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Assessment of Vegetation Cover Loss Using Satellite Imagery: A Case Study of Baramati

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ABSTRACT:

Rapid urbanization and industrial growth have significantly altered natural land use and land cover patterns in semi-urban regions of India. This study evaluates vegetation cover loss and associated land use transformations in Baramati Tehsil, Pune District, Maharashtra, between 2014 and 2024 using multi-temporal Landsat-8 satellite imagery and geospatial techniques. Supervised classification in ArcMap 10.8 was applied to delineate four major land cover classes: agriculture, vegetation, built-up area, and water bodies. The analysis reveals substantial land use changes over the decade. Built-up areas expanded from 26% (34,830 ha) in 2014 to 35% (48,243 ha) in 2024, reflecting rapid urban expansion. Agricultural land decreased drastically from 66% (90,467 ha) to 34% (46,202 ha), underscoring a decline in traditional farmlands due to urban pressures and changing economic conditions. Conversely, vegetation cover increased from 8.2% (11,231 ha) to 31% (41,706 ha), which may be attributed to afforestation efforts, natural regeneration, or improved classification accuracy. Water bodies showed a marginal increase from 0.31% to 0.6% during the study period. The findings highlight the dynamic interplay between developmental activities and environmental change in Baramati, demonstrating both the pressures of urban growth and opportunities for ecological restoration.

Keywords:

Vegetation cover loss, Land use and land cover (LULC) change, Remote sensing, GIS analysis, Urbanization, Baramati

1. INTRODUCTION:

The processes of urbanization and industrial development are among the most powerful forces reshaping land use and land cover (LULC) across the developing world. As cities expand, large tracts of agricultural land, vegetation, and open spaces are rapidly converted into built-up environments, generating severe ecological challenges such as biodiversity loss, ecosystem disruption, and changes in regional climate systems (Seto et al., 2011; Liu et al., 2014; Du et al., 2019; Nalawade et al., 2023; Saraf & Regulwar, 2024). In India, where demographic and economic transitions are particularly pronounced, the last three decades have witnessed unprecedented LULC

shifts, especially in peri-urban belts that act as transitional zones between rural and metropolitan landscapes (Rimal et al., 2025; Bairwa et al., 2025; Seyam et al., 2023).

Baramati Tehsil in Pune district, Maharashtra, is a representative case of such transformations. Traditionally an agriculturally rich area, well-known for sugarcane cultivation, vineyards, and horticulture, Baramati has in recent years diversified into industrial, educational, and service-oriented sectors. This structural change has exerted pressure on its land resources, leading to the fragmentation of vegetation, conversion of farmlands, and reduction of natural green cover (Karale, 2011; Sampat et al., 2024; Huyen et al., 2022). Comparable land use dynamics have been reported elsewhere in Maharashtra, such as Nashik, Gadchiroli, and the Godavari basin, where farmland and vegetation are increasingly replaced by urban and industrial infrastructure (Allawai & Ahmed, 2020; Furusawa et al., 2023; Gadhave et al., 2022).

To accurately monitor and quantify such changes, remote sensing combined with Geographic Information System (GIS) analysis provides a reliable and cost-effective framework. These tools allow multi-temporal tracking of vegetation cover, farmland, built-up areas, and water bodies at local to regional scales (Dhorde et al., 2014; Bagwan & Gavali, 2018; Khan, 2024). Medium-resolution satellite datasets such as Landsat and Sentinel have been widely applied in LULC research, while supervised classification methods enable effective discrimination of land cover categories (Congalton & Green, 2019; Zhang et al., 2024; Gabisa et al., 2025). Furthermore, the integration of post-classification comparison techniques with accuracy assessment indices, such as user's and producer's accuracy and Kappa coefficients, enhances the credibility of spatio-temporal analyses (Zubair et al., 2023; Deb et al., 2025).

Despite the availability of such methodologies, relatively few long-term assessments have been conducted for agriculturally intensive but rapidly urbanizing semi-urban towns in Maharashtra. Most prior research emphasizes either metropolitan regions or large river basins, leaving a gap in understanding vegetation dynamics at the local level. Addressing this gap is critical for ensuring sustainable land use and conservation of fragile ecosystems in drought-prone areas like Baramati (Nalawade et al., 2023; Saraf & Regulwar, 2024).

This study seeks to analyze the spatio-temporal patterns of vegetation cover in Baramati Tehsil over the decade 2014–2024 using Landsat-8 imagery and geospatial techniques. The objectives are threefold: (i) to classify and map major LULC categories including agriculture, vegetation, built-up areas, and water bodies for selected years; (ii) to quantify the magnitude and rate of vegetation cover loss during this period; and (iii) to examine the spatial relationship between vegetation dynamics and drivers such as urban expansion and agricultural transitions.

By integrating satellite data, GIS-based classification, and change detection approaches, this study contributes to the broader discourse on sustainable land management in semi-urban India. The outcomes are expected to support evidence-based planning and policymaking, particularly in promoting afforestation, agroforestry, and ecologically sensitive urban development strategies for Baramati.

2. STUDY AREA:

Baramati Tehsil, situated in the eastern part of Pune district, Maharashtra, extends between 18º04′–18º32′ N latitude and 74º26′–74º69′ E longitude at an elevation of about 540–550 m. It is located 100 km east of Pune and 240 km from Mumbai, bordered by Indapur, Satara, Purandar, and Daund. The landscape is characterized by plains, low hills, and plateaus formed mainly from Deccan basalt, which gives rise to fertile black soils along the Nira River and coarser calcareous soils on the uplands. The region experiences a semi-arid, drought-prone climate with around 550 mm of annual rainfall, cooler winters (12°C), and hot summers (up to 39°C). Agriculture dominates land use, with sugarcane, grapes, wheat, and cotton as major crops, alongside horticulture such as banana and pomegranate. Noted for its sugarcane economy and viticulture, Baramati has also seen industrial and service-sector growth, increasing pressure on land resources. These physical and socio-economic features make it a representative site for assessing vegetation cover change under the combined influence of agriculture, urbanization, and climatic stress

3. MATERIAL AND METHODS:

3.1 Data Acquisition:

To analyze vegetation cover dynamics in Baramati Tehsil, multi-temporal satellite imagery was acquired from the United States Geological Survey (USGS) Earth Explorer portal. Landsat-8 Operational Land Imager (OLI) datasets with a 30 m spatial resolution were selected for the years 2014, 2016, and 2024, ensuring temporal consistency and cloud-free conditions. These datasets were chosen because of their wide availability, free access, and proven suitability for land use and land cover (LULC) studies. Ancillary data such as administrative boundaries (shapefiles) and topographic maps were also used to delineate the study area.

3.2 Image Preprocessing:

Preprocessing of the Landsat images included mosaicking of adjacent scenes, georeferencing, and clipping of the study area using the Baramati boundary shapefile. Standard corrections (radiometric and atmospheric) were applied to minimize noise and enhance spectral reliability. The processed images were then projected to a uniform coordinate system (UTM, WGS 84 Zone 43N) to ensure compatibility across datasets.

3.3 Land Use/Land Cover Classification:

LULC mapping was performed through a supervised classification approach using the Maximum Likelihood Classifier (MLC) in ArcGIS 10.8. Four major land cover categories were identified: Agriculture, Vegetation (forest patches, plantations, orchards, and regenerating areas), Built-up area (settlements, industrial zones, roads, and infrastructure) and Water bodies (rivers, lakes, ponds, reservoirs). Training samples for each class were generated through visual interpretation of false color composites (FCC) and supported by Google Earth imagery. The classification outputs were then converted into raster maps representing land cover for each study year.

3.4 Change Detection Analysis:

To quantify temporal changes, a post-classification comparison technique was employed. The classified images of 2014, 2016, and 2024 were compared to detect transitions between land cover classes. Pixel counts for each category were extracted from the attribute tables, and corresponding areas were calculated using the following formula:

Area (m^2) = Pixel Count × Pixel Size^2

Given the 30 m resolution of Landsat-8, each pixel represented 900 m^2. The results were converted into hectares (ha) by dividing the total area (m^2) by 10,000. Graphs and tabular summaries were prepared in Microsoft Excel to represent year-wise changes and trends in vegetation cover.

3.5 Thematic Mapping and Visualization:

The classified and change detection outputs were translated into thematic maps using ArcGIS. These maps illustrate the spatial distribution of agriculture, vegetation, built-up areas, and water bodies for each time point. Comparative maps highlighting vegetation gain or loss zones were also generated to visualize spatio-temporal dynamics.

4. RESULTS AND DISCUSSION:

4.1 Land Use and Land Cover in 2014:

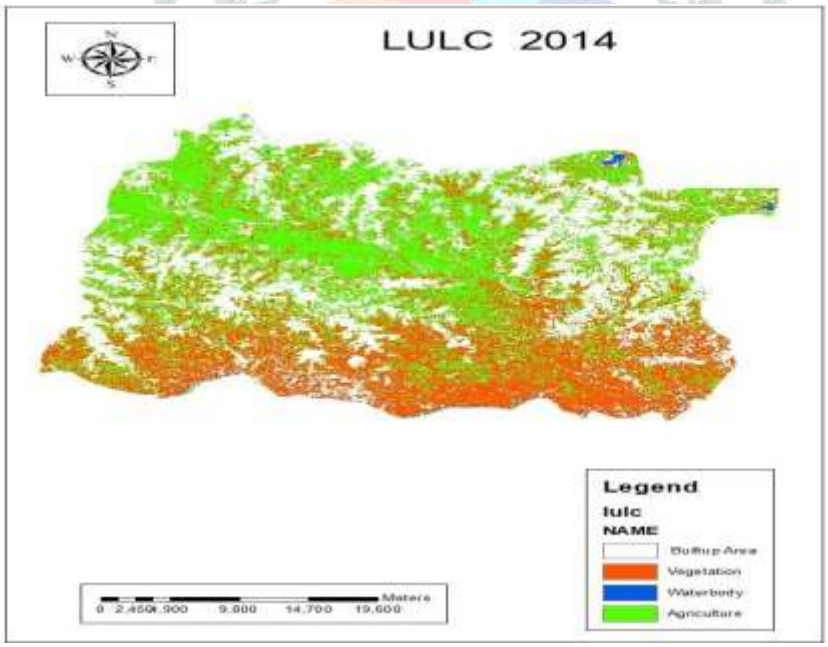

Fig. 1. Land Use and Land Cover map of Baramati Tehsil for the year 2014.

The Land Use and Land Cover (LULC) pattern of Baramati Tehsil in 2014 shows a landscape dominated by agricultural land, covering nearly two-thirds of the total area (Fig. 1). This class is spatially extensive in the southern and eastern parts of the tehsil, where broad fertile plains and irrigation from the Nira River support

intensive cropping. Large contiguous tracts of agriculture are particularly noticeable around Malegaon, Someshwar, and Indapur boundary areas, reflecting the predominance of sugarcane and cereal cultivation.

Vegetation cover is mainly concentrated in the northern and northwestern regions, extending along hill slopes, plateaus, and scattered patches across the central part of the tehsil. Significant vegetation occurs near Baramati town's periphery and along the western uplands adjoining Purandar Tehsil. These patches represent orchards, plantations, and remnant natural vegetation.

The built-up areas are clustered around Baramati town in the central part of the tehsil, extending along major road corridors and smaller settlements (Fig. 1). The spatial pattern shows linear growth of settlements along transport networks connecting Baramati with Pune (west) and Indapur (east). Smaller built-up clusters appear in the northeastern corner and along the central-southern road networks, indicating a gradual spread of residential and industrial areas.

Water bodies are limited in extent, with the most prominent being the Nira River in the north and northeast, along with small reservoirs and tanks scattered in the central and southeastern zones. Their spatial distribution highlights the dependency of agriculture on both surface and groundwater sources in this semi-arid region.

Overall, the spatial analysis of 2014 demonstrates that agriculture dominated the southern and eastern plains, vegetation was more prevalent in the north and west, built-up zones were concentrated in the central region around Baramati town, and water bodies were sparsely distributed, mainly along the northern boundary. This baseline spatial distribution highlights the agrarian character of Baramati, with emerging signs of urban concentration in the central core.

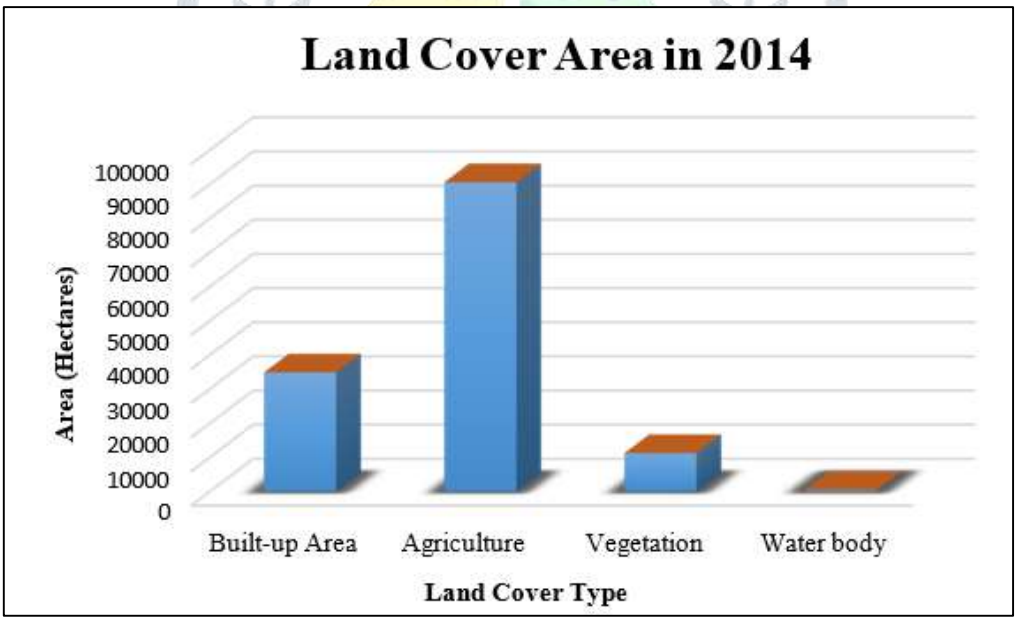

Fig. 2. Land Use and Land Cover area of Baramati Tehsil for the year 2014.

The land use and land cover area of Baramati Tehsil in 2014 across four major categories: built-up area, agriculture, vegetation, and water bodies presented in Fig. 2. The analysis clearly indicates that agriculture dominated the landscape, covering approximately 90,467 hectares (66% of the total area). This dominance reflects

the agrarian base of Baramati, supported by fertile black soils and irrigation facilities along the Nira River, with sugarcane, grapes, wheat, and cotton as key crops.

The built-up area was the second-largest category, covering around 34,830 hectares (26%). Urban settlements were concentrated around Baramati town and extended along road corridors, reflecting the emerging importance of residential, industrial, and service activities (Fig. 2).

Vegetation accounted for about 11,231 hectares (8.2%), found in scattered patches across the northern, northwestern, and peri-urban regions. This included orchards, plantations, and remnant natural green areas that provided ecological support to the largely agricultural landscape.

Water bodies occupied only 423 hectares (0.3%), the smallest share, mostly along the Nira River and small tanks scattered in the central and eastern parts (Fig. 2). Their limited extent emphasizes the scarcity of surface water resources in this semi-arid, drought-prone tehsil.

In summary, the 2014 LULC statistics highlight the agrarian character of Baramati, with agriculture as the defining land use, built-up areas showing significant expansion, and relatively minor but ecologically important contributions from vegetation and water bodies. This serves as the baseline against which future LULC transformations (2016 and 2024) are assessed.

4.2 Land use and Landcover in 2016:

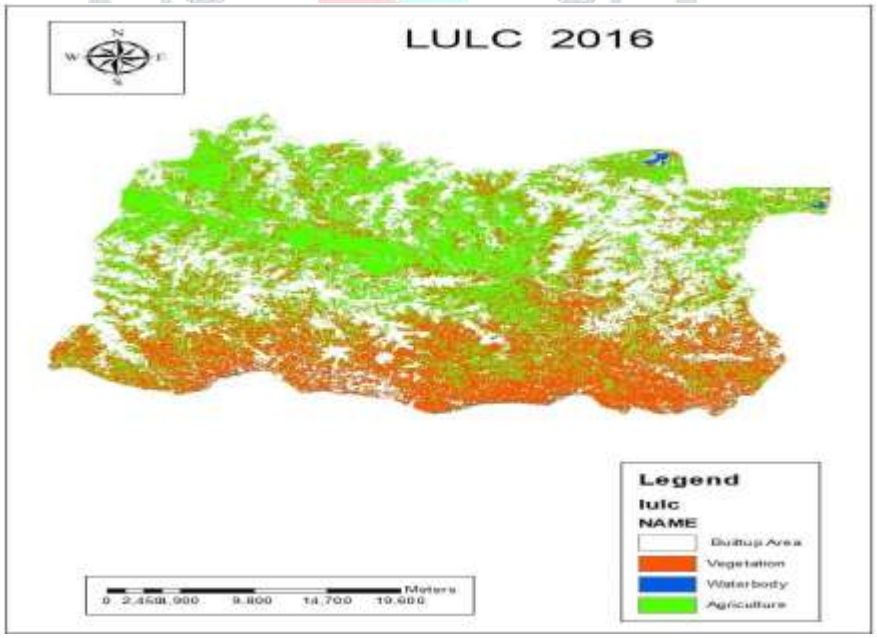

Fig. 3. Land Use and Land Cover map of Baramati Tehsil for the year 2016.

The LULC map of 2016 indicates a gradual transition in land cover compared to 2014. Agriculture continued to dominate, especially in the southern and southeastern plains, but with visible reduction around the central and northern zones, where land was increasingly converted for urban use (Fig. 3). Built-up areas expanded around Baramati town, radiating outward toward the northeast and northwest corridors, reflecting residential, industrial,

and institutional growth. Secondary settlements along transport routes, particularly toward Indapur (east) and Pune (west), also witnessed noticeable expansion.

Vegetation cover increased slightly, particularly in the northwestern and western uplands, possibly due to plantation activities and orchard development. Pockets of vegetation were also identifiable along the central and eastern fringes, interspersed with agricultural land (Fig 3.). Water bodies remained limited, but small reservoirs and tanks in the northeastern and southeastern parts showed marginal growth, suggesting improved water conservation efforts. Overall, 2016 marked the beginning of a discernible shift, with agricultural dominance giving way to expanding urban footprints and localized vegetation gains.

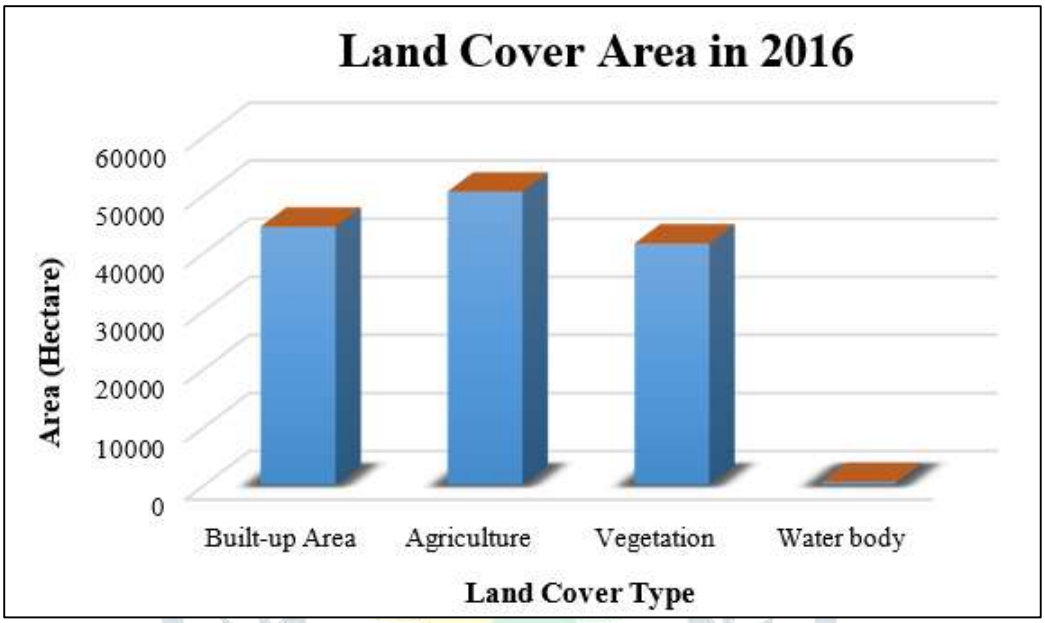

Fig. 4. Land Use and Land Cover area of Baramati Tehsil for the year 2016.

The year 2016 marks a turning point in the land use dynamics of Baramati Tehsil (Fig. 4). Unlike 2014, when agriculture clearly dominated the landscape, the distribution of land cover classes in 2016 shows a more competitive balance between built-up, agriculture, and vegetation categories.

Agricultural land, once the backbone of the region, contracted to nearly 56,613 ha (34%), losing ground to both urban and horticultural expansion (Fig. 4). The contraction is particularly evident around the central and northern parts of the tehsil, where new residential colonies, industries, and service establishments began replacing farmlands.

At the same time, built-up areas surged to 48,243 ha (35%), reflecting Baramati's transformation into a growing urban hub. Expansion was not only limited to the municipal core but also radiated outward along highways and transport corridors, resulting in a dispersed urban footprint.

Interestingly, vegetation cover registered a remarkable rise to about 46,202 ha (31%). This increase was largely associated with the spread of orchards, vineyards, and plantations in peri-urban and upland areas. The shift indicates a diversification of land use, with farmers investing in high-value crops and plantations that provide better returns compared to traditional cereals (Fig. 4).

Water bodies remained the least represented category, covering just 460 ha (0.6%), though small reservoirs and tanks continued to play an important role in sustaining both agriculture and household water needs in this drought-prone zone.

In essence, 2016 portrays a landscape in transition agriculture losing its traditional dominance, urban areas consolidating their presence, and vegetation gaining prominence through agroforestry and horticulture. This period highlights the adaptive responses of local land use systems to the twin forces of urban growth and economic diversification.

4.3 Land Use and Land Cover in 2024:

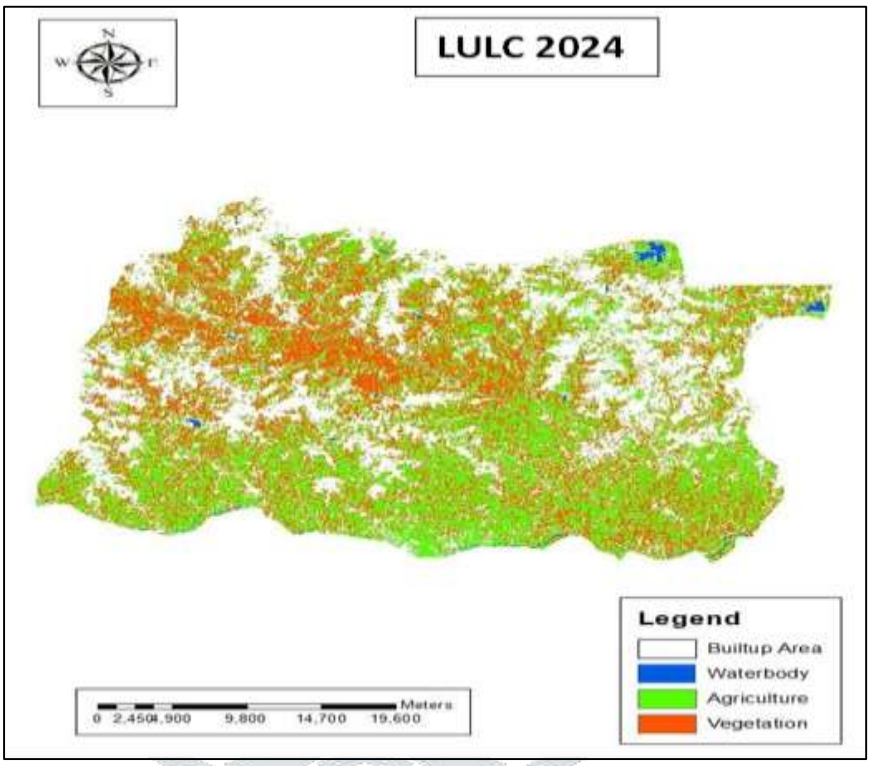

Fig. 5. Land Use and Land Cover map of Baramati Tehsil for the year 2024.

By 2024, the LULC configuration of Baramati reflected a pronounced transformation. Built-up land showed the most significant spatial expansion, occupying the central region around Baramati and extending radially into the north, northeast, and western directions. Urban spread was particularly visible along transport corridors, industrial zones, and educational clusters, indicating intensified urbanization (Fig. 5).

Agricultural land, once the defining feature of the tehsil, showed sharp contraction, now largely concentrated in the southern, southeastern, and peripheral eastern parts. Even in these zones, fragmentation of fields into smaller patches was evident, highlighting the pressures of land conversion.

Vegetation cover displayed remarkable growth compared to 2014, with substantial patches observed in the northern, northwestern, and western uplands, as well as around river corridors and peri-urban fringes (Fig. 5). This

increase likely represents both natural regeneration and expansion of orchards, vineyards, and plantation activities in response to changing agricultural practices.

Water bodies showed marginal but spatially important increases, particularly along the Nira River in the north and in scattered reservoirs and tanks in the central and eastern sectors. These expansions reflect localized irrigation and water harvesting measures, though water resources remained relatively sparse compared to agricultural demand (Fig. 5).

Overall, by 2024, the LULC pattern revealed a shift from agriculture-dominated landscapes toward urban-industrial growth, with significant gains in managed vegetation cover and modest improvements in water resources. The central and northern zones emerged as hotspots of urban expansion, while agriculture retreated toward the southern and eastern margins.

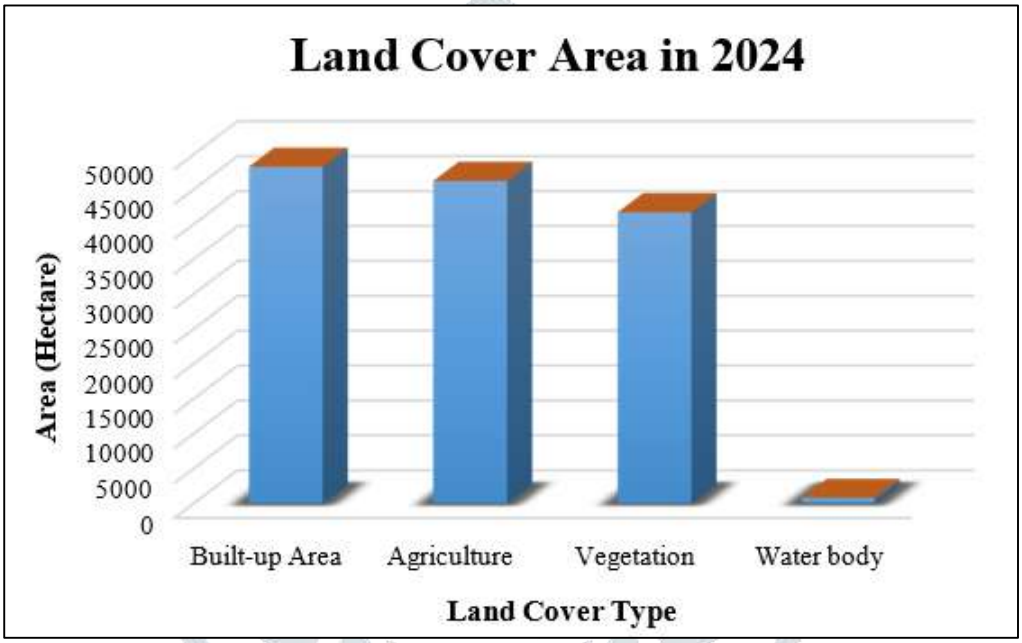

Fig. 6. Land Use and Land Cover area of Baramati Tehsil for the year 2016.

By 2024, the land use profile of Baramati Tehsil (Fig. 6) reflects a landscape that has been dramatically reshaped over the last decade. Unlike earlier years, when agriculture held a clear dominance, the distribution now shows near parity among built-up, agriculture, and vegetation classes, underscoring the intensity of recent transformations.

The built-up category expanded to about 51,280 ha (35%), making it the single largest land use class. This expansion is concentrated around Baramati town and radiates along major highways, industrial estates, and educational hubs (Fig. 6). The urban fabric has become more fragmented yet widespread, signaling not just population growth but also the establishment of new economic activities that demand land.

Agriculture, though still significant at 50,927 ha (34%), has clearly lost its historical dominance. Large, contiguous agricultural tracts have given way to smaller, fragmented fields, particularly in the central and northern parts of the

tehsil. Traditional crops such as sugarcane and wheat have been partially replaced by land diverted for construction and alternative vegetation uses (Fig. 6).

The vegetation class reached 47,706 ha (31%), sustaining the upward trajectory observed in 2016. Much of this category is associated with managed land uses such as orchards, vineyards, and plantations rather than natural forests. The shift toward high-value crops like grapes and pomegranate reflects both farmer adaptation to market opportunities and the changing agricultural economy of Baramati (Fig. 6).

Water bodies, although limited to 460 ha (0.6%), remain crucial. Small reservoirs, tanks, and the Nira River continue to serve as vital water sources, especially in a drought-prone climate where irrigation demand remains high.

Taken together, the 2024 scenario illustrates a triple character of Baramati's landscape: urban expansion emerging as the dominant force, agriculture retaining importance but under increasing stress, and vegetation gaining prominence through deliberate land-use shifts. This evolving pattern captures the dynamic balance between urban growth, agricultural transitions, and ecological adaptation in one of western Maharashtra's most rapidly transforming tehsils.

4.4 Change Detection Analysis (2014-2024)

Table 1. Land Use and Land Cover (LULC) Change in Baramati Tehsil, 2014–2024

Land cover class	Land Cover in 2014		Land Cover in 2016		Land Cover in 2024	
	Area (Hectares)	%	Area (Hectares)	%	Area (Hectares)	%
Built-up Area	34830.36	26	44452.17	33	48243.33	35
Agriculture	90467.37	66	50467.77	37	46202.4	34
Vegetation	11230.83	8.20	41552.19	30.03	41705.64	31
Water body	423.45	0.31	453.3	0.3	804.06	0.6

The change detection analysis of Baramati Tehsil between 2014 and 2024 highlights remarkable shifts in land use and land cover, reflecting the combined influence of urban growth, agricultural decline, and diversification into horticulture. Built-up land increased significantly from 34,830 ha (26%) in 2014 to 48,243 ha (35%) in 2024,

adding nearly 13,413 ha over the decade (Table 1). This growth was most evident around Baramati town and along major road corridors, where new residential colonies, industries, and service establishments have reshaped the central and northern parts of the tehsil. In contrast, agriculture experienced the steepest decline, shrinking from 90,467 ha (66%) to 46,202 ha (34%), a loss of more than 44,000 ha. Much of this farmland was either absorbed by urban expansion or converted into orchards and plantations now recorded under vegetation, which indicates a weakening dominance of traditional agriculture in Baramati's economy.

Vegetation cover, on the other hand, rose sharply from 11,231 ha (8.2%) in 2014 to 41,706 ha (31%) in 2024, recording a net gain of 30,475 ha. This increase is primarily linked with managed vegetation such as vineyards, pomegranate orchards, and plantation crops rather than natural forests, reflecting the economic shift of local farmers toward high-value horticulture and viticulture. Water bodies, though limited in area, also showed a modest increase from 423 ha (0.31%) to 804 ha (0.6%), suggesting localized improvements in water storage and irrigation through tanks and small reservoirs (Table 1).

Overall, the land cover structure of Baramati has transitioned from an agriculture-dominated landscape in 2014 to a mixed-use system by 2024, with agriculture, built-up areas, and vegetation now holding nearly equal shares. This transformation signifies the intensifying pressure of urbanization alongside the adaptive strategies of farmers who are diversifying their land use to align with market demands. While these shifts enhance economic opportunities, they also raise concerns regarding the sustainability of agriculture, food security, and long-term water resource management in this drought-prone region

5. CONCLUSION:

The present study assessed the spatio-temporal dynamics of land use and land cover in Baramati Tehsil between 2014 and 2024 using multi-temporal Landsat-8 imagery and GIS techniques. The findings demonstrate a profound transformation of the region's landscape over the past decade, with agriculture, once the dominant land use, declining sharply from 66% in 2014 to just 34% in 2024. Much of this agricultural land has been absorbed by the rapid expansion of built-up areas, which increased by nearly 13,500 ha, and by the remarkable rise in managed vegetation cover, including orchards, vineyards, and plantations. The built-up category, now occupying 35% of the total area, reflects the urban and industrial growth of Baramati, while vegetation has emerged as an important component of the land cover structure, reaching 31% of the area by 2024. Water bodies, though limited, showed slight gains, indicating localized efforts in water management and storage.

These results highlight a clear transition in Baramati from a predominantly agrarian landscape to a mixed-use system where urban expansion, agricultural contraction, and horticultural diversification coexist. The patterns observed underline the intensifying pressures of urbanization, land fragmentation, and socio-economic change, but they also reveal adaptive strategies by farmers who have shifted to high-value crops to sustain livelihoods in a semi-arid environment.

In conclusion, Baramati's land use transition over the past decade reflects both opportunities and challenges: opportunities in terms of urban development and horticultural growth, and challenges regarding the sustainability of traditional agriculture, water resources, and ecological balance. Integrating scientific evidence into local

planning will therefore be crucial to ensure that Baramati continues to evolve as a resilient and sustainable socio-ecological system.

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COMPETING INTERESTS:

The authors declare no competing interests.

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