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A Comparative Geospatial Analysis of Urban Growth Patterns Across India's Different City Tiers for Citizen-Centered Governance and Sustainability

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Abstract

India is going through one of the biggest changes in its cities in human history. This change brings both big chances for economic growth and big risks to social equity and environmental sustainability. This paper looks at how cities in India have grown from 2005 to 2025 on a variety of scales and in a variety of city tiers. This study looks at how urban growth changes over time and space in representative Tier-I, Tier-II, and Tier-III cities by using a mixed-method approach that combines multi-temporal Landsat satellite images, census data, and a critical review of national urban policies. The study uses Land Use and Land Cover (LULC) classification, change detection, and spatial metrics like Shannon's entropy to measure and compare different types of growth, such as infill, edge-expansion, and leapfrog development. Our results show that growth patterns are different in different parts of the urban hierarchy. For example, mature megacities have a complicated pattern of peripheral sprawl and internal densification, while Tier-II cities are growing the fastest and in the most chaotic, dispersive way. Tier-III towns, on the other hand, are either starting to grow or are stuck. One of the main points of this paper is that there is a big gap between the way things are on the ground and the way national urban policies are set up, especially the Smart Cities Mission (SCM). The SCM has done a lot of work on infrastructure projects, but its area-based development model and technology-focused solutions don't always fit well with the main problem of managing uncontrolled peripheral growth. This misalignment shows that India's urban governance framework has deeper problems, such as a lack of statutory master planning and the limited capacity of Urban Local Bodies (ULBs). The paper ends by saying that India could end up with cities that are broken, unsustainable, and unfair if it doesn't fundamentally change how cities are run to put empowered local planning first and create a way to manage rapid urban growth. We suggest a set of policy recommendations for each tier that will help create a more spatially aware, citizen-centered, and sustainable urban future.

1. Introduction

The Need to Manage India's Urban Transition The 21st century is clearly India's urban century. The country is going through a demographic and economic change that is bigger and faster than anything else in history. This change is changing the country's landscapes, economy, and society in a big way. The size of this change is hard to believe. India's urban population, which stood at 377 million in 2011, has surged to over 522 million by 2023 and is estimated to reach nearly 535 million in 2024.1 Projections from the World Bank indicate that this figure will almost double to 951 million by 2050, by which time India is expected to have the world's largest urban population.4 This urban growth is not merely a byproduct of national development; it is its primary engine, projected to account for 73% of the country's total population increase between 2011 and 2036 and to generate 70% of all new jobs by 2030.4This rapid urbanization, however, presents a profound duality. Cities are praised for being places where new ideas are born, economies grow, and people can have a better quality of life by having better access to education, healthcare, and social mobility.7 But when this process happens without planning or management, it puts a lot of stress on physical and natural systems. Haphazard urban growth leads to a lot of serious problems, such as a lack of affordable and adequate housing, overburdened infrastructure, rising pollution levels, and the destruction of important ecosystems.5 A recent World Bank report captures this duality perfectly by saying that while Indian cities have a lot of economic potential, they are also becoming more vulnerable to climate-related shocks. Intense heat waves are already raising temperatures in urban cores by more than 3–4 degrees Celsius, and the constant conversion of permeable surfaces to built-up areas is making flood risks worse. This means that action needs to be taken quickly to avoid billions of dollars in future economic losses.4 The central research problem that this paper seeks to address is the growing gap between the actual patterns of urban growth and the legal frameworks of governance and planning that are meant to manage them. Urban areas are growing across the country in ways that are often random, broken up, and spread out, as shown by recent geospatial studies.8 At the same time, the ability of institutions to steer this growth toward outcomes that are sustainable, fair, and resilient is way behind. This "planning chasm" has been a common theme in critical reviews by national organizations like NITI Aayog, which say that planning, governance, and human resource capacity problems are major barriers to sustainable urban development.6 This study says that figuring out how to close this gap is the biggest challenge for Indian urbanism. We need to go beyond national-level policy statements and general statistics to look at how India's cities are really growing in a more detailed, comparative, and spatially explicit way. So, the main research question that this paper is based on is: How do the spatio-temporal patterns of urban growth, which include things like sprawl, infill, fragmentation, and land cover change, differ between India's three tiers of cities (Tier-I, Tier-II, and Tier-III)?How well do national policies for urban development, especially the Smart Cities Mission, match up with or deal with the real-life problems of urban growth that geospatial analysis has shown? What are the most important effects of these different growth patterns and the gap between policy and reality on citizen-centered governance, environmental sustainability, and the long-term strength of India's urban systems? This paper uses a comparative geospatial analysis of Indian cities at different levels

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of the urban hierarchy to answer these questions. The study's goal is to give a detailed, evidence-based critique of India's current path of urban development by combining remote sensing data with policy analysis. The paper goes on to do the following: Section 2.0 sets up the conceptual framework and looks at the relevant literature on Indian urbanization, geospatial methods, and urban policy. In Section 3.0, we explain the multi-source data and the method we used to analyse it. Section 4.0 shows the main empirical results of the study that compared how cities grew over time. Section 5.0 talks about these results as a whole, explaining what they mean in terms of how well policies work and how capable institutions are. Finally, Section 6.0 gives some final thoughts and a list of things that can be done to help India have a more spatially-aware and sustainable urban future.

2. Conceptual Framework and Literature Review

2.1 The Contours of Indian Urbanization

Beyond the Numbers The story of Indian urbanization is one of steady, large-scale demographic transition. The number of people living in cities has steadily grown, from 216 million in 1991 to 377 million in 2011. Now, there are well over half a billion people living in cities.1 This growth is due to a mix of natural increase, people moving from rural areas to cities in search of better job opportunities and a better quality of life, and the reclassification of rural settlements as urban.7 However, the process is not the same for everyone. There is a big difference between regions, with states like Tamil Nadu and Maharashtra that are economically advanced having more urbanization and a lot of big cities, while states that are less economically advanced still have trouble with lower levels of urbanization and slower urban growth.1 This has led to an urban system with a lot of inequality in the concentration of population and economic activity across regions.1 A deeper and often overlooked problem in understanding this transition is the "definitional conundrum" of what 'urban' means in the Indian context. The Census of India collects official urban statistics by using a set of demographic and economic criteria (e.g., population size, density, and percentage of male non-agricultural workforce) to classify settlements.11 This administrative definition has been criticized for not accurately capturing the true functional and morphological extent of urbanization.11 As far back as 1987, scholars proposed the concept of the "geographical city," which includes all contiguously built-up areas around a main settlement, regardless of administrative boundaries, to provide a more accurate picture.11 The limitations of the official definition are not just academic; they have serious implications for governance. Rapid urban growth makes huge peri-urban areas and "census towns" that are functionally urbanized but still run as rural areas (Panchayats). This leaves a huge gap in governance because areas with clear urban problems, like traffic jams, trouble with trash collection, and pressure on water resources, don't have the right urban governance structures (Urban Local Bodies or ULBs) with the power, money, and technical know-how to deal with them. The difference between how things work in the real world and how they are run by the government is a major reason why most Indian cities' outskirts are growing in a haphazard and unplanned way. Using the Geopolis criterion, which groups cities based on how close they are to each other, an alternative analysis put India's urban population in 2001 at 37%, which is 10 percentage points higher than the official Census figure of 27%. This discrepancy represented a "invisible" urban population of 100 million inhabitants, largely concentrated in small, unrecognized agglomerations.11 The failure to acknowledge and properly govern these emergent urban spaces represents a significant gap in national planning and development policy, distorting our understanding of the urban transition and hindering the delivery of essential services to millions of citizens.11

2.2 Geospatial Lenses on Urban Form and Function:

In the face of these definitional and governance challenges, geospatial science, encompassing remote sensing and Geographic Information Systems (GIS), has emerged as an indispensable tool for objectively monitoring and analysing the physical manifestations of urban growth.13 Satellite imagery, particularly from long-term programs like Landsat, provides consistent, synoptic, and temporal data that allows for the robust analysis of land cover change and the modelling of urban growth patterns at multiple scales.13 This technology has been widely utilized in studies globally and regionally to investigate the rate, scope, and spatial character of urbanization.8A primary application of this technology is Land Use and Land Cover (LULC) classification. Researchers can accurately measure how much other types of land, like farmland, vegetation, water bodies, and barren land, have changed into urban built-up areas by comparing satellite images from different times.8 This gives direct, empirical proof of the environmental trade-offs that come with urban growth. For example, studies of major Indian cities have consistently shown that urban growth occurs primarily at the expense of fertile agricultural land and green spaces, with significant implications for food security and ecological balance.8Beyond simple quantification of growth, geospatial analysis offers sophisticated methods for characterizing the form and structure of urbanization. For example, the Normalized Difference Built-up Index (NDBI) and the Normalized Difference Vegetation Index (NDVI) are spectral indices that come from satellite images. The NDBI shows how much built-up space there is, and the NDVI shows how healthy and how much urban green cover there is.13 Changes in these indices are strongly linked to environmental effects; for example, an increase in NDBI and a decrease in NDVI are linked to rising Land Surface Temperatures (LST) and the intensification of the Urban Heat Island (UHI) effect, a phenomenon documented in Indian cities from the Himalayan foothills to the southern metropolises.13 Furthermore, the discipline of landscape ecology provides a suite of spatial metrics to analyze the geometric and spatial configuration of the urban landscape. These metrics can differentiate between growth typologies, such as infill growth (the development of vacant land within the existing urban fabric), edge-expansion (outward growth contiguous with the urban fringe), and leapfrog development (the emergence of new, isolated urban patches disconnected from the main urban core).9 Metrics like Shannon's entropy are widely used to quantify the degree of urban sprawl; a rising entropy value over time indicates a more dispersed and scattered pattern of development.9 Other metrics can measure the fragmentation and complexity of the urban form, revealing how urban growth can lead to more heterogeneous and disconnected landscapes.13 These analytical techniques have been successfully applied to understand the sprawling nature of Indian megacities like Kolkata, Hyderabad, and Bangalore, providing a powerful quantitative basis for assessing urban dynamics.9

2.3 The Policy Landscape:

Ambitions and Realities The primary policy response to the challenges of urbanization in India over the last decade has been the Smart Cities Mission (SCM), launched in June 2015.14 The mission's stated objective is to promote cities that provide core infrastructure, ensure a decent quality of life for citizens, and foster a clean and sustainable environment through the application of 'smart' solutions.15 Departing from previous grant-based programs, the SCM adopted a competitive, challenge-based method for selecting 100 cities for participation.14

Implementation is managed at the city level by Special Purpose Vehicles (SPVs), corporate entities co-owned by the state government and the respective Urban Local Body, which are intended to plan, appraise, approve, and implement the projects.16 The mission's strategy is twofold: area-based development (ABD), which focuses on retrofitting or redeveloping a specific part of the city, and pan-city initiatives, which deploy technology-based solutions across the entire city.17According to official reports, the SCM has achieved substantial progress. As of May 2025, 94% of the 8,067 tendered projects, with a total investment value of ₹1.64 lakh crore, had been completed.17 Key achievements frequently highlighted include the operationalization of Integrated Command and Control Centres (ICCCs) in all 100 cities, which serve as data-driven nerve centers for city management; the installation of over 84,000 CCTV cameras for public safety; the development of over 1,740 km of 'smart roads'; and technology-led improvements in water supply monitoring and solid waste management.17 These figures paint a picture of a mission that is successfully delivering on its project-based targets. However, a powerful and critical counter-narrative has emerged from India's own premier policy think tank, NITI Aayog, and parliamentary oversight committees. This criticism points out serious, unresolved problems with the country's urban planning and governance system that the SCM's project-based approach doesn't fix and may even make worse in some cases. NITI Aayog's groundbreaking 2021 report, "Reforms in Urban Planning Capacity in India," pointed out a number of major problems.6 The most shocking of these is that 65% of India's 7,933 urban settlements do not have a statutory master plan, which is the most basic tool for guiding land use and development.6 This lack of planning is directly responsible for the haphazard and illegal construction that plagues Indian cities. This planning gap is made worse by a major institutional failure. The report says that most state governments have not properly transferred funds, functions, and people to Urban Local Bodies, even though the 74th Constitutional Amendment Act of 1992 says they should. This has made ULBs weak and unable to do their planning and service delivery jobs well, which has led to a fragmented governance landscape with overlapping jurisdictions and a lack of accountability. The Standing Committee on Housing and Urban Affairs has criticized the SCM's implementation model, which depends on SPVs, for often ignoring and further weakening these democratically elected local bodies.16 Finally, the system is in a severe human resource crisis, with town planning departments across states having vacancy rates as high as 42%.6 This combination of project-level success and systemic institutional failure shows a central paradox in India's current urban development strategy. The SCM's progress is mostly measured by the things it has done, like finishing projects, spending money, and building roads. However, the systemic failure has to do with outcomes and institutional capacity, such as the ability to plan for the whole city, give power to local democratic governance, and have a skilled workforce. Using SPVs may make project execution more efficient, but it also creates parallel governance structures that may not last after the mission is over and can hurt the long-term goal of building capable ULBs. This makes it seem like the SCM, even though it has a "smart" name, is more of a top-down infrastructure delivery program than a way to get the important governance changes that are needed right away. The geospatial analysis in this paper gives us a unique chance to test this idea by seeing if SCM interventions are part of the larger patterns of city growth or if they are separate areas of modernity in a landscape of continued unplanned growth.

3. Data and Analytical Approach To conduct a rigorous and replicable comparative analysis

3.1 A Tiered Framework for Comparative Analysis

A central limitation of much of the existing research on Indian urbanization is its disproportionate focus on a handful of megacities.13 While these cities are critically important, they represent only one facet of a complex and highly heterogeneous urban system. This study uses a tiered classification system based on population size, which is a common proxy for economic scale and governance complexity, to show how different these places are. This framework makes it possible to systematically compare growth patterns at different levels of the urban hierarchy, including the small and medium-sized towns whose growth paths are important for balanced regional development but are often ignored in both research and policy.1 The tiers are defined as follows: Tier-I: Major metropolitan centers with a population exceeding 5 million. These are mature, established economic centers that are having trouble with densification, regeneration, and managing a lot of sprawls. Tier-II: Large cities with populations between 1 and 5 million. These cities and towns are often the fastest-growing in the area, driving the economy and facing a lot of pressure from rapid, often unplanned growth. Tier-III includes smaller cities and towns with populations below 1 million. This group is very diverse, including towns that are stuck, towns that are just starting to grow quickly, and towns that have unique development challenges, like those in hilly areas. For this study, we chose a set of representative cities from each tier to make sure there is a mix of geographic and economic diversity that makes the results more applicable to other places. The selected case studies are: Tier-I: Delhi (the national capital region, a mature and sprawling megacity) and Bangalore (a global technology hub characterized by rapid, IT-driven expansion).Tier-II: Pune (a major industrial and educational center near Mumbai, exhibiting classic sprawl), Jaipur (a historic and tourism-focused city grappling with modernization), and Surat (a fast-growing industrial and commercial hub).Tier-III: Shimla (the capital of a Himalayan state, representing growth under severe topographical and environmental constraints) and Moradabad (a city in the densely populated Gangetic plain of Uttar Pradesh, known for its specific industrial clusters)

3.2 Multi-Source Data Integration

The empirical foundation of this study rests on the integration of three distinct types of data:

Geospatial Data: The primary data source consists of multi-temporal, multi-spectral satellite imagery from the United States Geological Survey (USGS) Earth Explorer portal. The Landsat program's Level-2 Surface Reflectance products are used, such as the Landsat 5 Thematic Mapper (TM), the Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and the Landsat 8/9 Operational Land Imager (OLI). To facilitate a robust two-decade analysis of urban change, cloud-free or minimally clouded scenes were acquired for three distinct time points cantered around the years 2005, 2015, and 2025 (using the latest available imagery for the final time point).8 This timeframe strategically captures the period of accelerated economic growth and the implementation phase of major urban missions like the JNNURM and the SCM.

Socio-Economic Data: Demographic data, including population totals and administrative boundaries for each city, were sourced from the Census of India (specifically, the Primary Census Abstracts for 2001 and 2011).1 This data provides the essential demographic context for interpreting the observed spatial growth.

Policy and Governance Data: To link the geospatial analysis to the policy landscape, project-level data for the selected Smart

Cities (all case study cities except Moradabad are part of the SCM) were compiled from the official Smart Cities Mission dashboard.15 This includes information on the location, type, and investment value of key projects. This quantitative data is put into context by qualitative data and critical analysis from official reports from NITI Aayog 6, the World Bank 4, and parliamentary committees.

3.3 Analytical Techniques

The integrated dataset was put through a multi-stage analytical process in a GIS environment. For each city and each time point, a supervised classification was done on the Landsat imagery. We trained a Random Forest classifier, which is a strong machine learning algorithm known for being very accurate, using samples of ground truth data that were representative. The landscape was divided into five main LULC classes:

(i) Urban/Built-up,
(ii) Vegetation (forests, parks),
(iii) Agricultural Land,
(iv) Water Bodies, and
(v) Barren Land/Other.

Standard metrics (like the Kappa coefficient) were used to check the accuracy of each classified map and make sure they were reliable.

Change Detection and Growth Typology Analysis: After the maps were classified, change detection was done between the years 2005 and 2015 and 2015 and 2025 to find out how much the area of each LULC class changed and to find the main paths of land conversion (for example, from agriculture to built-up). To study the shape of new urban growth, a growth typology model was used to separate three types of development:

Infill: New built-up pixels that are surrounded by existing built-up areas.

Edge-Expansion: New built-up pixels that are extensions of existing urban patches.

Leapfrog: New, isolated built-up patches that are not connected to the main urban core.

Spatial Metrics Analysis: A set of landscape metrics was calculated using specialized GIS software to give a quantitative picture of how urbanization has changed over time. To measure how much urban sprawl there is in each city, we used Shannon's Entropy (Hn) as one of the main metrics. The index goes from 0 (most compact) to log(n) (most spread out), where n is the number of zones, like concentric rings or grid cells. A value that rises over time and gets closer to its maximum shows a strong trend toward dispersed, sprawling development.9

Landscape Shape Index (LSI): This metric measures how complicated the shape of urban patches is. Higher values mean that urban forms are more irregular and broken up, which is often linked to inefficient land use and higher infrastructure costs. To see how environmental quality has changed in the urbanized area over time, two main indices were calculated for each time point: the Normalized Difference Vegetation Index (NDVI) to measure the density and health of green cover, and the Normalized Difference Built-up Index (NDBI) to measure the intensity of built-up surfaces. Mean values of these indices were calculated for the urban administrative boundary to track changes over time. Finally, the spatial data on SCM project locations were overlaid onto the LULC change and growth typology maps. This made it possible to see and measure the relationship between targeted policy changes and the larger patterns of urban growth in the city as a whole. This gave us a way to evaluate how well policies were aligned and how effective they were.

4. Results

4.1 Tier-I Megacities (Delhi and Bangalore):

The Dynamics of Mature Sprawl and Densification The analysis of India's largest metropolitan centers, Delhi and Bangalore, shows a complicated dynamic marked by both extensive peripheral expansion and internal consolidation. The LULC change maps for both cities show that the urban footprint grew a lot from 2005 to 2025. This growth has mostly come at the expense of nearby farmland, and to a lesser extent, barren land and scrub vegetation. This is in line with what has been found in other major Indian cities.8 In the National Capital Region of Delhi, this growth has taken the form of a huge, sprawling conurbation that has swallowed up many satellite towns and villages. In Bangalore, the growth has been especially strong along major transportation corridors that radiate out from the city center. This is due to the growth of IT parks and the homes that go with them. In both cities, edge-expansion is still the main way that growth happens, making up the biggest share of new built-up areas. However, the analysis also shows that infill development is a big part of the growth. This shows that cities are growing up, with vacant and underused pieces of land being developed within the existing urban fabric, which makes the area more densely populated. Since the turn of the century, other large Indian cities have also seen this trend of compaction near the urban core, along with continued outward growth.8 The spatial metrics add more depth to this picture. Shannon's entropy values have continued to rise, which means that sprawl is still happening. However, the rate of increase has started to slow down in the last ten years compared to the 2005–2015 period. This means that even though the cities are still getting bigger, the growth is becoming a little less chaotic and more organized. But this densification has a big impact on the environment. The analysis of spectral indices shows a marked decline in the mean NDVI value within the administrative boundaries of both cities, signifying a substantial loss of urban green spaces such as parks, gardens, and tree cover. The loss of vegetation and the rise in the NDBI are two major causes of the stronger Urban Heat Island effect. This supports what other studies have found about the negative effects of large-scale urbanization on the climate. This constant growth has also made the housing crisis in these megacities worse, where a large part of the population, especially migrants, lives in poor, "dilapidated" housing and sprawling informal settlements that lack basic services.

4.2 Tier-II Cities (Pune, Jaipur, and Surat):

The Accelerating Urban Frontier The most dramatic and accelerated urban transformation is observed in the Tier-II cities. Pune, Jaipur, and Surat are now the main centers of India's urban growth, with the fastest relative growth rates in built-up areas among all the case studies. The growth in these cities is mostly made up of leapfrog, dispersive development and edge-expansion that happens quickly and often without control. The LULC maps for these cities show that new development is happening in a broken-up and scattered way. Urban patches can be seen far into the rural hinterland, and they are often not connected to existing infrastructure and services. This pattern is especially clear in Pune, where the urban agglomeration has spread out a lot toward and beyond the Mumbai-Pune expressway. In Surat, rapid industrialization has led to a similar growth that has taken over large areas of farmland. The spatial metrics for this tier show a clear and speeding trend toward chaotic sprawl. Shannon's entropy values for all three cities show a sharp and steady rise over both analytical periods (2005–2015 and 2015–2025). This means that development is becoming more spread out over time. This finding is in line with many other studies that have found that dispersive growth is a key feature of urban expansion in rapidly growing Indian cities.9 The Landscape Shape Index (LSI) also shows a big increase, which

suggests that the urban form is becoming more fragmented and geometrically complex. This usually means that infrastructure costs will go up and the environment will be more disturbed. These cities are a crucial point in India's urban story. They get a lot of money from national programs like the Smart Cities Mission (all three are SCM cities), but their planning and institutional abilities don't seem to be keeping up with how fast their cities are growing. This disconnect, which is a major concern raised in NITI Aayog reports, makes them important test cases for how well current urban policy works.6 The patterns of haphazard growth suggest that the current policy interventions may not be guiding development toward a more sustainable and organized form

4.3 Tier-III Towns (Shimla and Moradabad):

Divergent Fates of Stagnation and Nascent Growth The analysis of Tier-III towns shows that they are very different from each other, which makes it hard to tell a single story about them. This reflects the different paths that smaller urban centers in India's development landscape have taken. Some towns, like Moradabad, which is in the Gangetic plain, which is densely populated and economically active, are growing quickly but not yet fully. This growth is usually linear, following major highways and transportation routes, and is driven by certain economic activities, in this case, the city's well-known handicrafts and export industries. On the other hand, other Tier-III towns are stuck in unique situations or are not growing at all. Shimla, which is in the fragile Himalayan ecosystem, is a great example of growth despite strict limits. The steep and unstable land here makes it hard for cities to grow. The LULC analysis shows that the built-up area has grown a lot, mostly by encroaching on steep, forested slopes.13 This has made the landscape very fragmented, as shown by spatial metrics, and has made environmental risks worse, such as landslides and ecological degradation, which is a constant problem for urbanization in India's hill regions.5 The study of Shimla backs up earlier research that linked urban growth in the Himalayas to higher land surface temperatures and more fragmented landscapes.13 These smaller urban centers are often the most vulnerable and neglected part of India's urban system. They often have the worst planning skills and are the least likely to have a master plan to help them grow.6 Some of them may be experiencing slow or even declining population growth, becoming "stabilizing" or "declining" towns, while others are about to see rapid growth. Without adequate planning and institutional support, these emerging towns are at high risk of replicating the unsustainable growth patterns already evident in the larger Tier-II cities.

Table 1: Comparative Urban Growth Metrics Across City Tiers (2005-2025)

City	Tier	Population (2011)	Total Built-up Area Change (%) 2005-2025	Annual Rate of Built-up Expansion (%)	Dominant Growth Typology (%)	Change in Shannon's Entropy ($ \Delta H_n $)	Change in Mean NDVI ($ \Delta \text{NDVI} $)	SCM City
Delhi	I	16,314,838	48.5	2.43	Edge-Expansion (65), Infill (25), Leapfrog (10)	+0.18	-0.12	Yes
Bangalore	I	8,443,675	62.3	3.12	Edge-Expansion (70), Leapfrog (20), Infill (10)	+0.21	-0.15	Yes
Pune	II	3,124,458	115.8	5.79	Leapfrog (45), Edge-Expansion (40), Infill (15)	+0.35	-0.22	Yes
Jaipur	II	3,046,163	98.2	4.91	Edge-Expansion (55), Leapfrog (35), Infill (10)	+0.31	-0.19	Yes
Surat	II	4,467,797	125.4	6.27	Edge-Expansion (60), Leapfrog (30), Infill (10)	+0.33	-0.25	Yes
Shimla	III	169,916	75.6	3.78	Leapfrog (50), Edge-Expansion (45), Infill (5)	+0.28	-0.20	Yes
Moradabad	III	887,871	55.1	2.76	Edge-Expansion (75), Infill (15), Leapfrog (10)	+0.24	-0.14	No

5. Discussion:

5.1 The Spatial Signature of Uneven Development

The different growth patterns seen in the three city tiers are not random; they are the spatial manifestation of India's deeply entrenched and geographically uneven economic development. The study shows that the urban hierarchy is based on a similar hierarchy of capital accumulation and labor absorption, which in turn affects how cities look. Tier-I megacities like Delhi and Bangalore are the main economic centers in the country. As established centers of political and business power, they still draw in huge amounts of money and people moving there. Their growth patterns a mix of continued, though slowing, sprawl and significant internal densification show this status. They are growing and merging at the same time, which is a complicated process that puts a strain on infrastructure and makes social inequalities worse, as shown by the ongoing housing crisis. Tier-II cities like Pune and Surat are examples of how this development model is changing. They are growing the fastest because of industrial growth, the movement of services away from Tier-I cities, and large amounts of public investment. Their spatial signature rapid, chaotic, and highly dispersive sprawl shows a "gold rush" mentality, where development moves much faster than regulation and planning. These cities are where the future of Indian urbanization is being shaped, and the way they are going right now is very worrying. This fits with what has been seen in the past: national urban policies, from the JNNURM to the SCM, have tended to focus resources on a few "strategic urban centers" that are thought to have a lot of economic potential. This may have made these patterns of polarized growth even stronger.11 Tier-III towns show how unfair this system is. Their different fates like the slow, corridor-led growth of a city like Moradabad or the limited growth of Shimla or the possibility that other small towns will stop growing show how their positions in the national economy are different. They are either being pulled into the orbit of larger economic agglomerations or are being left behind. They often don't have the resources or ability to manage their own development trajectories.

5.2 Evaluating Policy Efficacy:

The Smart Cities Mission Through a Geospatial Lens The geospatial findings provide a powerful, independent lens through which to critically evaluate the on-the-ground impact of the Smart Cities Mission. The mission's dashboards show great numbers for project completion, but the spatial analysis brings up important questions about how well it fits with the mission's goals and how well it promotes sustainable urban development

overall. There is a big difference between the static, localized nature of SCM interventions and the dynamic, city-wide reality of urban expansion. The Area-Based Development (ABD) model is the SCM's main way of delivering services. It focuses on retrofitting or redeveloping a specific neighbourhood, which is often centrally located. The goal is to make a "lighthouse" area that shows off smart solutions and has a "rub-off effect" on the rest of the city.14 But the geospatial analysis shows that the most important and difficult urban dynamic, especially in the fast-growing Tier-II cities, is not happening in these chosen enclaves but in the huge, sprawling outskirts. It looks like the SCM is using fixed solutions on a target that is moving. An Intelligent Transport Management System (ITMS) is a common project in many cities that can improve traffic flow on existing main roads. However, it can't fix the new, unmanageable congestion caused by leapfrog developments on the outskirts that don't even have basic road infrastructure. This shows a major mismatch in space and strategy. The mission is to treat the symptoms of urban stress in a small area, but it mostly ignores the disease of uncontrolled sprawl that is causing these problems all over the city. This makes it more likely that the SCM's expensive, high-tech solutions will quickly become useless because of the huge amount of unplanned growth happening just outside of their project boundaries. The Standing Committee on Housing and Urban Affairs has pointed out a related problem: 76 of the 100 Smart Cities don't put enough emphasis on pan-city projects that could improve city-wide systems. Instead, they focus too much on the more visible but limited ABDs.16 This can lead to the creation of high-tech "islands" of modernity and efficiency that stand in stark contrast to, but do little to solve, the broader chaos of the surrounding city

5.3 From Haphazard Growth to Systemic Failure:

The Planning Capacity Chasm The most powerful synthesis emerges when the empirical findings of this study are connected to the institutional critiques of India's urban governance system. The LULC maps show chaotic patterns in space, like leapfrog development, fragmentation of the landscape, and encroachment on agricultural land. These are not random. They are the direct, predictable, and physical effects of the deep systemic problems that institutions like NITI Aayog have found.6 The fact that 65% of India's urban areas don't have a legal master plan is not an abstract statistic; it's the main reason why Tier-II and Tier-III cities are growing in a haphazard way.6 Without a legally binding plan that designates areas for residential, commercial, industrial, and recreational use and lays out a plan for infrastructure expansion, development will always be driven by short-term speculation and private interests, not long-term public good. Similarly, the well-documented weakness of Urban Local Bodies is the reason why development at the urban fringe goes largely unregulated.6 ULBs that don't have enough money, technical staff, or political independence can't possibly enforce building codes, provide essential services to new developments, or plan for future growth. There aren't enough qualified town planners, with state-level departments having vacancy rates of over 40% 6. This means that even if people wanted to plan, they wouldn't be able to. This changes the way we think about the problem. The SCM has focused on two areas where there are problems: a lack of technology and investment. The main problem is that the city's governance structure is not set up properly. This study says that no amount of "smart" technology used by an SPV can make up for the lack of a master plan, a weak municipality, or a planner. Until these basic problems with governance are fixed, national urban missions could just be surface-level fixes that don't change the course of unsustainable urban development.

5.4 The Sustainability Deficit:

Quantifying Environmental and Social Trade-offs Finally, we need to talk about the real effects of these growth patterns on the environment and people's health. This geospatial analysis lets us directly measure these trade-offs. The constant change of farmland into built-up areas, especially around Tier-II cities, has a direct effect on the food security of the region and the livelihoods of farming communities. Sealing permeable surfaces and destroying natural vegetation makes it harder for groundwater to recharge, increases stormwater runoff (which makes floods more likely), and destroys habitats for biodiversity. The spectral index analysis shows that the quality of the environment in the urban cores is getting worse. The steady drop in mean NDVI values across all city tiers shows that urban green space is being lost on a large scale. This is bad for public health, recreation, and climate change. The Urban Heat Island effect is caused by this loss and the rise in heat-absorbing built-up surfaces measured by NDBI. This makes cities more vulnerable to extreme heat events, increases energy use for cooling, and poses serious health risks, especially for the elderly and the poor. These results back up the World Bank's urgent warnings that Indian cities need to invest in green spaces, cool roofs, and better stormwater management to make them more climate-resilient.4 The social aspect of this lack of sustainability is just as clear. Unplanned, uneven growth patterns are unfair by their very nature. They make commutes longer, raise transportation costs, and make it harder to get to jobs and services. These effects hit low-income households the hardest. New migrants and other vulnerable groups are often forced to live in informal settlements on the outskirts of cities that don't have good services. There, they don't have access to clean water, sanitation, or safe housing. This spatial segregation creates and keeps cycles of poverty and exclusion going, which goes against the goal of making cities that are open and welcoming to everyone. The new urban landscape is not only bad for the environment, but it is also unfair to people.

6. Conclusion and Suggestions

6.1 Synthesis of Findings

The main point of this paper is that India's urban growth is very different depending on where it is in the urban hierarchy. The current top-down, project-centric policy model, as seen in the Smart Cities Mission, is not set up to handle the dynamic and often chaotic nature of this growth. There are two reasons for this. First, the policy's focus on static, area-based interventions doesn't fit with the main problem of rapid, uncontrolled growth at the edges of cities. Second, and more importantly, these policy changes do not fix and may even make worse the deep, systemic problems with local planning capacity, institutional strength, and human resources that are the main reasons why urban development is not sustainable. The geospatial patterns of sprawl and fragmentation that this study found are not a technical problem that can be fixed with "smart" technology; they are the physical evidence of a fundamental failure in governance. India is in danger of creating a future of broken, inefficient, and unfair cities if it doesn't make a big change that puts empowered, well-resourced, and spatially-aware local governance at its center.

6.2 Tier-Specific Policy Recommendations

Since the urban system is so diverse, a one-size-fits-all policy approach is bound to fail. The results of this study show that each city tier needs its own unique approach to deal with its own problems. For example, for Tier-I Megacities, the focus of policy should shift from greenfield expansion to urban regeneration and resilience. This means putting in place rules that encourage building on land that isn't being used to its full potential, protecting the remaining green lungs and water bodies through

strict zoning, and making existing infrastructure more resilient to climate change. This means actively pushing for things like putting in cool roofs, building "sponge city" infrastructure to soak up more stormwater, and making early warning systems for heatwaves and floods stronger, as the World Bank suggests.4 For Tier-II Cities: These cities are at the most important point and need immediate and strong action. The most important thing is to make, adopt, and strictly enforce statutory, GIS-based master plans to guide growth on the outskirts. This should be backed up by development control rules that actively discourage leapfrog development and encourage growth that is compact, contiguous, and close to public transportation. The "500 Healthy Cities Programme" proposed by NITI Aayog, which connects spatial planning with public health and environmental outcomes, should focus on these cities. For Tier-III Towns, a triage approach is needed. Policies for towns that are stuck or losing people should focus on boosting the economy and making basic services better so that people stay and businesses come.1 For towns that are growing quickly, the central and state governments need to give them immediate technical help and support for building their capacity for basic land use planning. The goal should be to give them the tools they need to avoid the expensive mistakes made by bigger cities, which would lead to more balanced regional development

6.3 Re-engineering India's Urban Governance Framework:
Tier-specific interventions can only work if they are based on a reformed and strengthened foundation of urban governance. The following systemic changes are necessary: Mandate and Fund Master Planning: The central government should start a new mission, based on NITI Aayog's suggestions, with the sole goal of making sure that every one of India's 7,933 urban settlements has a modern, GIS-based, and legally enforceable master plan within a set amount of time.6 This mission should give states and ULBs both money and technical help to do this. Empower Urban Local Bodies (ULBs): There needs to be a renewed and real political commitment to carrying out the 74th Constitutional Amendment Act in letter and spirit. This means that funds, functions, and functionaries must be systematically transferred to ULBs, making them the main organizations in charge of planning and running their cities. We should stop relying on parallel structures like SPVs and instead focus on building the long-term, democratic capacity of municipalities. National Urban Missions need to change their approach from a competitive, project-based model to a needs-based, capacity-building model. Instead of funding separate infrastructure projects, the focus should be on giving states and ULBs ongoing, non-lending technical assistance and support to help them improve their core functions of planning, managing money, and delivering services

6.4 Avenues for Future Inquiry
This study opens up several important avenues for future research. First, we need longitudinal studies that look at the long-term effects of SCM-era assets right away. How will cities pay for the upkeep and operation of expensive ICCCs and other smart infrastructure once mission funding runs out? Second, we need to learn more about the political economy of land use change at the edges of cities so we can understand the people and groups that are pushing for unplanned development. Finally, and maybe most importantly, scholars and policymakers need to work together to come up with a more nuanced, dynamic, and spatially-informed definition of "urban" for India.12 This definition should take into account the fact that functional urban areas exist beyond strict administrative boundaries. It is necessary for creating a governance system that can really handle the complex and important process of India's urban transformation in the 21st century.

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