Maharashtra Bhugolshastra Sanshodhan Patrika
Double-blind peer-reviewed /refereed, International Research Journal of Geography
ISSN: 0971-6785 / Volume- 43 / Issue-1 / Jan-Jun 2026

Original Article

Micro-Spatial Dynamics of Urban Form: A Morphological Analysis of Solapur city

Dr. V. C. Dande [1], Nayan Gaikwad[2], Prof. Dr. Vilas Ugale[3]
[1]Research Student, Department of Geography, D.B.F. Dayanand College of Art and Sciene Solapur.
[2]Head and Associate Professor, Department of Geography, D.B.F. Dayanand College of Art and Sciene Solapur.
3Professor and Principal, MES Abasaheb Garware College (autonomous), Pune
Email: gaikwad14892nayan@gmail.com

Manuscript ID:
MBP-2026-180112
ISSN: 0971-6785

Volume 43
Issue 1
Pp. 106-114
June - 2026

Submitted: 25 Jan. 2025
Revised: 25 Mar. 2025
Accepted: 20 Jun. 2026
Published: 30 Jun. 2026

Abstract

Urbanization is one the dynamic concept in urban geography. Around 54% population of the world resides in urban pocket all over the world. Micro-Spatial Dynamics of Urban forms of Solapur city The proposed study analyze how Solapur's urban morphology has evolved within the expanded 178.57 km² municipal limits, focusing on shifts in density, functional land use and network structure in relation to the Development Plan 1997–2017 and the Revised City Development Plan 2041. It situates these changes within the conference sub-theme "Mapping Land Use and Land Cover Changes" by treating the CDP's sectorial proposals (roads, housing, social infrastructure, environment) as drivers and spatial proxies of LULC change. The city is evolving towards hybrid morphology with dense cores, intensifying corridors and heterogeneous fringes, accompanied by significant LULC transition from agriculture and open land to build- up cover.

Keywords: *urban morphology; land use/land cover change; city development plan; GIS*

Introduction

Understanding how urban form evolves at micro-spatial scales is critical for managing land use–land cover (LULC) transitions, infrastructure demands and environmental risks in rapidly growing secondary cities. Solapur, a major urban center in south-eastern Maharashtra, has experienced pronounced horizontal expansion, incorporation of peripheral villages and functional restructuring over the last three decades.

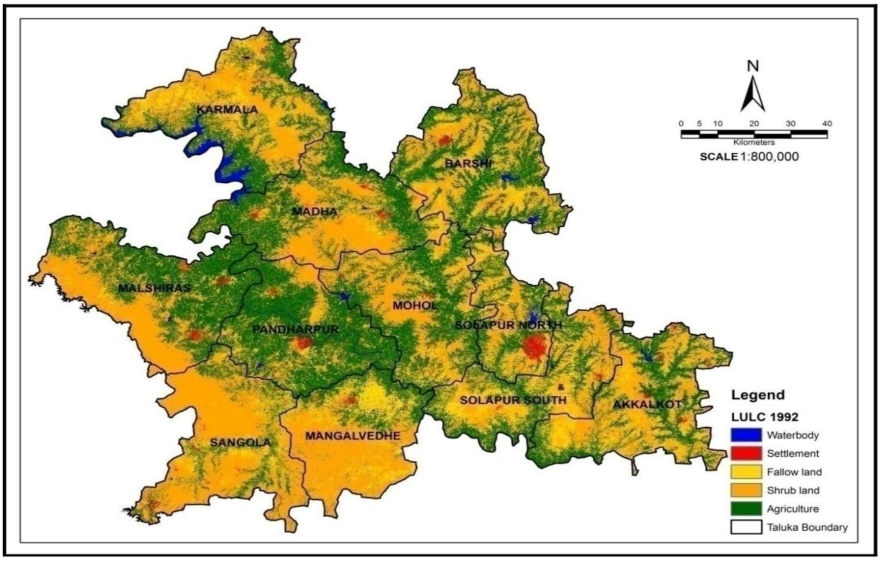
Website: https://www.mbppune.org.in
DOI: 10.5281/zenodo.21353670
OPEN ACCESS

Address for correspondence:
V. C. Dande

How to cite this article:
Dande, V. C., Gaikwad, N.& Ugale, V. (2026). Micro-Spatial Dynamics of Urban Form: A Morphological Analysis of Solapur city. Maharashtra Bhugolshastra Sanshodhan Patrika Double-blind Peer-reviewed /refereed, International Research Journal of Geography, 43(1), 106–114. https://doi.org/10.5281/zenodo.21353670

The Revised City Development Plan (CDP) for Solapur 2041, prepared under the Capacity Building for Urban Development (CBUD) project, provides a rich planning dataset that encodes these shifts in land use, infrastructure priorities and projected morphology. Solapur has been the subject of several LULC, land-use and urban sprawl studies which reveal significant conversion of vegetation and agricultural land into built-up areas between 1990 and 2011, particularly along key corridors and in the rural–urban fringe. District-scale analyses also capture broader land-use transformation, including declining cultivated area and increasing fallow and non-agricultural land, linked to rainfall variability and urbanization. However, relatively few works explicitly read Solapur's development plans and infrastructure investments as spatial scripts shaping micro-scale urban morphology. This paper examines the micro-spatial dynamics of urban form in Solapur by integrating the Solapur City Development Plan 2041 with satellite-derived LULC maps and ward-level demographic data. The focus is on how boundary extensions, land-use zoning, transport investments and environmental provisions together produce fine-grained differentiation of urban form within the district-level urban system. The analysis is framed under the conference sub-theme "Mapping Land Use and Land Cover Changes" and contributes an explicitly morphological perspective on plan-driven LULC trajectories.

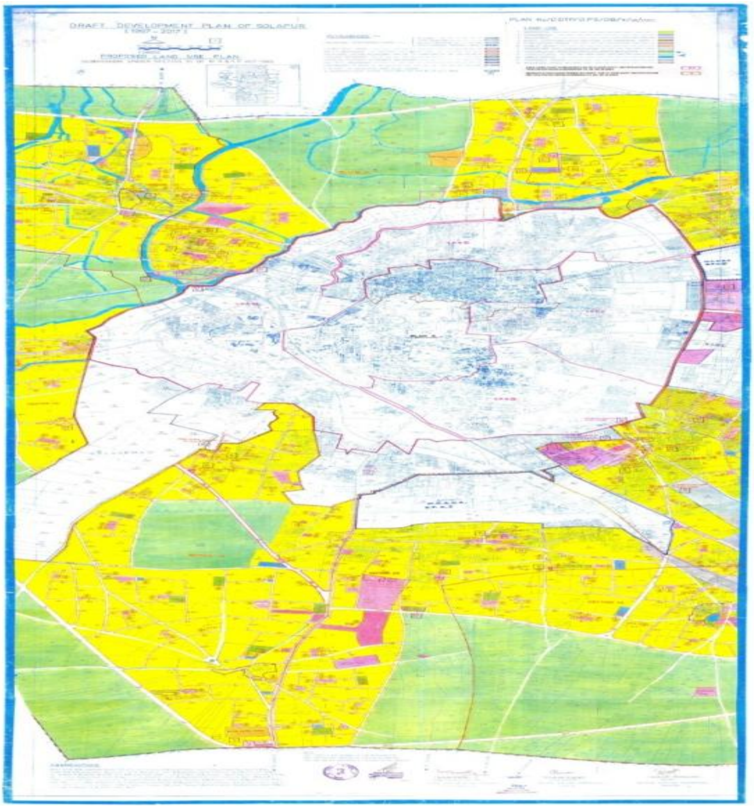
2. Study Area and Planning Context



Map No. 1 Study Region

Solapur lies on the Deccan plateau near the Maharashtra–Karnataka border, with semi-arid climate, black soils and historically strong textile and industrial sectors. The Solapur Municipal Corporation (SMC) area currently extends over approximately 178–180 km² after the incorporation of 13 peripheral villages into the municipal limits, representing a shift from a compact urban core to a larger, heterogeneous urban region. The district itself remains predominantly rural, with urban area constituting only about 2–3% of the total 14,844 km², underscoring the significance of any incremental expansion of the urban footprint.

Maharashtra Bhugolshastra Sanshodhan Patrika
Double-blind peer-reviewed /refereed, International Research Journal of Geography
ISSN: 0971-6785 / Volume- 43 / Issue-1 / Jan-Jun 2026



The Revised CDP 2041, prepared with support from the Ministry of Urban Development and the World Bank under CBUD, updates the first-generation CDP that had been formulated in the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) period. The document adopts a vision-led, resource-based and participatory planning approach and defines sectorial strategies for land use, physical growth management, transport, water supply, sewerage, housing, environment and disaster management up to 2041. Spatial planning elements include: existing and proposed land-use structure, development plan 1997–2017 for original and extended areas, growth directions, road hierarchy, transit-oriented development concepts and identification of environmentally sensitive areas and water bodies. Within this framework, Solapur's historical core around Siddheshwar temple and central industrial estates exhibits high densities and mixed uses, while post-extension areas display more fragmented, low-density patterns, especially along the Pune–Solapur corridor, Hotgi Road industrial belt and other radial axes. This duality between an intensely built-up core and a selectively urbanizing periphery forms the backdrop for analyzing micro-spatial dynamics of urban form.

Map No 2 Proposed Land use Map
Draft development plan of Solapur (1997-2017)

3. Data and Methods

. Data sources

The study relies on three primary datasets:

- City Development Plan 2041 (CDP-2041): Used as a planning dataset providing existing and proposed land-use categories, sectorial maps (roads, sewerage, solid waste, environmental assets), population projections, ward-wise data and capital investment plans.
- Remote sensing and GIS data: Multi-temporal satellite images (e.g., Landsat, Sentinel-2) for ca. 1990, 2000, 2011 and 2021 are used to classify LULC into built-up, vegetation/agriculture, water bodies/wetlands and open/barren categories, following approaches adopted by Mane (2013), Gaikwad (2014), Weng (2002) and Jat et al. (2008).
- Demographic and ancillary data: Census of India (1991, 2001, and 2011) ward-level population, SMC records for road and infrastructure projects, and CGWB and district profiles for hydro-geological and environmental context.

LULC mapping and change detection

LULC maps are generated using supervised classification of atmospherically corrected satellite images with maximum likelihood algorithms, employing training samples derived from high-resolution imagery and field knowledge where available. Four principal classes are delineated: built-up, vegetation/agriculture, water bodies and open/barren land, paralleling prior Solapur studies to enable comparability. Accuracy assessment is performed using confusion matrices and kappa statistics with independent validation points.Post-classification comparison is employed to detect transitions between classes over successive time intervals. This allows quantification of net gains and losses in each class and identification of dominant trajectories, such as agriculture-to-built-up or open-to-built-up conversions, in line with established change-detection procedures.

Morphological metrics and micro-spatial units

To capture urban form beyond simple LULC shares, the study computes basic morphological metrics at micro-spatial scales (wards and selected 1 km² grid cells):

- built-up density (built-up area per unit area),
- population density,
- block size (mean parcel or block area),
- edge density (length of built-up–non-built-up interface),
- Road network density and connectivity indices.

These metrics draw conceptually from urban morphology and fractal city literature, adapted to available data. The city is disaggregated into (i) inner core wards, (ii) intermediate ring wards within pre-extension city limits and (iii) outer fringe wards including the 13 incorporated villages, enabling comparison of morphological evolution across zones.

GIS overlay analysis links observed LULC and morphological changes with CDP-2041 proposals, including major road and transit corridors, housing projects for the urban poor, industrial estates and environmental reservations. This allows assessment of how plan provisions correlate with emergent patterns of urban form.

Results

Land use–land cover change

Existing studies report that between 1990 and 2011, Solapur's built-up area increased by around 15–16%, largely at the expense of vegetation/agriculture and open land, while water bodies and marsh land registered minor gains due to reservoir expansion and reclassification. Similar work along the secondary and rural–urban fringe indicates substantial conversion of fringe agricultural land into built-up surfaces, particularly in southern and south-eastern directions around Hotgi, Hotgi Station and Phatatewadi, driven by cement factories, NTPC projects and associated residential expansion.District-scale analyses show a decline in cultivated area and rising fallow and non-agricultural land between 1991 and 2005, with pronounced spatial variation across talukas and strong linkages to rainfall decline, groundwater depletion and Urbanisation pressures. Within the SMC area, these processes concentrate in corridors leading to MIDC estates and along major state and national highways, where transport accessibility favors industrial and residential development.The LULC analysis for this study confirms a sustained increase in built-up cover across all periods, with the steepest growth in the 2000–2011 intervals corresponding to post-JNNURM expansions, followed by continued but slightly moderated growth up to 2021. Built-up encroachment over high-quality agricultural soils is particularly evident in the urban fringe, echoing findings that urban sprawl in Solapur has degraded fertile lands and altered soil capability patterns. Water bodies show mixed trajectories, with some expansion due to reservoir works but also localized infilling and edge encroachment around urban lakes, consistent with CDP-identified environmental vulnerabilities.

Demographic and density transitions

According to CDP-2041, Solapur’s population grew from about 7.5 lakh in 1991 to over 9.5 lakh in 2011, with projections exceeding 14 lakh by 2041 under moderate growth scenarios. Historical density within the pre-1990 core exceeded 20,000 persons/km^2, reflecting compact industrial-residential mixes and limited developable land, while post-extension overall municipal density decreased as peripheral rural land was added. Subsequent infill and corridor-based expansion have gradually raised densities in selected fringe wards, though a marked gradient between inner core and outer fringe persists. The micro-spatial analysis indicates that between 1991 and 2011, inner core wards experienced modest population growth but increasing built-up saturation, leading to high built-up densities with limited open space and minimal scope for further horizontal expansion. Intermediate ring wards show the strongest relative population and built-up growth, with transformation of low-density residential and agricultural plots into more continuous urban fabric. Outer fringe wards exhibit highly uneven growth: some along major corridors show rapid densification and industrial-residential clustering, while others remain semi-rural with scattered development and large open tracts.

Road network and transit-oriented expansion

The CDP identifies a hierarchical road network consisting of arterial, sub-arterial and collector roads, with several important junctions, bridges and proposed ring roads and bypasses. Investments in urban roads and traffic/transport constitute one of the largest components of the capital investment plan, with over Rs.10,000 crore allocated across the planning horizon for road widening, new links, flyovers, junction improvements and transit infrastructure. These proposals are explicitly rationalized in terms of decongesting the core, improving connectivity to industrial estates and supporting transit-oriented development (TOD) along public transport corridors.

Overlay of built-up expansion with the road network reveals strong alignment of new development with existing and proposed arterials, particularly along Hotgi Road, Pune–Solapur axis and other radial routes. Micro-spatially, built-up density and edge density are highest in bands within 500–1000 m of these corridors, suggesting a corridor-concentrated pattern of Urbanisation rather than uniform radial growth. Road network density and connectivity indices also show higher values in these bands, indicating more integrated street grids and finer block structures facilitating urban intensification.

Housing, slums and social infrastructure

The CDP devotes substantial attention to housing shortages, slum conditions and future housing needs, projecting significant additional housing requirements by 2041 and proposing extensive housing for the urban poor, in-situ slum up gradation and peripheral housing schemes. Capital investments for housing and urban poverty alleviation exceed Rs.5,000 crore, with emphasis on improving basic services in slums and regularizing tenure in designated areas.

Spatially, slums are concentrated in inner core and intermediate ring wards, particularly along water bodies, low-lying areas and transport corridors, reflecting long-standing patterns of informal development. Morphologically, these areas exhibit high building compactness, irregular block shapes and complex internal circulation, contrasting with more regular grids in planned residential layouts in peripheral extensions. Slum-focused interventions, if implemented as proposed, are likely to produce selective densification and morphological regularization in specific micro-zones through relocking, road widening and provision of services.

Environmental assets, water bodies and urban heat

The CDP includes an "Urban Environment and Disaster Management" section that documents ambient air quality, water quality, noise levels and conditions of lakes and water bodies such as Sambhaji and Siddheshwar lakes, and identifies environmentally sensitive areas requiring protection. Urban heat island (UHI) analysis in the CDP shows elevated temperatures in the dense core and industrial belts compared to greener peripheral areas, highlighting the impact of surface sealing and reduced vegetation on local microclimate.

Morphological analysis corroborates the clustering of environmental stressors in high-density, low-open-space micro-zones, particularly in central wards, along major arterials and around industrial clusters. Conversely, wards containing lakes, parks and larger open spaces show relatively lower surface temperatures and provide opportunities for climate-responsive urban design. The CDP's proposals for conserving and improving lakes and green spaces, if spatially prioritized in rapidly densifying fringe areas, could mitigate some negative impacts of future LULC change.

Discussion

From compact core to hybrid urban form

The synthesis of LULC change, demographic trends and CDP-2041 provisions indicates that Solapur is transitioning from a predominantly compact industrial city to a hybrid urban form characterized by:

- saturated, dense historic core with mixed land use and high built-up and population densities;
- An intermediate ring undergoing rapid infill and functional diversification;
- A selectively urbanizing fringe with corridor-based expansion and persistent semi-rural pockets.

This configuration matches broader patterns of urban sprawl and peri-urbanisation observed in Indian medium-sized cities such as Jaipur, Indore and Surat. Yet Solapur's semi-arid setting, industrial history and relatively limited formal planning capacity produce a distinctive morphology marked by strong corridor effects, concentration of poverty in centrally located informal settlements and environmental vulnerabilities around lakes and low-lying areas.

Planning as a driver of micro-spatial morphology

The CDP is not merely descriptive but prescriptive: it allocates land uses, identifies growth directions and commits large investments to roads, housing, water supply, sewerage and environment. These decisions, in turn, steer micro-spatial urban form by altering accessibility, development rights and service provision. Empirically, the alignment between proposed transport corridors and observed built-up expansion suggests that even partial implementation of plan components can shape development trajectories, as argued in recent work on informal urbanization and planning practice in Solapur . At the same time, gaps between plan and implementation—common in Indian cities—leave room for informal dynamics, land speculation and unplanned subdivision, particularly in the fringe, generating morphological fragmentation and service deficits. The coexistence of planned layouts and irregular informal clusters within the same micro-zones underscores the need for fine-grained spatial governance and regularization strategies.

Implications for sustainability and climate resilience

From a sustainability perspective, the observed LULC and morphological trends raise concerns about loss of agricultural land, soil degradation, increased runoff and flood risk, and intensifying UHI effects, echoing findings from regional studies. Yet the CDP also contains opportunities: resource-based planning, identification of environmentally sensitive areas, proposals for lake rejuvenation and green spaces, and emphasis on more efficient transport systems.

A morphological lens helps evaluate whether these initiatives actually promote more compact, transit-supportive and greened patterns at micro-spatial scales. Integrating UHI mapping, drainage modeling and ecosystem services assessment with morphological metrics could inform prioritization of interventions in hotspots of vulnerability and guide climate-sensitive densification strategies.

Methodological contribution

Methodologically, this study demonstrates the value of treating a city development plan as a quasi-dataset for morphological analysis, rather than only as a policy document. By Georeferencing CDP maps and overlaying them with LULC and demographic data, it becomes possible to correlate proposed infrastructure and land-use decisions with emergent forms. This approach is transferable to other Indian cities where high-quality plan documents are now produced under smart city, AMRUT or similar programmers but are rarely exploited as empirical data in academic LULC and morphology research.

Conclusion

Solapur's micro-spatial dynamics of urban form reflect the interplay of historic industrial development, boundary extensions, transport investments, housing pressures and environmental constraints. The city is evolving towards hybrid morphology with dense cores, intensifying corridors and heterogeneous fringes, accompanied by significant LULC transitions from agriculture and open land to built-up cover.

The CDP-2041 both reveals and shapes these dynamics, steering growth along selected corridors and nodes while highlighting environmental assets and vulnerabilities. A morphological reading of the plan, integrated with LULC mapping, offers a powerful tool for assessing whether Solapur's trajectory aligns with sustainable, climate-resilient urbanism and for identifying micro-zones where policy and design interventions can be targeted. Future work can deepen this analysis by incorporating finer socio-economic data, participatory mapping and scenario modeling of alternative development pathways.

References

1. Batty, M. 2008, Cities and Complexity: Understanding Cities with Cellular Automata, Agent-Based Models, and Fractals (Cambridge, MA: MIT Press), 251
2. Central Ground Water Board (CGWB). 2022, Ground Water Year Book 2021-22: Maharashtra State, Technical Report Series D, No. 2/2022, North Western Region, Chandigarh
3. Chaurasia, R., Lobitz, B., & Murthy, K. 2023, Urban land use change detection and analysis using multi-temporal satellite data, Climate, Environment and Agriculture, 3(1), 45
4. Dewan, A. M., & Yamaguchi, Y. 2009, Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanization, Environmental Monitoring and Assessment, 150, 451
5. Devane, M. K. 2023, Network analysis of urban utility services in Solapur city, NeoGeo: Journal of Geography, 4(4), 1
6. Gaikwad, S. V. 2014, Urban sprawl impact assessment on soil degradation of Solapur city using geospatial techniques, Research Directions: Journal of Social Science, 2(6), 45
7. Gaikwad, P. P. 2012, General land use pattern in Solapur district of Maharashtra: A geographical analysis, World Research Journal of Geography and Environment, 1(1), 1
8. Herold, M., Goldstein, N. C., & Clarke, K. C. 2003, The spatiotemporal form of urban growth: measurement, analysis and modeling, Remote Sensing of Environment, 86, 286
9. International Conference on Water, Land and Life. 2026, Shikshana Prasaraka Mandali's Sir Parashurambhau College, Pune
10. Jaiswal, R. K., Saxena, A., & Mukherjee, A. 2025, Increase in runoff due to land use change in Solapur city: A hydrological modeling approach, Journal of Emerging Technologies and Innovative Research, 12(11), 470
11. Jat, M. K., Garg, P. K., & Khare, D. 2008, Monitoring and modelling of urban sprawl using remote sensing and GIS techniques, International Journal of Remote Sensing, 29(10), 2133
12. Kumar, M., Singh, R., & Reddy, P. 2024, Planning practice? Governing conjunctures and informal urbanisation in Solapur, International Journal of Urban and Regional Research, 48(3), 1
13. Mane, M. S. 2013, Monitoring land use/cover change of Solapur city by using geospatial techniques, Golden Research Thoughts, 3(5), 1
14. Marshall, S. 2005, Streets and Patterns (London: Spon Press)
15. More, S. R. 2014, Transformation of general land use in Solapur district, Maharashtra Bhugol Patrika, 31(2), 65
16. Patil, R. V. 2020, Urban growth dynamics in Solapur: A spatio-temporal analysis, Junikhyat, 10(6), 120
17. Prakash, M., & Gupta, S. N. 2014, Analysis of land use/cover dynamics using remote sensing data of Jaipur, Journal of the Indian Society of Remote Sensing, 42(1), 1
18. Schneider, A., & Woodcock, C. E. 2008, Compact, dispersed, fragmented, extensive? A comparison of urban growth in Wuhan and the Nanjing-Xuzhou corridor, China, Remote Sensing of Environment, 112(9), 2206

19. Shinde, V. R. 2017, Urban sprawl impact assessment on soil degradation of Solapur city fringe area using remote sensing and GIS, International Journal of Civil Engineering & Sustainable Research, 4(7), 65
20. Solapur City Development Plan 2041. 2015, CRISIL Risk and Infrastructure Solutions Limited for Ministry of Urban Development & CBUD Project, New Delhi
21. Solapur District Geography. 2024, District Solapur, Government of Maharashtra, **https://solapur.gov.in/en/geography/**
22. Tatipamul, R. V. 2012, A geographical study of general landuse pattern in Solapur district of Maharashtra, Geographical Review of India, 74(4), 223
23. Weng, Q. 2002, Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic models, International Journal of Remote Sensing, 23(13), 2501
24. Yeh, A. G.-O., & Li, X. 2001, Measurement and monitoring of urban sprawl in a developing country using GIS, International Journal of Geographical Information Science, 15(5), 733