GEOSPATIAL ANALYSIS OF LAND USE AND LAND COVER TRANSFORMATIONS IN THE COASTAL AREA OF VISAKHAPATNAM, ANDHRA PRADESH

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***Abstract*—Coastal areas represent vital ecosystems in which land use and land cover changes significantly influence ecological balance, economic development and community resilience. Analysis of Sentinel-2 L2A satellite imagery and Geographic Information Systems (GIS) data reveals substantial shifts in land categories, such as urban expansion, agricultural modification, and alterations in tree cover. The results indicate a marked increase in built-up areas by 207.05 km², reflecting rapid urbanization, while agricultural land decreased by 170.84 km² due to encroachment. Water bodies and flooded vegetation remained relatively stable, underscoring the importance of sustainable land management. These findings demonstrate the complex relationship between urban development and environmental conservation, providing critical insights for policymakers aiming to balance growth with ecological integrity in coastal regions. Understanding these dynamics is essential for effective coastal management and for strengthening resilience in vulnerable ecosystems.**

***Index Terms*—Coastal zone, Land use, Ecosystem, Agriculture and RS & GIS**

I. Introduction

Coastal areas are constantly changing, and shifts in land use and land cover (LULC) can affect the environment, economy, and how communities cope with change. This study looks at the geospatial aspects of LULC changes, focusing on what cause them, how they happen, and what they mean. Fast growth in cities, more industry and tourism often lead to habitat loss, more pollution and changes in water flow, which can harm biodiversity and the services ecosystems provide. Using tools like Geographic Information Systems and remote sensing the study examines both past and present land use to show how coastal landscapes change over time. By combining social and economic data with environmental information, the research identifies the main factors behind LULC changes and how they affect people living in coastal areas. Understanding these changes is important for managing coasts well and supporting sustainable development. This knowledge can help shape policies that reduce negative impacts, strengthen coastal resilience and find a better balance between human needs and protecting the environment.

II. Study Area

Visakhapatnam is bordered by the Simhachalam Hill Range to the west, the Yarada Hills to the southeast, and the Kambalakonda Wildlife Sanctuary to the northwest. These hills play a vital role in the region's ecological landscape, covering more than 621.52 km². The city, located between the Eastern Ghats and the Bay of Bengal, experiences a tropical savanna climate. It spans 682 km² and has an average elevation of 45 meters. Situated in the Coastal Andhra Region, Visakhapatnam lies between the Eastern Ghats and the Bay of Bengal coastline. It is the second-largest city on India's east coast after Chennai and the fourth largest in South India. As one of four smart cities in Andhra Pradesh under the Smart Cities

Mission, Visakhapatnam serves as the administrative center for the district. Known as the shipbuilding capital of India, the city hosts major shipyards such as Hindustan Shipyard and Naval Dockyard and houses the central naval command for the eastern coast. Visakhapatnam district, one of nine coastal districts in Andhra Pradesh, is susceptible to natural disasters and has encountered significant challenges from major calamities since independence. According to the 2011 Census, the district's population is 1.96 million, with a growth rate of 11.96%, accounting for 3.95% of the state's total population. The district covers 1,049 km², representing 0.64% of the state's total area. Climatic conditions vary across the district: coastal areas experience moist and pleasant air, inland regions are generally warmer, and hilly areas are cooler due to elevation and vegetation (fig.1).

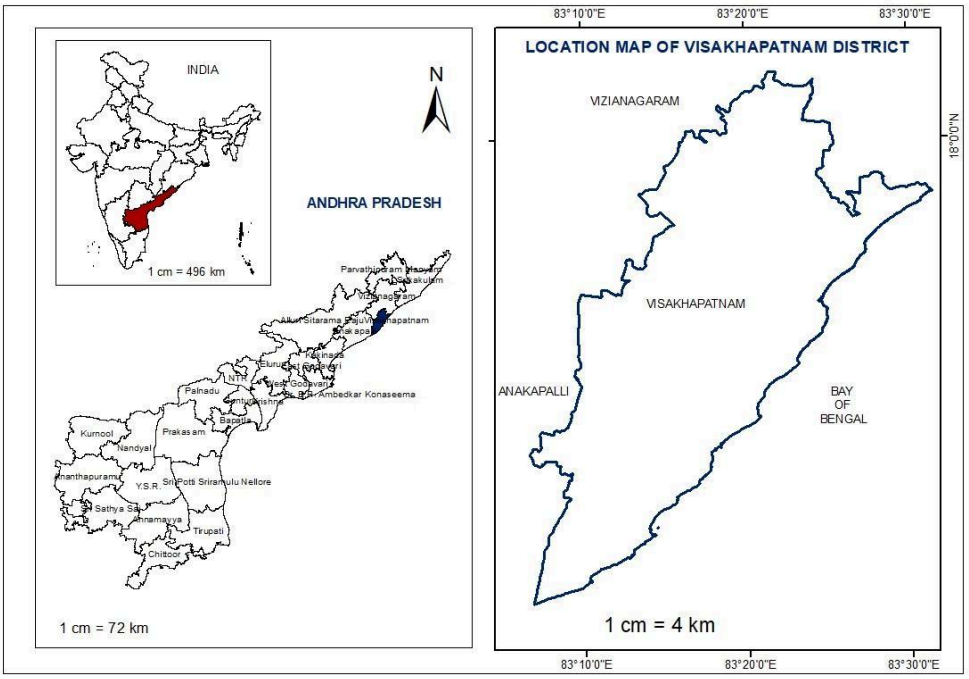


Fig:1

Research Objectives

1. To examine land utilization and changes in the coastal area between 2017 to 2025.
2. To analyze land cover changes and detect alterations in the coastal area during the period from 2017 to 2025.

Research Methodology

The methodology involved collecting secondary data from Sentinel-2 L2A (Esri) with a spatial resolution of 10 meters, covering the entire study area. Data evaluation and analysis were conducted to assess changes in land use and land cover classes. ArcGIS and statistical techniques were we used employed for this analysis. The raster data is converted to polygons after dissolving the classes and the area and percentage of the study area are calculated.

Software used: ArcGIS 10.3 & simple Statistical techniques

III. Result & Discussion

The land use and land cover change analysis for Visakhapatnam district in 2017 and 2025 reveals a diverse distribution of land categories, each contributing to the ecological and socio-economic landscape of the region. It categorizes the land into various classes, each with its corresponding area measured in square kilometers and expressed as a percentage of the total land area (fig, 2 &3 and table, 1).

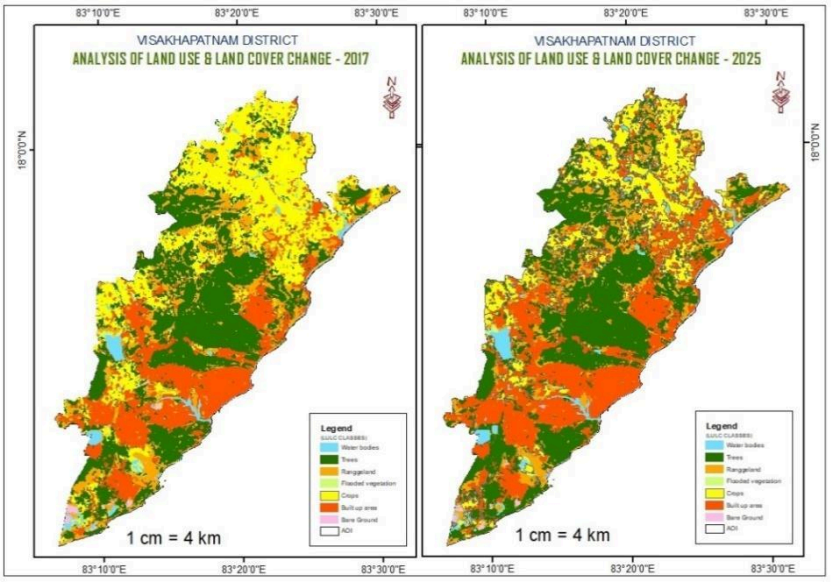


Fig:2

Fig:3

Table: 1
Visakhapatnam District
Analysis of Land use and Land cover Changes: 2017-2025

s.no	Name of Class	2017		2025	
		Area in sq.km	%	Area in sq.km	%
1	Water bodies	27.32	2.74	34.81	3.49
2	Trees	344.07	34.54	366.81	36.82
3	Flooded vegetation	3.66	0.37	3.68	0.37
4	Crops	258.29	25.93	201.79	20.26
5	Built up area	220.26	22.11	274.52	27.56
6	Bare ground	5.5	0.55	3.39	0.34
7	Rangeland	137.13	13.76	111.21	11.16

Land use and Land cover Change -2017:

Water bodies:

Even though water bodies cover only a relatively small area 27.32 square kilometers, which is 2.74% of the land they have an important ecological function since they support aquatic life and supply the essential resources needed for both irrigation and drinking water.

Tree covers:

Trees take up the greatest area, amounting to about 344.07 square kilometers, which is roughly 34.54% of the total land area. This extensive coverage of trees is important for biodiversity, for carbon sequestration, and for the regulation of the local climate.

Flooded vegetation:

The vegetation that is flooded covers only 3.66 square kilometers (0.37%) and forms a minor but significant ecological niche. Such areas are generally found in association with wetlands which offer habitat for a variety of species.

Crops/Human plantation:

258.29 square kilometers are covered by crops, which makes up 25.93 per cent of land use. This shows how important agriculture is to the district's economy and to food security.

Built up area/ Human construction:

The area that is developed, this including urban infrastructure and settlements, is 220.26 square kilometers, or 22.11% of the total land cover. This shows that there are continued pressures towards urbanization and development in the region.

Bare ground/rock/soil:

5.5 square kilometers (0.55%) are taken up by bare ground, rock, and soil, which shows areas that have little or no vegetation and could therefore be prone to erosion or other forms of land degradation.

Rangeland/Homogenous grasses:

137.13 square kilometers (13.76 per cent) are covered by rangeland and this is important for livestock grazing and for keeping pastoral livelihoods going. This analysis of land use and land cover shows the complex interaction between natural and human factors in determining the appearance of the district's landscape.

Land use and Land cover Change -2025:

Water bodies:

The area taken up by water is 34.81 square kilometers, which amounts to 3.49 per cent of the land cover. This shows that while water resources are available they are nevertheless limited when compared to other types of land use.

Tree cover:

Trees make up the biggest land cover category, covering an area of 366.81 square kilometers or about 36.82 percent of the total land area. The large amount involved shows how important forested areas are for supporting biodiversity and for contributing to carbon sequestration.

Flooded vegetation:

Only 3.68 square kilometers (0.37%) are covered by vegetation that has been flooded and this constitutes a minor but significant ecological niche. Such areas are generally found in association with wetlands which offer habitat for a variety of species.

Agriculture/Human Plantation:

The area used for crops is 201.79 square kilometers, or 20.26 per cent of the total area, which shows that agriculture is still a vital economic activity in the district and is important for food production and for the livelihoods of local people.

Built up area/ Human construction:

The area that is developed, including urban regions, amounts to 274.52 square kilometers, or 27.56% of the total land area. This indicates a high degree of urbanization, which is a sign of the district's growth and the rising demand for both infrastructure and housing.

Bare ground/ rock/soil:

3.39 square kilometers (0.34%) is the area made up of bare ground, rock, and soil, which constitutes a small amount of land cover. Such areas are either not properly used or are affected by environmental conditions that prevent their use.

Rangeland/ Homogenous grasses:

The area covered by rangeland is 111.21 square kilometers (11.16 per cent), this representing the land used for grazing livestock, a factor important for the agricultural economy.

The data show a varied pattern of land use in the Visakhapatnam district, pointing out areas that have ecological importance as well as possible difficulties relating to land management and sustainability. As the region approaches 2017 and 2025, the findings have significant implications for environmental management, urban planning, and agricultural practices. It is essential for policymakers and stakeholders who wish to achieve a balance between development and sustainability to understand these dynamics.

Analysis of Land use and Land cover Change Detection:

An examination of the changes in land use and land cover in Visakhapatnam district between 2017 and 2025 shows the various transitions that occur among the different land cover classes. The entries in (table,2) give the area changes (in square kilometers) associated with specific transitions between lands cover types, giving insights into the land-use dynamics of the area.

Table: 2
Visakhapatnam District
Land use and Land cover change Detection: 2017 to 2025

Change Detection of Classes	Area change in sq.km
Bare ground-Bare Ground	2.07
Bare ground-Built up area	1.14
Bare ground-Crops	0.34
Bare ground-Flooded vegetation	0.02
Bare ground-Rangeland	1.16
Bare ground-Trees	0.23
Bare ground-Water bodies	0.55
Built up area-Bare Ground	0.2
Built up area-Built up area	207.05
Built up area-Crops	2.49
Built up area-Rangeland	3.58
Built up area-Trees	6.7
Built up area-Water bodies	0.25
Crops-Bare Ground	0.07
Crops-Built up area	33.24
Crops-Crops	170.84
Crops-Flooded vegetation	0.32
Crops-Rangeland	18.69
Crops-Trees	28.92
Crops-Water bodies	6.18
Flooded vegetation-Bare Ground	0
Flooded vegetation-Built up area	0.02
Flooded vegetation-Crops	0.55
Flooded vegetation-Flooded vegetation	1.25
Flooded vegetation-Rangeland	0.15
Flooded vegetation-Trees	0.04

Flooded vegetation-Water bodies	1.64
Rangeland-Bare Ground	0.34
Rangeland-Built up area	20.41
Rangeland-Crops	10.16
Rangeland-Flooded vegetation	1.25
Rangeland-Rangeland	67.86
Rangeland-Trees	35.15
Rangeland-Water bodies	1.94
Trees-Bare Ground	0.13
Trees-Built up area	12.16
Trees-Crops	16.42
Trees-Flooded vegetation	0.34
Trees-Rangeland	19.09
Trees-Trees	295.29
Trees-Water bodies	0.62
Water bodies-Bare Ground	0.58
Water bodies-Built up area	0.5
Water bodies-Crops	0.98
Water bodies-Flooded vegetation	0.5
Water bodies-Rangeland	0.68
Water bodies-Trees	0.47
Water bodies-Water bodies	23.61

A clear trend is the shift from bare ground to built-up areas, which shows that the region is becoming more urbanized with a change in area of 1.14 square kilometers. This indicates a rise in urbanization in the district. On the other hand, bare ground also changed into crops, rangeland and water bodies to a smaller degree, showing that the methods of land use are becoming more varied. The largest change in the built-up area category is an increase of 207.05 square kilometers, which points to rapid urban development in the district.

The area devoted to crops changed significantly by 170.84 sq.km, indicating a steady level of agricultural activity. Yet the shifts from crops to other kinds of land cover, for example to rangeland (18.69 sq.km) and to trees (28.92 sq.km), point to a change in agricultural practices, possibly as a result of market demands or environmental factors. The land converted from crops to built-up areas (33.24 sq.km) also highlights the extent to which urban areas are advancing into agricultural land.

Flooded vegetation shows only small changes, with 1.25 sq.km still in that category, suggesting this land cover is stable. Some transitions into water bodies also suggest hydrological changes in the area. The rangeland, on the other hand, shows a great deal of transition, especially into built-up areas (20.41 sq.km) and into crops (10.16 sq.km), indicating a change in land use predicating

Tree cover remains largely unchanged at 295.29 sq.km, suggesting that forested areas have been preserved despite urban and agricultural development. Yet the figures showing transitions to built-up areas (12.16 sq.km) and crops (16.42 sq.km) show some encroachment.

Water areas show a certain level of stability, with an area of 23.61 sq.km staying the same and there being only small changes into other land cover categories. The observed changes result from complex interactions among urbanization, agricultural expansion, and environmental protection initiatives in Visakhapatnam district, underscoring the importance of sustainable land management to balance development and environmental health.

IV. Conclusion

The results reveal a diverse distribution of land categories each contributing to the region's ecological and socio-economic landscape. In 2017, tree cover was the largest land use type, occupying 344.07 square kilometers (34.54%), followed by crops at 258.29 square kilometers (25.93%) and built-up areas at 220.26 square kilometers (22.11%). Water bodies, while small, were crucial for the ecosystem, covering 27.32 square kilometers (2.74%). Other categories included rangeland (137.13 square kilometers or 13.76%) and minimal areas of bare ground (5.5 square kilometers or 0.55%).

By 2025, tree cover increased to 366.81 square kilometers (36.82%), while built-up areas expanded significantly to 274.52 square kilometers (27.56%), indicating rapid urbanization. Agricultural land decreased to 201.79 square kilometers (20.26%), and water bodies slightly increased to 34.81 square kilometers (3.49%). Rangeland decreased to 111.21 square kilometers (11.16%), reflecting shifts in land use priorities.

The analysis highlighted significant transitions, particularly the conversion of bare ground to built-up areas, indicating urban expansion. Crops experienced a notable area change, adapting to market demands and environmental conditions. The stability of tree cover amidst urban pressures suggests some preservation efforts, while water bodies showed minimal transitions, reflecting hydrological stability.

The findings underscore the complex interactions between urbanization, agriculture and environmental conservation in Visakhapatnam, emphasizing the need for sustainable land management practices to balance development with ecological integrity.

References

[1] Davis, A. M., & Slocum, T. A. (2022). "Assessing Land Use Change in Coastal Areas: A Case Study of the Gulf Coast." Journal of Coastal Research, 38(2), 345-358. DOI: 10.2112/JCOASTRES-D-21-00045.1

[2] Mastrorillo, M., & Ghosh, S. (2023). "Remote Sensing for Monitoring Land Cover Changes in Coastal Ecosystems." Remote Sensing of Environment, 270, 112-123. DOI: 10.1016/j.rse.2022.112123

[3] Kumar, L., & Singh, R. (2023). "Impact of Urbanization on Coastal Land Use Patterns: A Global Perspective." Land Use Policy, 120, 106-115. DOI: 10.1016/j.landusepol.2022.106115

[4] Zhou, Y., & Chen, J. (2023). "Evaluating the Effects of Climate Change on Coastal Land Cover Dynamics." Environmental Science & Policy, 132, 45-56. DOI: 10.1016/j.envsci.2022.09.012

[5] Smith, J. R., & Thompson, L. M. (2023). "Integrating Socioeconomic Factors in Coastal Land Use Planning." Coastal Management, 51(1), 1-20. DOI: 10.1080/08920753.2022.2101234