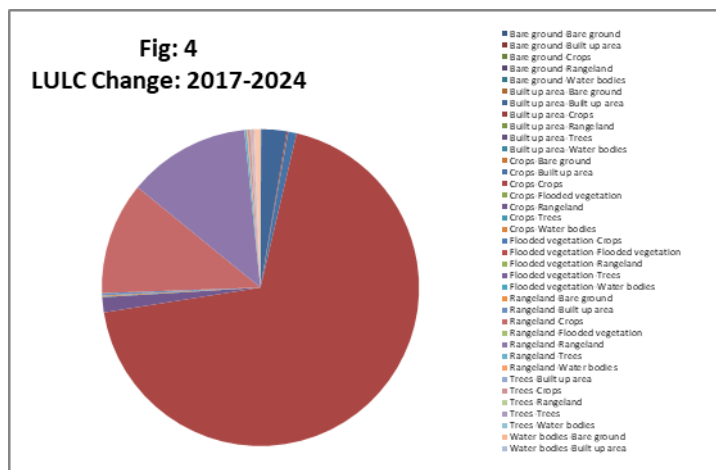
Flooded vegetation, which typically includes wetlands and marshes, occupies a mere 0.65 square kilometres, translating to 0.01%. This minimal coverage may reflect environmental conditions that are not conducive to the establishment of such ecosystems. The built-up area, indicative of urban development, covers 295.43 square kilometers, or 3.72%, highlighting a moderate level of urbanization within the landscape.

Additionally, bare ground is recorded at 1.91 square kilometres (0.02%), suggesting limited areas devoid of vegetation, while rangeland, which is essential for grazing livestock, occupies 1,128.21 square kilometres, making up 14.2% of the total land cover. This indicates a significant portion of the landscape is dedicated to pastoral activities, which may coexist with agricultural practices.

Table: 3

LULC Change Detection of Kurnool District: 2017 – 2024.

Change Detection	Area in sq km	Change Detection	Area in sq km
Bare ground-Bare ground	0.96	Flooded vegetation-Trees	0.1
Bare ground-Built up area	0.92	Flooded vegetation-Water bodies	0.02
Bare ground-Crops	1.77	Rangeland-Bare ground	0.3
Bare ground-Rangeland	1.48	Rangeland-Built up area	19.41
Bare ground-Water bodies	0.52	Rangeland-Crops	910.9
Built up area-Bare ground	0.05	Rangeland-Flooded vegetation	0.36
Built up area-Built up area	205.97	Rangeland-Rangeland	992.89
Built up area-Crops	10.3	Rangeland-Trees	18.22
Built up area-Rangeland	1.27	Rangeland-Water bodies	7.15
Built up area-Trees	0.02	Trees-Built up area	0.08
Built up area-Water bodies	0.12	Trees-Crops	19.45
Crops-Bare ground	0.16	Trees-Rangeland	2.66
Crops-Built up area	68.82	Trees-Trees	5.27
Crops-Crops	5473.12	Trees-Water bodies	0.01
Crops-Flooded vegetation	0.13	Water bodies-Bare ground	0.41
Crops-Rangeland	122.05	Water bodies-Built up area	0.58
Crops-Trees	3.77	Water bodies-Crops	16.76
Crops-Water bodies	8.61	Water bodies-Flooded vegetation	0.17
Flooded vegetation-Crops	0.78	Water bodies-Rangeland	8.12
Flooded vegetation-Flooded vegetation	0	Water bodies-Trees	0.11
Flooded vegetation-Rangeland	0.61	Water bodies-Water bodies	49.26



The distribution of land use and land cover in 2024 reflects a landscape heavily dominated by agricultural activities, with limited representation of natural ecosystems such as forests and wetlands. This distribution raises important considerations for land management, conservation efforts, and sustainable development in the region.

The table.3 & fig.4, presents a comprehensive analysis of land use and land cover change detection in Kurnool district over a seven-year period from 2017 to 2024. It categorizes the transitions between various land cover types, providing insights into the dynamics of land use in the region. The data is expressed in square kilometres, illustrating the extent of change between different land cover categories.

A significant finding from the table is the stability of certain land cover types, particularly the "Crops-Crops" category, which accounts for a substantial area of 5,473.12 sq km. This indicates a strong continuity in agricultural practices within the district, suggesting that crop cultivation remains a dominant land use. In contrast, the "Rangeland-Crops" transition shows a notable area of 910.9 sq km, indicating a shift from rangeland to agricultural land, which may reflect changing agricultural practices or land management strategies.

The built-up area also demonstrates considerable growth, with a transition from "Crops-Built up area" covering 68.82 sq km and "Rangeland-Built up area" at 19.41 sq km. This suggests urban expansion and development pressures in the district, potentially at the expense of agricultural and rangeland areas. The "Built up area-Built up area" category, which spans 205.97 sq km, further emphasizes the ongoing urbanization trend.

Water bodies exhibit some changes as well, with transitions such as "Water bodies-Crops" (16.76 sq km) and "Water bodies-Rangeland" (8.12 sq km), indicating interactions between

aquatic ecosystems and surrounding land uses. The presence of "Flooded vegetation" shows minimal change, with no transitions recorded to it, suggesting a stable condition for this land cover type.

The data reveals a complex interplay of land cover changes in Kurnool District, characterized by agricultural stability, urban expansion, and the dynamic nature of rangelands. These findings underscore the importance of monitoring land use changes to inform sustainable land management practices and policy decisions in the region. The insights gained from this analysis can serve as a foundation for further research into the socio-economic and environmental implications of these changes.

Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index is a widely used Remote sensing index that quantifies vegetation health and density. It is particularly valuable in the fields of agriculture, forestry, and environmental monitoring. NDVI leverages the distinct spectral reflectance properties of vegetation, particularly in the red and near-infrared (NIR) wavelengths, to assess plant health and biomass.

Calculation of NDVI: formula

$$NDVI = \frac{BAND\ 5 - BAND\ 4}{BAND\ 5 + BAND\ 4} \text{ or } \frac{NIR - RED}{NIR + RED}$$

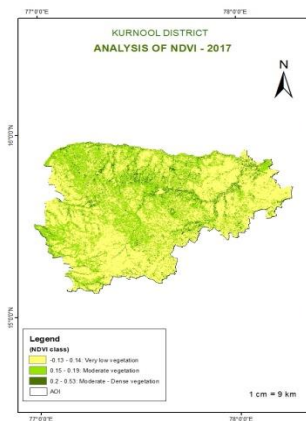


Fig:5

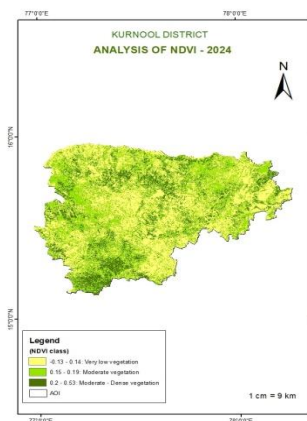


Fig: 6

Table: 4

Analysis of NDVI in Kurnool District – 2017 to 2024.

NDVI Values		Description
2017	2024	
-0.13 to 0.14	-0.3 to 0.2	Very low vegetation

0.15 to 0.19	0.21 to 0.31	Low vegetation
0.2 to 0.53	0.32 to 0.58	Moderate to Dense vegetation

The table. 4, fig. 5&6 presents a comparative analysis of the Normalized Difference Vegetation Index (NDVI) values in Kurnool District over a span from 2017 to 2024. NDVI is a widely used remote sensing index that quantifies vegetation health and density based on satellite imagery. The table categorizes NDVI values into three distinct vegetation classes: very low vegetation, low vegetation, and moderate to dense vegetation, providing insight into the changes in vegetation cover over the specified years.

In 2017, the NDVI values ranged from -0.13 to 0.14, indicating a classification of very low vegetation. This suggests that areas within this range exhibited minimal vegetation cover, potentially due to factors such as drought, land use changes, or other environmental stressors. The subsequent category, low vegetation, was represented by NDVI values from 0.15 to 0.19, indicating a slight increase in vegetation density compared to the very low category. The highest classification for 2017, moderate to dense vegetation, was observed within the NDVI range of 0.20 to 0.53, suggesting that certain areas maintained a healthier and more robust vegetation cover.

By 2024, the NDVI values had shifted, with the very low vegetation category expanding to a range of -0.3 to 0.2. This change indicates a potential decline in vegetation health or cover in some regions, which could be attributed to ongoing environmental pressures or land management practices. The low vegetation category saw an increase in its NDVI range, now spanning from 0.21 to 0.31, suggesting that some areas previously classified as very low vegetation may have experienced improvements in vegetation health. Notably, the moderate to dense vegetation category also expanded, with NDVI values ranging from 0.32 to 0.58, indicating a significant increase in vegetation density and health in certain regions of Kurnool District.

The analysis of NDVI values from 2017 to 2024 reveals dynamic changes in vegetation cover within Kurnool District, highlighting both areas of concern and improvement. These findings underscore the importance of continuous monitoring of vegetation health to inform land management and conservation strategies in the region.

CONCLUSION

The analysis of land use and land cover in Kurnool district reveals significant changes between 2017 and 2024. In 2017, agriculture was the dominant land use, occupying 5,677.33 square kilometres (71.37% of the area), with rangeland at 1,949.9 square kilometres (24.51%) and urban areas only covering 217.74 square kilometres (2.74%). Natural features like water bodies and trees were minimal.

By 2024, agricultural land increased to 6,423.71 square kilometres (80.87%), indicating a growing reliance on agriculture. Urban areas expanded to 295.43 square kilometres (3.72%), while rangeland decreased to 1,128.21 square kilometres (14.2%), reflecting a shift towards more intensive farming practices. The analysis highlights a stable crop cultivation pattern but a notable transition from rangeland to agricultural land, alongside increasing urbanization and limited natural ecosystems, raising concerns for land management and conservation.

Additionally, a comparative analysis of the Normalized Difference Vegetation Index from 2017 to 2024 shows changes in vegetation health. In 2017, NDVI values indicated very low vegetation, with ranges suggesting minimal cover due to environmental stressors. By 2024, the very low vegetation category expanded, indicating potential declines in some areas, while low and moderate to dense vegetation categories showed improvements in health and density. Overall, these findings emphasize the need for ongoing monitoring of vegetation health to guide land management and conservation efforts in Kurnool district.

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