LULC Change Detection in Drought Prone Areas of Anantapur District, Andhra Pradesh Using RS & GIS Technology

Dr. M. Karunakara Rao

Academic Consultant, Department of Geography, Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, India.

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ABSTRACT

The research or study of Land Use and Land Cover (LULC) changes in the drought-affected Anantapur District of Andhra Pradesh using Remote Sensing and GIS techniques over three time periods: 2017–2021, 2021–2024, and cumulatively from 2017 to 2024. Anantapur, located in the semi-arid region of southern India, is highly vulnerable to climatic variability and anthropogenic pressures, making it crucial to monitor landscape changes for sustainable development.

The analysis reveals significant transformations in key land cover categories. Agricultural land witnessed a substantial decline of 617.6 km² (6.12%) over the study period, raising concerns about food security and rural livelihoods. Tree cover also decreased by 46.77 km² (0.46%), indicating potential biodiversity loss. In contrast, rangelands increased by 782.64 km² (7.77%), suggesting a shift towards extensive grazing systems. Water bodies fluctuated due to climatic and human factors, resulting in a net loss of 15.92 km² (0.15%). Other land categories such as built-up areas, bare ground, and flooded vegetation also showed varying trends.

The findings highlight the dynamic nature of land use in drought-prone regions and emphasize the need for informed land management and climate-resilient policies. Remote Sensing and GIS have proven to be effective tools for tracking LULC changes and supporting decision-making for sustainable resource use in vulnerable areas like Anantapur.

Keywords: RS, GIS, Change Detection, Drought Prone & Rangeland

INTRODUCTION

Land Use and Land Cover (LULC) dynamics play a critical role in understanding the environmental and socio-economic impacts of climate variability, particularly in drought-prone regions. Anantapur District, located in the rain-shadow region of Andhra Pradesh, is one of the most drought-affected areas in India. Characterized by erratic rainfall, high evapotranspiration, and frequent agricultural distress, the district's fragile ecosystem is highly sensitive to land use changes.

Over the years, increasing human activities, agricultural expansion, groundwater exploitation, and shifting climatic patterns have significantly altered the natural landscape of Anantapur. Detecting and analyzing these changes is essential for developing sustainable land management and climate adaptation strategies. Remote Sensing and Geographic Information System (GIS) technologies offer effective tools for monitoring LULC changes over time, providing spatial and temporal insights into landscape transformation.

This study aims to assess the LULC changes in Anantapur District over two critical periods (2017–2021 and 2021–2024) and to understand the implications of these changes in the context of recurring droughts. By utilizing satellite imagery and GIS techniques, the research identifies patterns of land conversion—such as the decline in agricultural land, fluctuations in water bodies, expansion of rangelands, and loss of tree cover—offering valuable information for policymakers, planners, and environmental managers seeking to enhance resilience in the region.

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Study Area

Anantapur is an important district in Andhra Pradesh, covering an area of 10,205 square kilometers and divided into 31mandals across three revenue divisions: Anantapur, Guntakal, and

Kalyandurg. Anantapur District is located between 14° 17' and 15° 15' North Latitude and 76° 50' and 78° 13' East Longitude (Fig 1). The district is bordered to the north by Kurnool District and Bellary District in Karnataka, to the southeast by Sri SatyaSai District, to the east by YSR Kadapa District, and to the west and southwest by Karnataka. It shares borders with Kurnool and Nandyal to the north, Kadapa to the east, and Sri Sathya Sai to the south, while also neighboring Karnataka's Chitradurga and Bellary districts to the west and southwest. This district is part of the Rayalaseema region, which is known for its vulnerability to drought, requiring continuous monitoring for effective water and agricultural management. Geographically, Anantapur features a combination of black cotton soil in the north and poorer red soil in the south. It is home to two prominent hill ranges, the Mutchukota and Nagasamudram Hills, which together encompass a significant portion of the forested area. Key rivers in the district include the Penna, Chithravathi, and several others, which contribute to the region's water resources. With an average elevation of approximately 1,300 feet and an annual rainfall of about 508.2 mm, Anantapur is recognized as one of the driest districts in Andhra Pradesh.

Aims & objectives: The objective is to analyze the land use and land cover categories in 31mandals located in Anantapur District for the years 2017, 2021 & 2024 with a focus on identifying any changes that occurred during this period.

METHODOLOGY

Sentinel-2 satellite imagery for the years 2017, 2021, and 2024 was collected for the study. After acquiring the data, the Area of Interest (AOI) was extracted through digitization using administrative boundaries. Pre-processing steps, including atmospheric correction and layer stacking, were applied to the imagery. The Land Use and Land Cover (LULC) classification was then performed using various classification techniques. Post-classification, thematic LULC maps were generated for each year. The area and percentage of each LULC class were calculated and compared across the three time periods to analyze changes and trends in land use patterns.

Data used: Satellite imagery from the Sentinel-2 L1C/L2A Multispectral Instrument (MSI) was obtained from the Copernicus Open Access Hub. The images have a spatial resolution of 10 meters bands, which are utilized for land use and land cover classification as well as vegetation analysis.

Software used: ArcGIS 10.3 & MS office.

RESULT & DISCUSSIONS

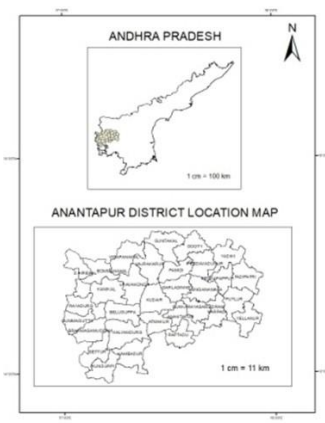
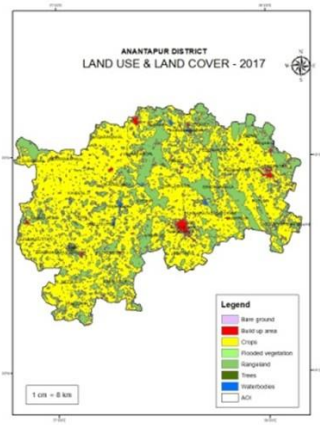


Fig:1



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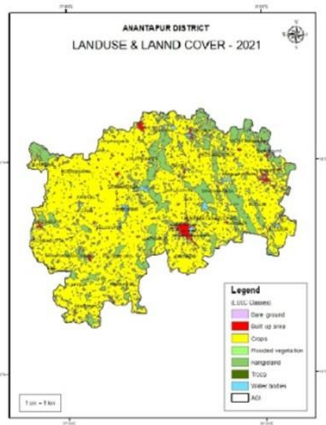

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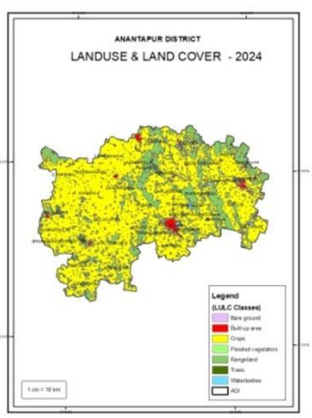

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Table: 1 Anantapur District

LANDUSE & LAND COVER – 2017

s.no	Name of classes	Area (km^2)	%
1	Waterbodies	58.04	0.58
2	Trees	37.28	0.37
3	Flooded vegetation	5.52	0.05
4	Crops	7098.51	70.42
5	Built up area	279.72	2.77
6	Bare ground	11.29	0.11
7	Rangeland	2590.59	25.7

The table 1, the land use and land cover analysis for Anantapur District in 2017 reveals a diverse distribution of various land classes, each contributing uniquely to the region's ecological and socio-economic landscape. The predominant land use category is crops, which occupies a substantial area of 7,098.51 square kilometers, accounting for approximately 70.42% of the total land cover. This significant proportion underscores the agricultural focus of the district, highlighting its reliance on crop production as a primary economic activity. In contrast, water bodies constitute a minor fraction of the land cover, with an area of 58.04 square kilometers, representing only 0.58%. This limited presence of water bodies may indicate challenges related to water availability, which could impact agricultural practices and biodiversity in the region. Similarly, trees and flooded vegetation cover minimal areas of 37.28 square kilometers (0.37%) and 5.52 square kilometers (0.05%), respectively (Fig 2).

These figures suggest that forested and wetland areas are scarce, potentially affecting local ecosystems and wildlife habitats. The built-up area, which includes urban and developed spaces, covers 279.72 square kilometers, making up 2.77% of the total land area. This relatively small percentage indicates that urbanization is not a dominant feature in Anantapur District, which may have implications for infrastructure development and population density. Additionally, bare ground is recorded at 11.29 square kilometers (0.11%), suggesting limited areas devoid of vegetation, which could be indicative of land degradation or other environmental factors. Rangeland, on the other hand, occupies a significant portion of the district, with 2,590.59 square kilometers, representing 25.7% of the land cover. This category is crucial for supporting livestock and maintaining biodiversity, reflecting the pastoral practices prevalent in the region.

Overall, the land use and land cover data for Anantapur District in 2017 illustrate a landscape heavily dominated by agricultural activities, with limited water resources and urban development, alongside significant rangeland areas that play a vital role in the local economy and ecology.

Table: 2 Anantapur District

LANDUSE & LAND COVER – 2021

s.no	Name of Class	Area (km^2)	%
1	Water bodies	136.34	1.35
2	Trees	30.44	0.3
3	Flooded vegetation	12.8	0.13
4	Crops	7945.13	78.81
5	Built up area	350.87	3.48
6	Bare ground	2.9	0.03
7	Rangeland	1602.47	15.9

The table 2, the land use and land cover data for Anantapur District in 2021 provides a detailed overview of the distribution of various land classes within the region. The table categorizes land into seven distinct

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classes, each representing a specific type of land cover, along with their respective areas in square kilometers and their percentage of the total land area.

The most significant land use category is crops, which occupies an extensive area of 7,945.13 square kilometers, accounting for approximately 78.81% of the total land cover. This dominance of agricultural land highlights the region's reliance on farming and crop production as a primary economic activity. In contrast, water bodies, which include lakes, rivers, and other aquatic environments, cover an area of 136.34 square kilometers, representing 1.35% of the total land area. This relatively small percentage indicates limited water resources in the district, which may have implications for irrigation and other water-dependent activities.

Other land cover types include rangeland, which spans 1,602.47 square kilometers or 15.9% of the area, suggesting the presence of grazing lands that support livestock. The built-up area, indicative of urbanization and infrastructure development, covers 350.87 square kilometers, making up 3.48% of the land. This reflects a modest level of urban development in the district.

Additionally, the table reveals the presence of trees, which occupy 30.44 square kilometers (0.3%), and flooded vegetation, covering 12.8 square kilometers (0.13%). These figures suggest that forested and wetland areas are minimal, potentially affecting biodiversity and ecosystem services. Lastly, bare ground is reported at 2.9 square kilometers (0.03%), indicating a very small portion of the land is devoid of vegetation.

Overall, the land use and land cover data for Anantapur District underscores the predominance of agricultural land, while also highlighting the limited extent of water bodies and forested areas. This information is crucial for understanding the ecological dynamics of the region and for planning sustainable land management practices.

Table: 3 Anantapur District

LANDUSE & LAND COVER – 2024

s.no	Name of Class	Area (km^2)	%
1	Water bodies	73.96	0.73
2	Trees	84.05	0.83
3	Flooded vegetation	2.64	0.03
4	Crops	7716.11	76.54
5	Built up area	391.15	3.88
6	Bare ground	5.15	0.05
7	Rangeland	1807.95	17.93

The land use and land cover data for Anantapur District (table-3) in 2024 reveals a diverse distribution of various land classes, each contributing uniquely to the region's ecological and economic landscape. The total area classified encompasses several categories, with the predominant land use being agricultural crops, which occupy a substantial 7,716.11 square kilometers, accounting for approximately 76.54% of the total land area. This significant proportion underscores the district's reliance on agriculture as a primary economic activity, highlighting its importance for food production and local livelihoods (Fig 3).

In addition to agricultural land, the table indicates the presence of rangeland, which covers 1,807.95 square kilometers, representing about 17.93% of the total area. This land class is crucial for supporting livestock and maintaining biodiversity, contributing to the district's pastoral economy. The built-up area, encompassing 391.15 square kilometers or 3.88%, reflects urban development and infrastructure, indicating a growing trend towards urbanization in the region.

Water bodies, including lakes and rivers, occupy 73.96 square kilometers, which is a mere 0.73% of the total area, suggesting limited freshwater resources that may impact both agricultural practices and local

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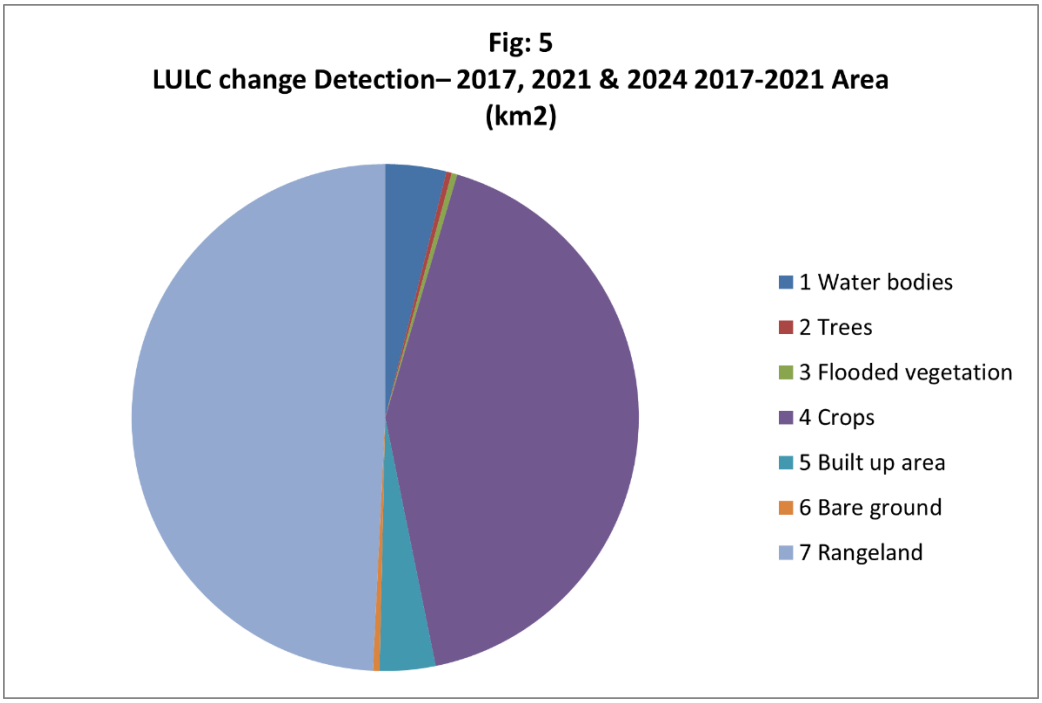
ecosystems. The presence of trees, covering 84.05 square kilometers (0.83%), and flooded vegetation, at 2.64 square kilometers (0.03%), indicates some degree of forest cover and wetland areas, although these are relatively small in comparison to other land uses. Furthermore, bare ground, which constitutes 5.15 square kilometers (0.05%), suggests areas that may be devoid of vegetation, potentially due to erosion or other land degradation processes.

Overall, the land use and land cover analysis for Anantapur District in 2024 highlights the dominance of agricultural practices, while also pointing to the need for sustainable management of natural resources to balance agricultural productivity with environmental conservation. The data serves as a critical foundation for understanding land dynamics in the region and can inform future planning and policy decisions aimed at promoting sustainable development.

Table: 4 Anantapur District

LULC change – 2017, 2021 & 2024

s.no	Name of Class	2017-2021		2021-2024		2017-2024	
		Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
1	Water bodies	-77.94	-0.77	62.38	0.62	-15.92	-0.15
2	Trees	6.84	0.07	-53.61	-0.53	-46.77	-0.46
3	Flooded vegetation	-7.28	-0.08	10.16	0.1	2.88	0.02
4	Crops	-846.62	-8.39	229.02	2.27	-617.6	-6.12
5	Built up area	-71.15	-0.71	-40.28	-0.4	-111.43	-1.11
6	Bare ground	8.39	0.08	-2.25	-0.02	6.14	0.06
7	Rangeland	987.12	9.8	-205.48	-2.03	782.64	7.77



The table 4 & Fig.5, presents a detailed analysis of land use and land cover (LULC) changes in Anantapur District over three distinct periods: 2017-2021, 2021-2024, and the cumulative change from 2017 to 2024. Each LULC class is quantified in terms of area (in square kilometers) and the percentage change relative to the previous period.

Starting with water bodies, there was a notable decrease of approximately 77.94 km² (0.77%) from 2017 to 2021, followed by a slight increase of 62.38 km² (0.62%) from 2021 to 2024. However, the overall change

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from 2017 to 2024 indicates a net reduction of 15.92 km² (0.15%). This trend suggests fluctuations in water body availability, potentially influenced by climatic or anthropogenic factors (Fig 4).

The tree cover experienced a contrasting trend, with an increase of 6.84 km² (0.07%) between 2017 and 2021, followed by a significant decline of 53.61 km² (0.53%) from 2021 to 2024. The cumulative effect over the entire period shows a decrease of 46.77 km² (0.46%), indicating a concerning reduction in forested areas that may impact biodiversity and ecosystem services.

Flooded vegetation showed a slight decrease of 7.28 km² (0.08%) from 2017 to 2021, but this was followed by an increase of 10.16 km² (0.1%) from 2021 to 2024, resulting in a modest net gain of 2.88 km² (0.02%) over the entire period. This change may reflect variations in hydrological conditions or land management practices.

In the agricultural sector, crop areas saw a significant decline of 846.62 km² (8.39%) from 2017 to 2021, followed by a recovery of 229.02 km² (2.27%) in the subsequent period. Nevertheless, the overall change from 2017 to 2024 indicates a substantial loss of 617.6 km² (6.12%), which raises concerns about food security and agricultural sustainability in the region.

The built-up area experienced a decrease of 71.15 km² (0.71%) from 2017 to 2021 and a further decline of 40.28 km² (0.4%) from 2021 to 2024, culminating in a total reduction of 111.43 km² (1.11%). This trend may reflect urban planning challenges or shifts in population dynamics.Conversely, bare ground showed a slight increase of 8.39 km² (0.08%) from 2017 to 2021, followed by a minor decrease of 2.25 km² (0.02%) from 2021 to 2024, leading to a net increase of 6.14 km² (0.06%). This change could indicate land degradation or shifts in land use practices.

Lastly, rangeland experienced a significant increase of 987.12 km² (9.8%) from 2017 to 2021, followed by a decrease of 205.48 km² (2.03%) from 2021 to 2024. The overall change reflects a net gain of 782.64 km² (7.77%), suggesting a potential shift towards more extensive grazing practices or land reclamation efforts.

In summary, the LULC changes in Anantapur District reveal a complex interplay of factors influencing land cover dynamics, with significant implications for environmental management, agricultural practices, and urban development. The data underscores the need for targeted interventions to address the challenges posed by these changes and to promote sustainable land use practices in the region.

CONCLUSION

The study of Land Use and Land Cover (LULC) changes in Anantapur District from 2017 to 2024 reveals dynamic and concerning trends. The significant decline in agricultural land and tree cover points to potential threats to food security, ecosystem stability, and biodiversity. Although rangeland expanded notably-suggesting increased reliance on extensive grazing-the reduction in water bodies and the built-up area may reflect broader climatic stress and demographic or economic shifts.

While certain categories, such as flooded vegetation and bare ground, showed marginal changes, the overall pattern underscores a landscape under pressure from both natural and anthropogenic factors. These findings highlight the urgent need for integrated land management practices, reforestation efforts, efficient water resource planning, and sustainable agricultural strategies to mitigate degradation and support resilience in this drought-prone region.Future policies must be evidence-based and community-focused to ensure long-term sustainability and adaptation to climate variability in Anantapur District.

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