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RESEARCH ARTICLE

Spatiotemporal Analysis of Land Use/Land Cover Changes and Urban Growth Dynamics in Salem District, India (1985–2024): Integrating Elevation and Infrastructure Networks.

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ABSTRACT

This study examines the spatial and temporal Land Use and Land Cover (LULC) changes in the Salem district, Tamil Nadu, over nearly four decades (1985–2024). Using remote sensing data and geospatial techniques, the landscape was classified into five major categories: agriculture, built-up, barren land, forest, and waterbodies. LULC data for 1985 and 2005 were obtained from national repositories, while the 2024 classification was generated from Sentinel-2 imagery using the Random Forest algorithm within the Google Earth Engine (GEE) platform. The results reveal significant urban expansion, reduced agricultural and forest areas, and a rise in barren land. Spatial analysis indicates that urban growth is strongly associated with transportation networks and low elevation areas. These findings highlight the need for integrated land use planning and sustainable resource management to mitigate the environmental impacts of rapid urbanization.

Keywords : *Land Use and Land Cover (LULC); Urban expansion; Google Earth Engine (GEE); Random forest; Remote sensing; Salem district.*

INTRODUCTION

Land Use and Land Cover (LULC) analysis has emerged as an essential tool for understanding human-environment interactions and assessing the impact of anthropogenic activities on landscape dynamics. Rapid urbanization, agricultural intensification, deforestation, and infrastructure development significantly alter land cover and land use patterns, especially in developing countries like India (Lambin *et al*., 2003; Turner *et al*., 2007). These changes influence natural resources, environmental quality, ecosystem services, and biodiversity, demanding careful monitoring and sustainable land management (Foley *et al*., 2005; Ellis, 2011).

Remote sensing and Geographic Information Systems (GIS) offer powerful platforms to map and analyze LULC changes over time and space (Jensen, 2005). With the advent of cloud-based platforms like Google Earth Engine (GEE), the availability and processing of high-resolution satellite data have become more efficient and scalable, enabling consistent long-term assessments across various geographies (Gorelick *et al*., 2017).

This study focuses on the Salem district in Tamil Nadu, India, a region witnessing rapid demographic and infrastructural growth. Salem, known for its mixed agro-industrial economy and increasing urban

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footprint, serves as a microcosm to understand the consequences of urbanization on land resources. By analyzing LULC changes in the years 1985, 2005, and 2024, this research aims to quantify land transformations, highlight patterns of urban sprawl, and investigate the spatial correlation of urban growth with elevation and transport infrastructure. Integrating historical LULC data and advanced classification techniques such as the Random Forest algorithm offers a robust framework for multi-temporal LULC monitoring (Breiman, 2001; Pal & Mather, 2005).

MATERIALS AND METHODS

Study Area

Salem District is located in the northwestern part of Tamil Nadu, India, between latitudes 11°14'N to 12°05'N and longitudes 77°44'E to 78°50'E. The region spans approximately 5,205.30 sq. km and is characterized by a semi-arid climate, undulating terrain, and a mixture of rural and urban settlements. It serves as a key transportation and industrial hub within the state. The district includes significant physiographic features such as Shevaroy and Kolli Hills (Fig. 1).

Data Sources

- LULC data for 1985 and 2005 were obtained from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) [https://doi.org/10.3334/ORNLDAAC/1336].
- 2024 LULC classification was performed using Sentinel-2 imagery in GEE with a Random Forest algorithm.
- Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM) was used to derive elevation profiles.
- Road and railway layers were digitized from Survey of India topographic maps and OpenStreetMap datasets.

Methodology:

The 1985 and 2005 datasets were reclassified into five main LULC classes: agriculture, built-up, barren land, forest, and waterbodies. The mapping accuracy for these datasets was reported as 94.46% (Roy *et al*., 2015). The 2024 classification was executed using Random

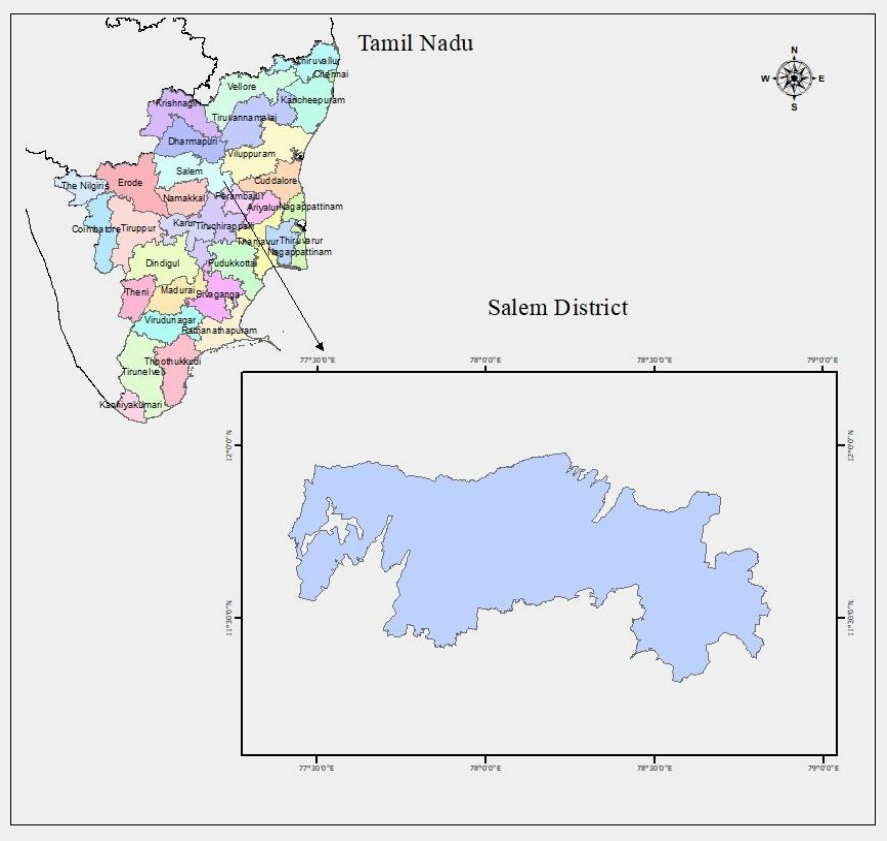

Fig. 1. Study area map of Salem District

Forest, a machine learning algorithm recognized for its high accuracy in land cover studies (Belgiu & Drăguț, 2016). The resulting classification achieved an accuracy of 92.34%.

The LULC maps for all three years were generated, verified, and compared through change detection analysis. Ancillary data, such as DEM and transportation layers, were used to evaluate elevation and proximity influences on urban growth. A flowchart of the overall methodology is presented in Fig. 2.

RESULTS AND DISCUSSION

The Land Use Land Cover (LULC) analysis between 1985, 2005, and 2024 reveals significant changes in land utilization patterns. Agricultural land showed a marginal increase of 1.11% from 1985 to 2005, followed by a substantial decrease of 10.86% by 2024. In contrast, the built-up area exhibited a consistent and steep increase, rising by 32.3% between 1985 and 2005 and surging by 223.3% between 2005 and 2024, highlighting rapid urbanization. Barren land

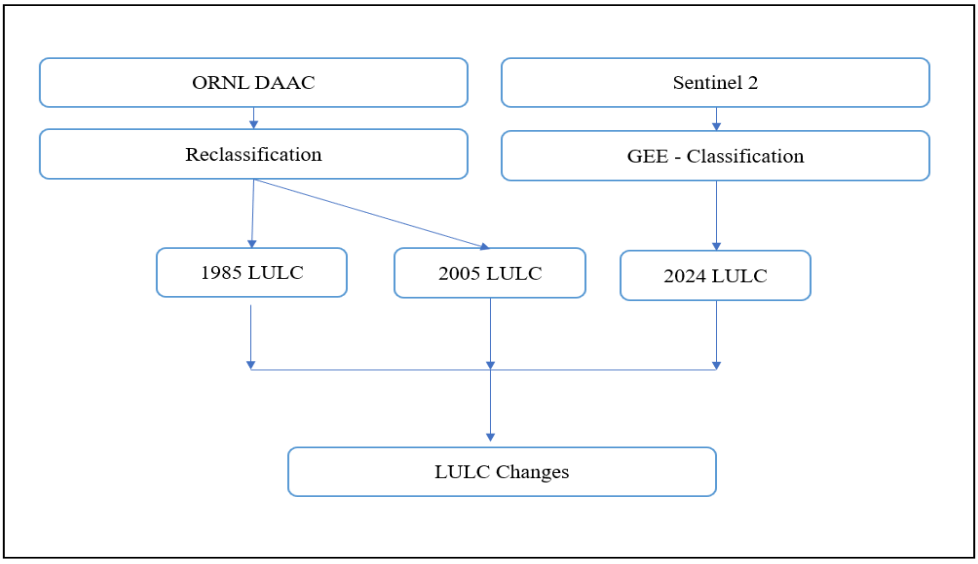

Fig. 2: Methodology flowchart for LULC classification and analysis

initially declined by 46.91% from 1985 to 2005, but then drastically rose by 4,404.78% by 2024, indicating significant land degradation or conversion. The forest cover saw a slight decline of 0.48% from 1985 to 2005 and a further 1.14% reduction by 2024, suggesting gradual deforestation. Lastly, waterbodies reduced steadily, showing a 10.81% decrease between 1985 and 2005 and another 3.52% decline by 2024. These findings reflect a trend of urban expansion and ecological loss over the decades.

Land Use Land Cover Trends

The LULC analysis between the years 1985, 2005, and 2024 reveals significant changes in land utilization patterns:

- ***Agriculture:***

Agricultural land showed a marginal increase of 1.11% from 1985 to 2005, followed by a substantial decrease of 10.86% by 2024. This decline likely reflects conversion to urban or non-agricultural uses, affecting rural livelihoods and local food security.

- ***Built-up Area:***

Built-up area exhibited steep and continuous growth, increasing by 32.3% between 1985 and 2005 and surging by 223.3% from 2005 to 2024. This results in a cumulative rise of 327.7% over the four-decade span, emphasizing the region's rapid urbanization.

- ***Barren Land:***

Initially, barren land declined by 46.91% from 1985 to 2005, potentially due to afforestation or agricultural activities. However, it increased dramatically by 4,404.8% by 2024, which may reflect land degradation, construction expansion, or resource extraction.

- ***Forest Cover:***

Forest area showed a slow and steady reduction —a 0.48% decrease from 1985 to 2005 and a further 1.14% decline by 2024. While relatively small, these losses can fragment ecosystems and impact biodiversity.

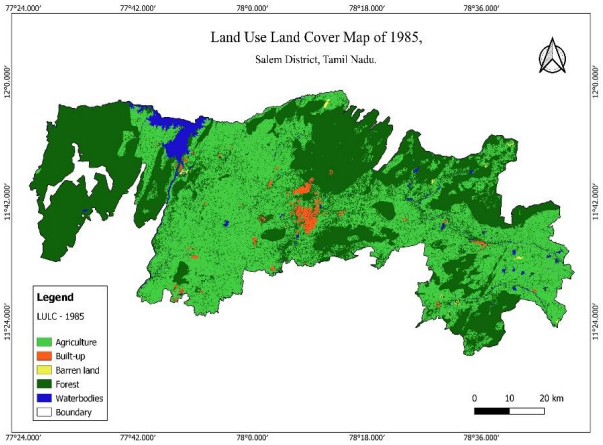

Fig. 3: 1985 LULC map of Salem

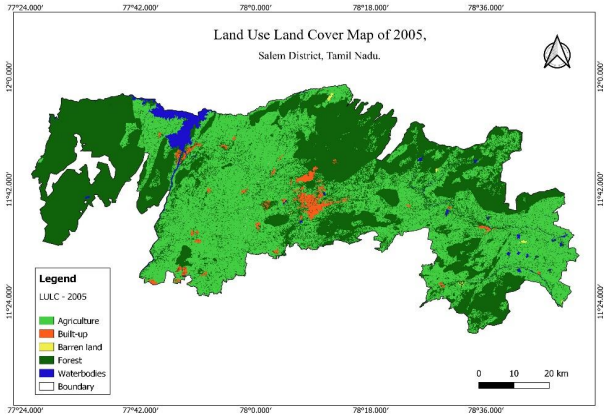

Fig. 4: 2005 LULC map of Salem

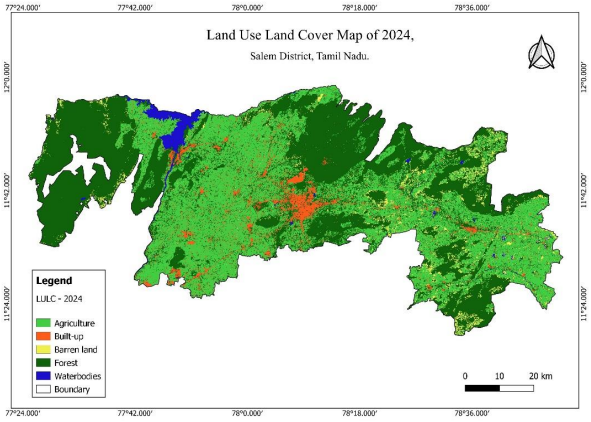

Fig. 5: 2024 LULC map of Salem

- ***Waterbodies***:

Waterbody areas declined steadily by 10.81% (1985–2005) and an additional 3.52% by 2024, likely due to encroachment, sedimentation, or climatic variability.

Influence of Elevation and Infrastructure

Further analysis using Shuttle Radar Topography Mission (SRTM) DEM data revealed that urban expansion is predominantly concentrated in low-elevation areas. The overlay of road and railway network maps with LULC maps from 1985, 2005, and 2024 demonstrates that most new built-up areas have emerged alongside these transport corridors.

Table 1. LULC area for each class, 1985, 2005, and 2024

LULC	1985 (sq. km)	2005 (sq. km)	2024 (sq. km)
Agriculture	2,715.55	2,745.85	2,447.44
Built-up	69.88	92.44	298.89
Barren land	9.46	5.02	226.18
Forest	2,989.96	2,975.61	2,941.59
Waterbodies	130.47	116.38	112.29
Total	5,205.30	5,205.30	5,205.30

Table 2. LULC change percentage-wise (1985-2005) and (2005-2024)

LULC Type	% Change (1985–2005)	% Change (2005–2024)
Agriculture	1.11%	-10.86%
Built-up	32.30%	223.30%
Barren land	-46.91%	4404.80%
Forest	-0.48%	-1.14%
Waterbodies	-10.81%	-3.52%

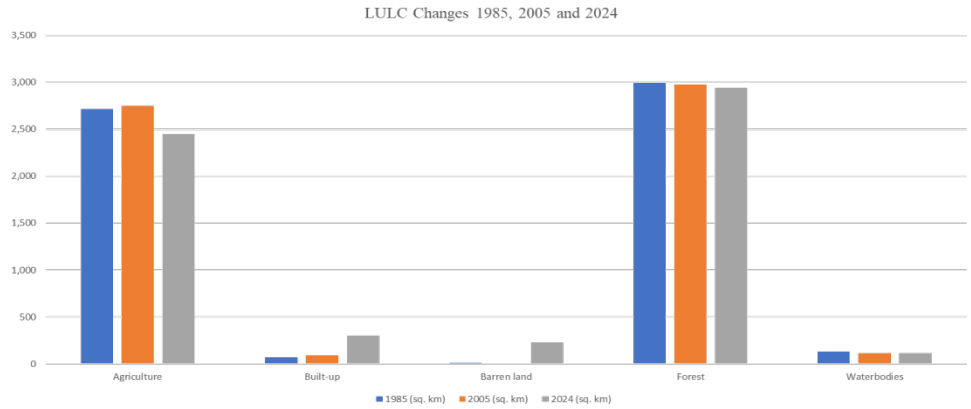

Fig. 6: LULC changes (1985–2024) comparison chart

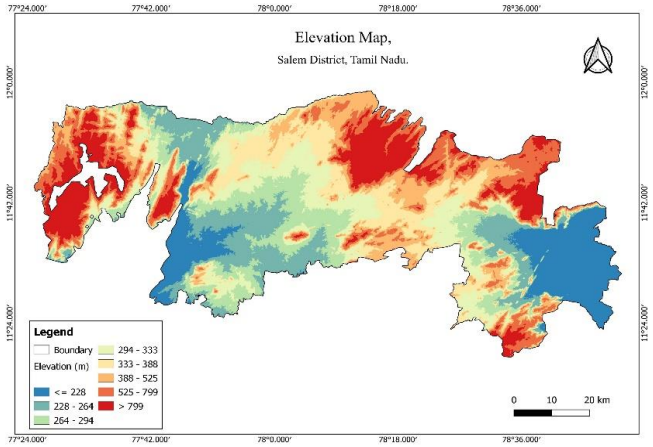

Fig. 7: Elevation map of Salem from SRTM DEM

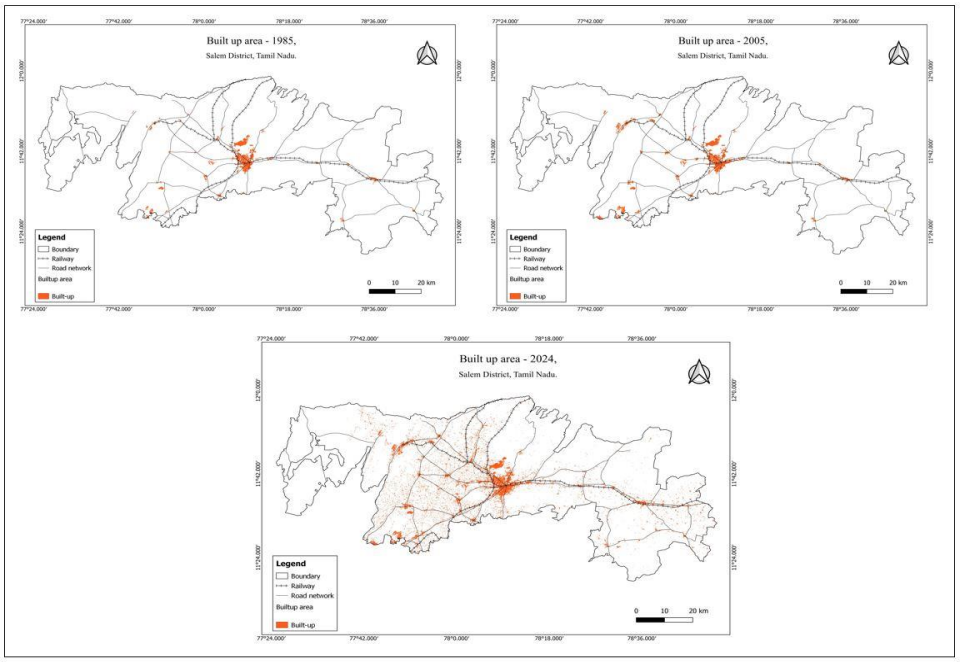

Fig. 8: Road and railway networks overlaid with urban areas for 1985, 2005, and 2024

This spatial relationship indicates the strong influence of accessibility and infrastructure in shaping urban development. The connectivity provided by these networks enhances the appeal for commercial, residential, and industrial activities, thus reinforcing growth along these axes (Verburg *et al*., 2004; Schneider & Woodcock, 2008).

Conclusions

The LULC assessment of the Salem district between 1985 and 2024 reveals profound landscape transformation driven by urbanization. Agricultural lands have significantly declined in recent decades, while built-up areas have expanded exponentially, especially in low-elevation zones and transportation networks. The substantial increase in barren land suggests rising land degradation, likely tied to unsustainable development practices.

The findings underscore the need for integrated urban and environmental planning. Decision-makers must adopt land use policies prioritizing sustainability, protecting ecological resources, and ensuring resilient infrastructure development. Strategies such as green belt zoning, conservation of forest patches, and waterbody restoration should be implemented to mitigate the ecological cost of urban growth.

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