The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 3 | Issue 11 | November 2025
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Urbanization and Land Transformation in the Rural–Urban Fringe: Evidence from Modinagar, Ghaziabad

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DOI : https://doi.org/10.5281/zenodo.17923388

ARTICLE DETAILS

Research Paper

Accepted: 24-11-2025

Published: 10-12-2025

Keywords:

Urbanization; Land Use / Land Cover; Rural–Urban Fringe; Modinagar;

ABSTRACT

The land use and land cover (LULC) transformation of rapidly urbanizing regions has become a central concern in contemporary geographic and environmental research. This study investigates the spatial and socio-economic consequences of urbanization on the rural–urban fringe of Modinagar city, located in the Ghaziabad district of Uttar Pradesh. Using satellite imagery for 2001, 2011 and 2025 alongside household-level survey data, the study analyzes the evolution of settlement patterns, agricultural decline, infrastructural expansion and demographic shifts in the fringe villages surrounding Modinagar, including Bhojpur, Chipiyana villages, Niwari block and the NH-58 rural belt. A sample of 120 households was surveyed to capture livelihood transitions, land sale patterns and changing access to amenities. The results reveal dramatic conversion of agricultural land into residential and commercial built-up areas, driven by urban pressure, real-estate speculation and improved transportation access. LULC analysis shows a significant decline in agricultural land and open spaces, while built-up land increased more than threefold between 2001 and 2025. Socio-economic findings indicate loss of agricultural livelihood, rising dependence on non-farm employment and increased cost of living. The study argues that unregulated expansion has created

a planning vacuum, leaving fringe settlements without adequate services. It concludes that coordinated regional planning and land governance policies are crucial for sustainable development of the Modinagar fringe in alignment with ecological balance and local livelihood security.

Introduction

Land is a fundamental natural resource and the basis of all human activities. The pattern of land use and land cover (LULC) in any geographic space is a product of complex interactions between physical factors, demographic conditions, economic activities and social choices. In the contemporary phase of global economic transformation, rapid urbanization has emerged as one of the strongest agents of land modification. The expansion of urban areas beyond their administrative boundaries towards the surrounding countryside produces a transitional zone known as the rural–urban fringe. This zone is dynamic, unstable and characterized by competing claims on land, overlapping administrative jurisdictions and mixed socio-economic structures.

Modinagar Block in Ghaziabad District of Uttar Pradesh State, belonging to Meerut Division, represents a textbook case of fringe-driven land transformation. It is located 27 km north of the district headquarters, Ghaziabad and functions as a Block headquarters. The location of Modinagar City ranges between 77º 55’ to 77 º 63’ East longitudes and 28º 80’ to 28º 87’ North latitude. Modinagar is one of the tehsils of Ghaziabad district, established in 1933 by industrialist Gujarmal Modi. By 1945, Modinagar was a town area and in 1963 it was notified as a municipal area. Situated just 25 km northeast of Ghaziabad along the Delhi–Mussoorie National Highway (NH-58) and 48 km from New Delhi, Modinagar has evolved into an industrial town within the district.

Strategically located within the National Capital Region (NCR), the city has experienced accelerated urban expansion over the last two decades. Its growth driven by industrial restructuring, real estate development, educational institutions and proximity to the Delhi metropolitan region, has produced considerable pressure on the rural hinterland. Agricultural fields, open fallow lands, village commons and orchards have progressively been replaced by residential housing, commercial complexes, warehouses and private institutions.

Classical literature on urban geography suggests that fringe areas remain administratively neglected municipal bodies do not effectively manage them, while village administrations often lack

planning capacity. Consequently, fringe dwellers face infrastructural and institutional deprivation even while living adjacent to prosperous cities. The Modinagar fringe presents the same paradox: it is increasingly urban in land use and lifestyle but rural in governance and planning provisions.

In this background, a comprehensive LULC investigation combined with a socio-economic assessment becomes essential to understand the drivers and consequences of spatial transformation. This study contributes to the literature by combining geospatial analysis from 2001–2025 with village-level survey data, offering a holistic picture of the urbanization process affecting Modinagar's fringe settlements.

Study Area

The study focuses on the fringe villages surrounding Modinagar city, including: Bhojpur region, Chipiyana villages, Niwari block and Rural belt along NH-58

These areas have experienced continuous spatial and demographic transition due to proximity to Modinagar's urban core and highway accessibility.

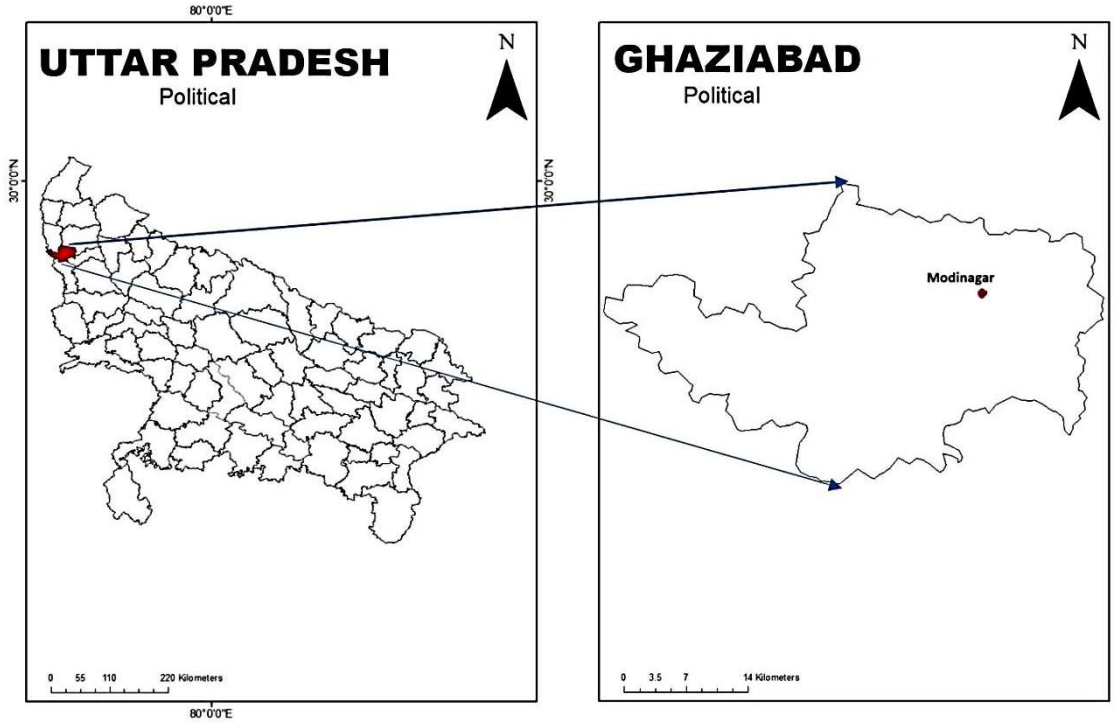

Figure 1. Location Map of Study Area

The study aims to investigate how land use and land cover (LULC) has changed in the rural–urban fringe of Modinagar from 2001 to 2025, with special attention to agricultural decline, expansion of settlements and growth of infrastructure. It further seeks to assess the socio-economic impacts of these

land transformations at the household level and identify inequalities in access to essential services between urban Modinagar and nearby fringe villages.

A mixed-method research design was adopted, integrating GIS-based spatial analysis with primary field survey data. Landsat satellite imagery (2001, 2011, 2025), Census records and administrative maps were processed using supervised classification (Maximum Likelihood) to map major LULC categories and generate a change-detection matrix for the 20-year period. To support the spatial findings, a household survey of 120 respondents from fringe settlements selected through stratified random sampling captured information on land ownership transitions, livelihood changes, land transactions and access to services. Statistical and correlation analyses were used to link spatial outcomes with socio-economic realities, providing a holistic understanding of the effects of urbanization on land and livelihoods in the Modinagar fringe.

Land Use and Land Cover in 2001

In 2001, Modinagar city still retained a largely semi-rural landscape. Agriculture was the dominant land use, covering around 241.79 sq. units, showing the city's strong dependence on farming and its fertile agricultural base. Vegetation was the second major category, spreading across about 143.39 sq. units and adding ecological stability, greenery and biodiversity to the surroundings.

Water bodies occupied a much smaller area of 12.07 sq. units but played an important role in maintaining the local water supply and environmental balance. Barren land appeared in two forms 4.31 sq. units of rocky or highly degraded land and a larger 46.48 sq. units of general wasteland indicating some ongoing issues of land degradation.

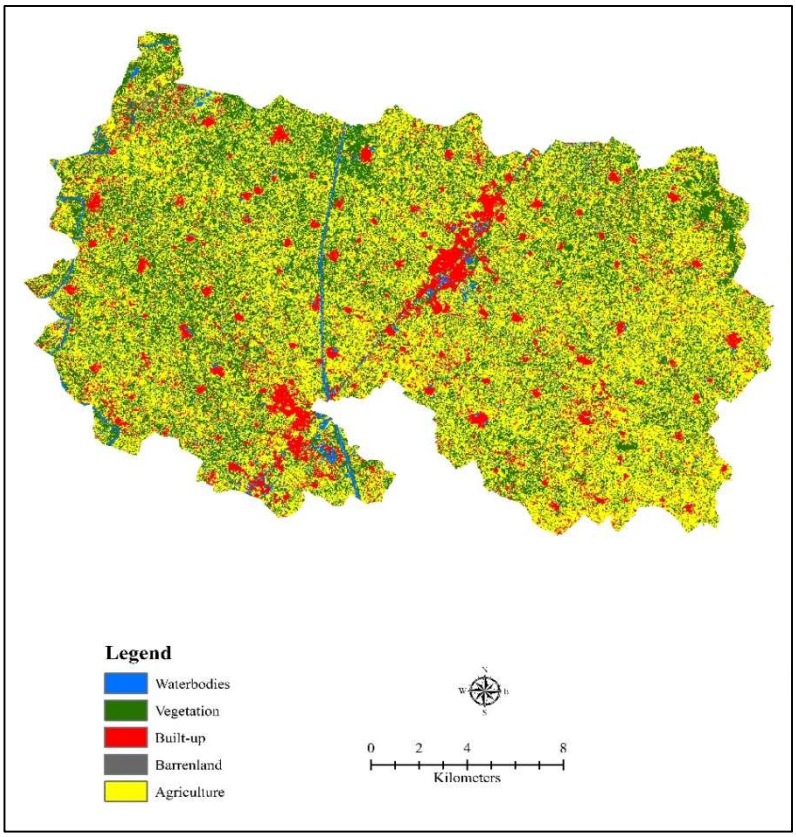

Figure 2. Land Use and Land Cover in 2001

Overall, the land cover in 2001 shows that Modinagar was still predominately agricultural and green, with limited barren land and moderate water resources (Fig. 2).

Land Use and Land Cover in 2011

By 2011, Modinagar experienced a noticeable shift in its land use pattern. Agriculture saw the steepest decline, dropping from 241.79 to 137.55 sq. units a loss of nearly 43% within just ten years. This sharp reduction clearly reflects rapid urban expansion, industrial development, real estate growth and the declining role of farming in the region. Vegetation also decreased, falling to 125.45 sq. units. This reduction points to deforestation, urban encroachment and increasing pressure on natural green spaces. In contrast, water bodies almost doubled from 12.07 to 24.61 sq. units, which may be a result of the creation of artificial ponds, canal developments, or the introduction of rainwater harvesting structures during this period.

The most notable shift, however, was seen in barren land. While the smaller barren category declined slightly to 2.91 sq. units, the larger barren land category grew dramatically from 46.48 to 157.53 sq. units, more than tripling in ten years. This sharp rise signals growing land degradation, large unused plots left by urban expansion and a potential loss of soil fertility.

Overall, the 2011 land cover pattern shows Modinagar at a decisive turning point. The city was transitioning from a predominantly agricultural and green landscape toward one increasingly shaped by urban growth and expanding degraded land areas (Fig. 3).

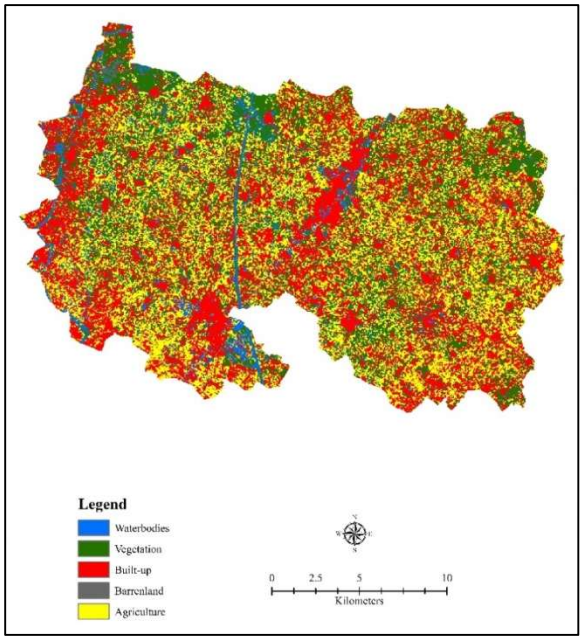

Figure 3. Land Use and Land Cover in 2011

Land Use and Land Cover in 2025

The projected land use pattern for 2025 indicates a further intensification of the changes already visible in 2011. Agricultural land is expected to decline even more, falling to just 111.03 sq. units. This continued reduction signals a long-term threat to the agrarian economy and local food production. Vegetation is also projected to drop sharply to only 45.52 sq. units, reflecting heavy deforestation, shrinking green spaces and a serious disturbance in ecological balance.

In contrast, waterbodies are expected to rise to 32.95 sq. units, likely due to urban water management projects, the creation of artificial lakes and improved rainwater retention systems. The most alarming shift, however, concerns barren land. The smaller barren category is anticipated to increase to 4.99 sq. units, while the larger barren land category may surge to 253.53 sq. units — making barren land the dominant land use type in Modinagar by 2025.

This projection suggests that rapid and largely unplanned urbanization, industrial activity and extensive land conversion are leading to vast stretches of unused or degraded land (Fig. 4), marking a worrying future for the city's environmental sustainability.

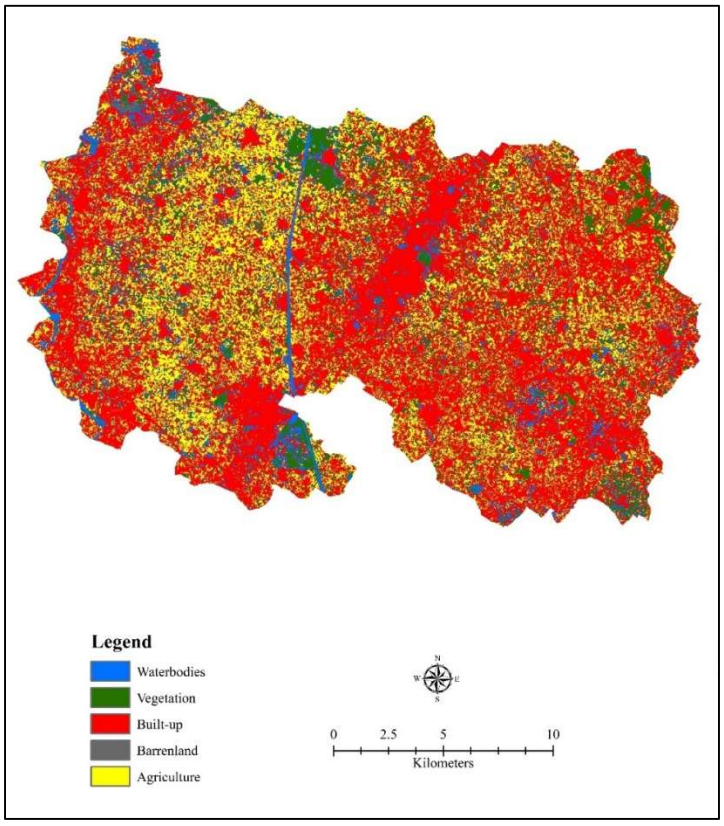

Figure 4. Land Use and Land Cover in 2025

The analysis of Land Use and Land Cover (LULC) change in Modinagar from 2001 to 2025 shows a major transformation in its landscape driven largely by rapid urbanization and human activities. In 2001, Modinagar was primarily an agrarian region with large expanses of agricultural and vegetative land and only limited built-up and barren areas. Over time, however, this balance shifted significantly. By 2011, agriculture and vegetation had declined sharply due to conversion of farmland and green spaces into residential, industrial and commercial land. At the same time, barren land and built-up areas increased drastically, marking the onset of a strong urban expansion phase. Waterbodies also expanded slightly, likely because of artificial ponds, drainage restructuring and water conservation efforts.

The projections for 2025 indicate a continuation of these trends. Built-up (barren) land is expected to become the dominant land use category, while agricultural land and vegetation may shrink to critically low levels. Although waterbodies show a moderate increase, the overall rise in barren land suggests significant land degradation, urban sprawl and unplanned land conversion.

Collectively, the LULC trajectory between 2001 and 2025 reflects a clear shift from a rural, agriculture-based landscape toward an urban-industrial one. This pattern emphasizes the urgent need for sustainable land management, protection of remaining agricultural and vegetative areas and long-term urban planning to prevent environmental degradation and ecological imbalance in Modinagar.

The land use statistics of Modinagar from 2001 to 2025 show a sharp and continuous transformation in major land cover categories. Agricultural land, which occupied 241.799 hectares in 2001, reduced significantly to 137.548 hectares in 2011 and is projected to decline further to 111.036 hectares by 2025. Vegetation also follows a similar decreasing trend, dropping from 143.394 hectares in 2001 to 125.446 hectares in 2011 and decreasing drastically to just 45.5223 hectares in 2025. Waterbodies, on the other hand, display a gradual increase—from 12.0719 hectares in 2001 to 24.6128 hectares in 2011 and further to 32.9546 hectares in 2025, indicating improvements in water retention structures or artificial reservoirs. The most dramatic change is observed in barren or built-up land. The smaller barren land category decreases slightly from 4.31238 hectares in 2001 to 2.91247 hectares in 2011, but rises again to 4.99782 hectares by 2025. In contrast, the larger barren land (or built-up) category expands rapidly from 46.479 hectares in 2001 to 157.534 hectares in 2011 and further escalates to 253.538 hectares by 2025, making it the dominant land use in the city. Overall, the figures highlight a continuing environmental shift from agriculture and vegetation toward urbanized and barren land uses.

Household Survey Findings

The household survey findings strongly reinforce the spatial evidence of rapid land use transformation in Modinagar. Responses from 120 households across fringe settlements—selected through stratified random sampling—reveal widespread land ownership transitions, with many families reporting the sale or subdivision of agricultural plots over the past two decades due to rising land values and pressure from real estate developers. A large proportion of respondents indicated a shift in livelihood patterns, moving away from farming and agro-based activities towards wage labour, small businesses and employment in nearby industries as agricultural opportunities declined. Residents also expressed concern about the shrinking vegetation and growing barren land around their settlements, noting visible environmental changes such as increased dust, reduced groundwater levels and loss of shade. While most households acknowledged some improvements in access to services such as roads, electricity, education and water supply, many highlighted unequal service distribution and rapid urban growth that has not been matched with adequate infrastructure. Overall, the survey shows that urban expansion has reshaped not only Modinagar's physical landscape but also the socio-economic fabric of its peri-urban communities, introducing both new opportunities and significant environmental stress.

Social and Cultural Transition

Urbanization has not only reshaped the physical landscape of Modinagar's fringe but has also transformed its social and cultural life. The survey shows that traditional community structures, once rooted in agriculture and shared cultural practices, are steadily weakening. Joint families are breaking into nuclear units as wage-based employment replaces farm-based livelihoods and the rise of gated colonies and rental housing has altered patterns of neighbourhood interaction. Long-standing interpersonal bonds and collective activities are slowly giving way to a more individualized, urban lifestyle.

Survey findings further indicate that the expansion of Modinagar's rural–urban fringe is driven not only by population growth but also by speculative real-estate investments. Although urbanization has opened new employment avenues and diversified income sources, it has come with heavy ecological and social costs. The loss of fertile agricultural land, reduced groundwater recharge due to concrete development, erosion of cultural cohesion and uneven access to public services are repeatedly highlighted by residents. A key concern is the lack of coordinated planning—municipal planning ends at city limits, while village administrations lack the capacity to manage rapid, unregulated development. This governance gap elevates the risks of environmental degradation, congestion and social fragmentation.

Conclusion

Over the past two decades, Modinagar's fringe has witnessed a deep transformation in land use and livelihoods. Agricultural and vegetative areas have shrunk dramatically, while built-up and barren land has expanded more than threefold, signalling rapid urban sprawl. Many residents have transitioned from farming to service-sector and industrial work, yet the benefits of development remain uneven due to weak administrative intervention and inadequate infrastructure in fringe settlements. For balanced and sustainable growth, it is essential to establish a dedicated peri-urban development authority, regulate real-estate expansion while protecting agricultural land, ensure equitable delivery of public services and adopt participatory land-use planning involving rural communities. These measures will help safeguard ecological balance, strengthen livelihood security and support orderly urbanization in Modinagar's fringe.

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