CHAPTER 13

Analyzing and Comparing the Urban Sprawl in Tier-2 Cities of India: A GIS-Based Study

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ABSTRACT

Urban sprawl represents the uncontrolled, often unplanned spread of urban areas into rural landscapes, typically characterized by low population density, high car dependency, and inefficient land use. This study employs Geographic Information System (GIS) technology to examine urban expansion patterns in Tier-2 cities across India, focusing on growth drivers, such as migration, industrial development, and socio-economic changes. Using GIS, the research captures the impact of urbanization on land use, infrastructure, and natural resources, providing insights into the spatial dynamics over six decades. The study covers five cities and explores urbanization as cities expand to meet the demands for housing, services, and infrastructure. This research underscores the importance of sustainable urban development, strongly emphasizing social, economic, and environmental aspects, advocating for growth that preserves essential resources. Additionally, the research addresses a gap in urban planning, where strategies largely favor Tier-1 cities, often overlooking Tier-2 cities' needs. By integrating empirical data, the study advocates for informed urban planning that ensures equitable distribution of facilities and promotes sustainable development. Through predictive analysis, it aims to offer insights that can guide policymakers and urban planners in managing urban expansion effectively. This study's findings are expected to refine approaches to tracking and directing Tier-2 city growth, with an emphasis on achieving inclusive, sustainable urbanization that benefits all residents.

Keywords: Urban Sprawl; GIS; Tier-2 Cities; Urbanization; Land Use, Sustainable Development.

1.0 Introduction

The rush to urbanize is a hallmark of the 21st century, and one being witnessed mainly in the developing countries where economic growth, industrialization, and demographic changes are provoking urban expansion on a large scale. Such long and uncontrolled urban development is threatening the very existence of sustainable management systems by governments and planning organizations.

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As of the United Nations (2014), more than half of the world's population live in urban areas, and this figure is set to reach dizzy heights by 2050. By this time, approximately 90 of urban expansion is expected to occur in developing countries, placing immense pressure on infrastructure, resources, and social utilities (United Nations, 2015). Urbanization in the developed world is significantly slower than in some of the developing regions. Urbanization in developed regions is stable and mature, primarily in North America (82%), Latin America (80%), and Europe (73%). Conversely, urbanization in African (40%) and Asian (48%) developing regions occurs at a breathtaking pace, giving rise to a spectrum of problems, often characterized as unbridled or uncontrolled urban expansion (UN, 2014). The Indian definition of an urban area is specific; it should have a minimum population of 5,000, of which 75% or more of the male working population is engaged in non-agricultural activities, and inherently, a minimum population density of 400 persons per sq. km (Census, 2011). Hence, these criteria establish parameters for tracing urban growth and expansion patterns as opposed to areas on their way to becoming urban centers.

Urban sprawl is a type of spatial development characterized by low density, scattered, and leapfrog growth (Noor NM, 2013). Urban sprawl is generally unplanned urban growth and does not respect zoning laws; it usually leads to patterns of fragmented development. Urban sprawl, by definition, refers to those types of urban expansion that occur beyond the established city limits and generally involve isolated residential, commercial, or industrial zones where infrastructure development begins in an unregulated manner over predominantly rural and agricultural land. Proliferation of urban land-use patterns countering their rural counterparts is a major driving force behind sprawl, including the loss of agricultural land, environmental degradation, and increasing demand for resources (Nejadi, 2011). Sprawl, on the other hand, typically witnesses traffic congestion, inefficient land use, and ecological unfriendliness, in stark contrast with well-behaved and well-planned urbanization. Tier-2 cities like Nashik, Gandhinagar, and Thiruvananthapuram are witnessing massive urban expansion in India. These cities have emerged as economic hubs and are crucial for strengthening the balanced development of a region. Factors triggering the speedy growth of these cities include rising out-migration from rural to urban areas for better employment and living standards and emerging businesses and commercial hubs to attract investments, all at comparatively cheaper land prices than Tier-1 metro cities. Infrastructure improvement and enhanced easily without guidelines and the absence of space infrastructure along various profiles, environmental stress is but a few of the challenges that have visited these Tier-2 cities. The key to holding this rapid growth in check is to manage this growth fairly for a sustainable context.

Geographic Information Systems (GIS) is a powerful technique for analyzing and understanding urban sprawl through spatial analysis of land-use patterns, urban densities, and trends of development over time. It involves superimposing satellite image above census information and land cover information to reflect land-use changes such as the transitions involved in agricultural land to settlements in the urban envelope and maps of city growth

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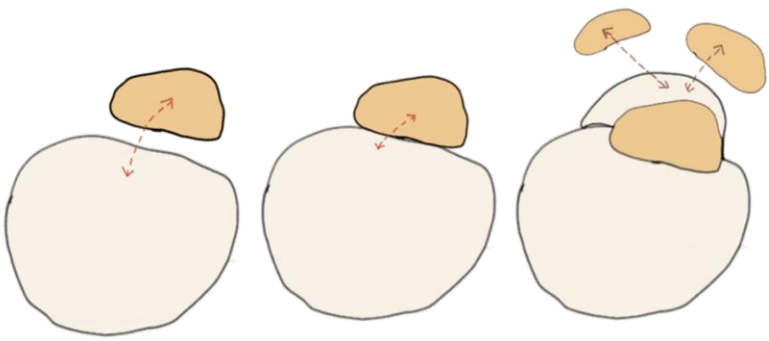
patterns across time. GIS critically assesses the environmental endue unsuitable expansion which accelerates future growth trends through a data-backed approach to policymakers and planners coming up with sustainability strategies for urban planning. Urban planners evaluate spatial dynamics concerning growth, future development trends, and strategies in sustainable urbanism through GIS analysis. In this manner, growth management is realized equitably with minor environmental footprints that are without neglecting the socio-economic rights of burgeoning urban citizenry.

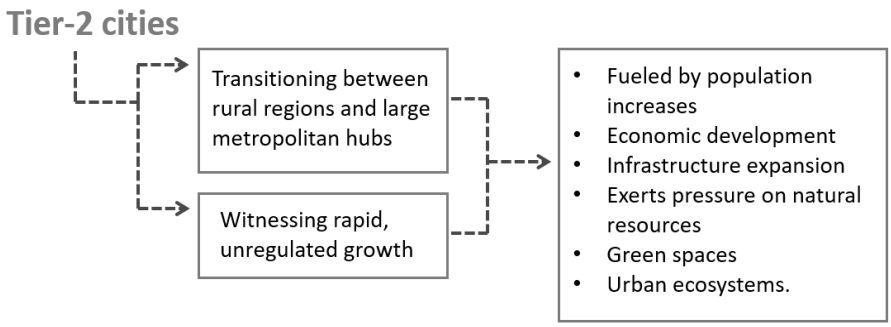
Using GIS-based analyses of Tier-2 cities, this research seeks to provide a complete view of the dynamics of urban sprawl. Important insights for policymakers, urban planners, and developers in formulating balancing acts between urban sprawl and other competing interests such as environmental conservation, infrastructural development, and social equity are provided by this study. As Tier-2 cities evolve, so will their role and importance of planning interventions powered through GIS for continual and sustainable growth and development.

Figure 1: How Cities Expand and Engulf the Neighboring Outgrowths, thus Extending the City's Boundaries



Source: Urbandesignlab

Figure 2: Tier 2



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1.1 Aim

This research utilizes GIS technology to assess urbanization dynamics and the factors driving growth in Tier-2 Indian cities. It examines spatial expansion and its impact on urban development, aiming to improve urban planning and policy formulation in India.

1.2 Objective

- To use GI tools to analyze the spatiotemporal urban growth patterns in selected Tier-2 cities.
- To examine the major socio-economic, infrastructural, and environmental causes of urban sprawl in these cities.
- To estimate the effects of urban sprawl on land use, infrastructure, and natural resources in the study areas.
- To evaluate the rate and growth of urban expansion in various Tier-2 cities and identify region-specific challenges.
- To explore sustainable urban development policies and strategies that can mitigate the problem of urban sprawl.

1.3 Need

Tier two cities in India are changing rapidly with better migration from the rural locales into the urban clusters. However, such rapid urbanization often results in unplanned urban sprawl that puts a lot of pressure on the existing infrastructure, eliminates farmland, and disturbs the ecosystem. To mitigate these situations, adequate urban planning, which is reliant on data, becomes a necessity. This research will analyze urban sprawl patterns using GIS and compare them, which aids in the preparation of better sustainable development and infrastructure planning. It will also be useful to fill in the policy voids as Tier-2 cities are easily neglected on a reasonable basis due to their sizeable assignments, unlike Tier-1 cities. The results will assist in more equitably directed and sustainable urbanization in the short term, cities with a rapid metabolic rate of changes.

1.4 Gap

Most studies and policies focus mainly on Tier-1 cities while very few seek to understand issues related to the rapid urban sprawl of Tier-2 cities. Little information is available concerning their patterns of urban sprawl, the effect on the growth of the city, how the city has been developing as a counter magnet over the decades, or the increase in the existing municipal boundaries over the decades. Further, scanty policies exist to meet these cities' specific needs. This study proposes addressing those gaps with the help of a GIS-based analysis of which city has growth potential as a Tier 1 city and enhance the sustainability of growth in Tier 2 cities.

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1.5 Novelty

This research brings novelty by shifting focus to Tier-2 cities, where urban growth is rapidly becoming critical but remains under-researched compared to Tier-1 cities. It addresses the gap by analyzing emerging urban centers and comparing their traditional development plans, often created without the use of GIS. By integrating GIS-based analysis, this study offers a fresh perspective on urban planning in these cities, providing more precise and data-driven insights for managing future growth.

1.6 Motivation

From the perspective of sustainable development, the unplanned, abrupt, and quick growth of cities—particularly in India's Tier-2 cities—is problematic. These cities are expanding quickly due to a lack of gender parity, widespread industrialization, economic growth, and environmental and agricultural land loss. They are also experiencing increased traffic from urbanization, poor basic infrastructure, and other issues. Understanding the patterns and processes of urbanization becomes crucial since these developing urban areas receive far less attention than Tier-1 cities. This effort aims to leverage the GIS capabilities to travel towards the geographical spread and is motivated by the requirement to provide timely responses about how these Tier-2 cities are expanding. Thus, this research will pinpoint present patterns, forecast future expansion, and develop strategies to help policymakers and urban planners control city expansion within their boundaries to prevent urban degradation and encourage constructive social, economic, and environmental development.

1.7 Studied theories

Various theoretical frameworks have shaped urban development and growth by providing insight into spatial order, social dynamics, and economic influences. Theories like those of the Garden City Movement, the Concentric Zone Model, and Multiple Nuclei Model emphasize spatial patterns that affect city expansion, zoning, and other land uses. Community-oriented models like the Theory of Community Development and Right to the City advocate for equitable 1and inclusive urban growth. Economic theories like Bid Rent Theory and Central Place Theory conceptualize the land value of goods and the distribution of services along urban hierarchies. Furthermore, theories spurred by sociological and behavioral understanding, such as the Theory of Creative Class, Broken Windows, and Drive-in Culture, analyze how prevailing societal trends and behavior in urban areas result in sprawl patterns and infrastructure. It is through an interaction with such a plethora of theories that this research aims to better understand urban sprawl and what can be done about it from the standpoint of sustainable urban planning and development.

2.0 Study Area

Uncontrolled urban growth, commonly resulting in urban sprawl, hurts the ecology, socioeconomic processes, and land use structures. The research explores the process of sprawl in

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Tier-2 Indian cities that are rapidly urbanizing, experiencing in-migration, and industrialization through GIS tools and LULC data. The findings seek to promote sustainable urbanization in these new economic centers.

Table 1: Details of Studied Theories

Theory/Model	Category	Focus Area	Key Implications for Urban Sprawl
Garden City Movement	Spatial Model	Planned self-contained cities surrounded by greenbelts.	Promotes controlled urban growth with green space preservation.
The Theory of the City	Urban Development	Explains city formation and spatial organization.	Provides a framework for understanding city expansion and dynamics.
Concentric Zone Model	Spatial Model	Urban growth as a series of concentric rings.	Highlights urban core expansion and land use zoning.
Sector Model	Spatial Model	Urban growth along transportation routes forming sectors.	Emphasizes the role of transport in guiding urban sprawl.
Multiple Nuclei Model	Spatial Model	Cities with multiple centers of activity rather than one central core.	Identifies polycentric urban growth patterns.
Theory of Community Development	Community Theory	Focuses on inclusive development for urban communities.	Promotes sustainable, equitable growth in urban and peri-urban areas.
Right to the City	Community Theory	Advocates for equitable access to urban spaces and resources.	Guides policies for inclusive urbanization.
Range and Threshold	Economic Theory	Explains the minimum population needed to support services.	Affects service distribution and urban land use patterns.
Rank Size Rule	Economic Theory	Describes the distribution of city sizes within a country.	Helps in understanding urban hierarchy and sprawl dynamics.
Bid Rent Theory	Economic Theory	Land value decreases as the distance from the city center increases.	Explains urban land use zoning and density variations.
Central Place Theory	Economic Theory	Explains the spatial arrangement of cities based on market areas.	Supports city planning for service allocation and development.
Theory of Creative Class	Economic/Social	Emphasizes the role of creative professionals in urban growth.	Highlights the impact of creativity and innovation on urban expansion.
Ladder of Citizen Participation	Governance/Community	Explains levels of public involvement in decision-making.	Encourages participatory urban planning and reduces resistance to sprawl policies.
Theory of Broken Windows	Urban Behavior	Suggests that visible signs of disorder encourage further crime and neglect.	Highlights the importance of maintaining urban spaces to reduce social decay.
Theory of Drive-in Culture	Cultural	Explores how automobile dependence shapes urban form.	Explains sprawl due to car-centric infrastructure development.

Source: Urban Design Lab

2.1 Study area selection

The study area chosen is Class II cities, which are characterized by a population size of 50,000 to 99,999. Three criteria for selection are used: the definition of Class II cities, an extensive study of the population, and the choice of appropriate cities. In Nashik, Maharashtra, the population has increased dramatically over the years. Nashik had a population of 330,000 in 1975, which rose to 886,000 in 1995. In 2015, the population decreased marginally to 782,000 but is expected to grow to 1,767,000 by 2025. Gandhinagar, Gujarat, also had steady population growth. The city was home to a population of 2,050,000 in 1975, and this rose to 4,140,000 by 1995. In 2015, the population was 7,109,000 with a forecasted value of 9,062,000 by 2025. Thiruvananthapuram, Kerala, had a similar pattern of growth. Its population was 550,000 in 1975, increasing to 998,000 in 1995. Its population grew to 2,058,000 in 2015 and is estimated to reach 3,073,000 by 2025. These are patterns of accelerated urbanization and population growth in these major cities over the decades.

2.2 Nashik, Maharashtra

Nashik, in the state of Maharashtra, enjoys a rich history. It was renamed from Gulshanabad in 1734, and Nashik district came into existence formally in 1869. Nashik lies

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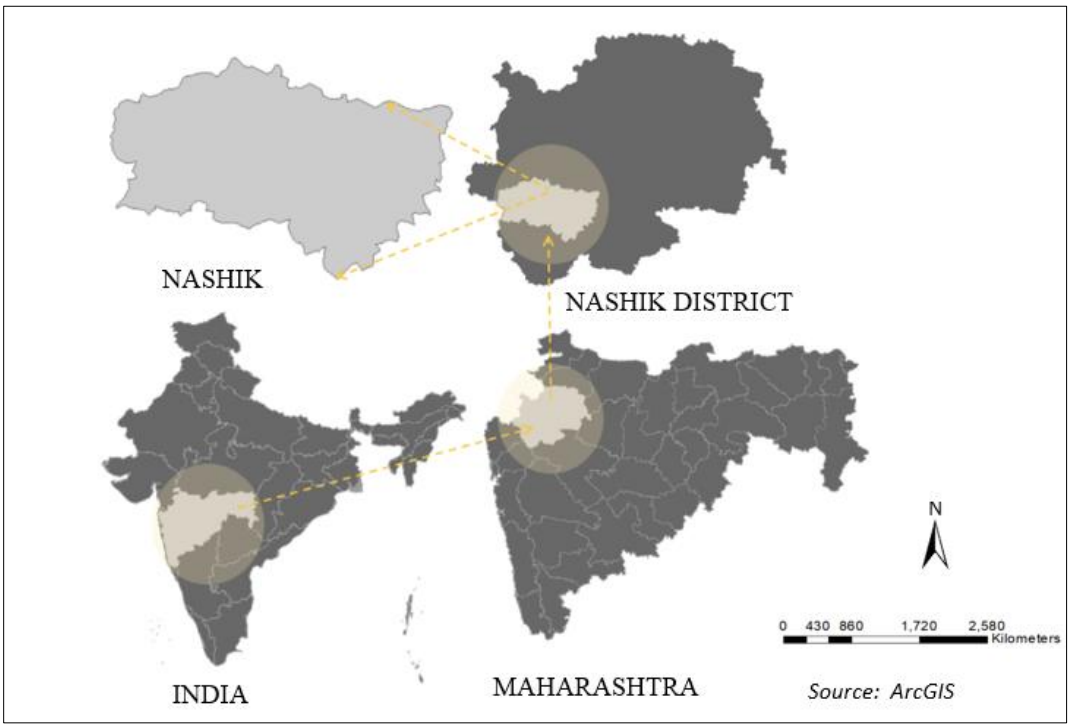
geographically in the Western Ghats on the Deccan Plateau at an elevation of 700 meters above sea level, with coordinates ranging from 19°35'–20°50' N latitude and 73°16'–74°56' E longitude. The climate of the city measures approximately 25°C, with winter seasons having temperatures almost up to 20°C and summer seasons reaching 38°C, especially in May. Nashik has economic as well as cultural importance as it flows through the Godavari River and is renowned throughout the world as the "Wine Capital of India", merging classical as well as contemporary elements. Economically, Nashik has earned its status based on the Smart City initiative and acts as a hub of industries related to automobile, engineering, and agricultural manufacturing. The city has good connectivity, located 180 km from Mumbai and Pune, thus making it open for trade and travel. According to the 2011 Census, Nashik had a population of 1.49 million, with a significant 22.3% growth rate, indicating its increasing urban growth and economic opportunities.

Figure 3: Location Map of Nashik, Maharashtra



Source: Survey of India

2.3 Thiruvananthapuram, Kerala

Thiruvananthapuram, also in Kerala, has been steeped in history as the capital of Travancore since 1745, founded by Marthanda Varma. The city's geographical location is

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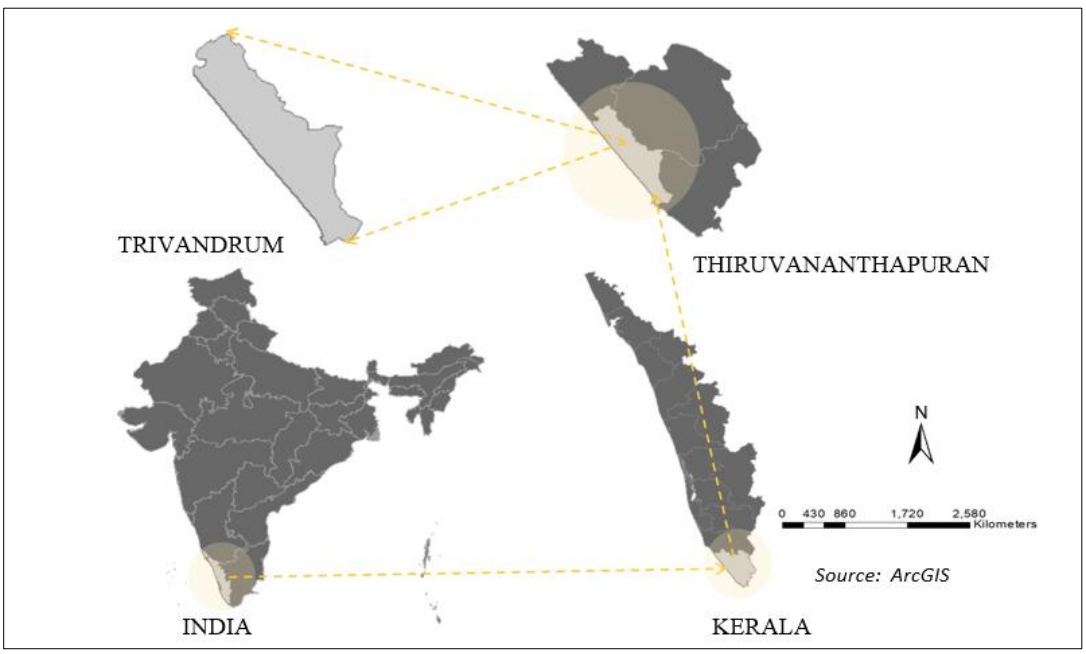
between the Western Ghats and the Arabian Sea and at an altitude of 16 feet above sea level. The climate of the city is of tropical savanna and monsoon type, with maximum and minimum temperatures rising to 34°C and falling to 19°C, respectively. Thiruvananthapuram is important as the capital of Kerala and a major cultural center. It is famous for its beautiful beaches such as Kovalam and Varkala, as well as notable landmarks including the Sree Padmanabhaswamy Temple. The city is economically prosperous through its IT industry, led by Technopark, and its thriving services and tourism sectors. According to the 2011 Census, the population of Thiruvananthapuram was 3.3 million, with a reported 3.25% growth rate, demonstrating consistent growth and urbanization.

Figure 4: Location Map of Thiruvananthapuram, Kerala



Source: Survey of India

2.4 Gandhinagar, Gujarat

The state capital of Gujarat, Gandhinagar, is a planned city formed in 1960 upon the creation of the state of Gujarat. Mahatma Gandhi-inspired, Gandhinagar is an organized and systematically planned city with large open spaces. In geography, Gandhinagar sits at the shores of the Sabarmati River and is set around 81 meters above mean sea level. The city has a semi-arid climate, with mean temperatures of 42°C for summer and approximately 14°C for winter. Gandhinagar is famous for its importance as Gujarat's administrative capital and contains important landmarks like the Akshardham Temple, Indroda Nature Park, and Sarita Udyan. The

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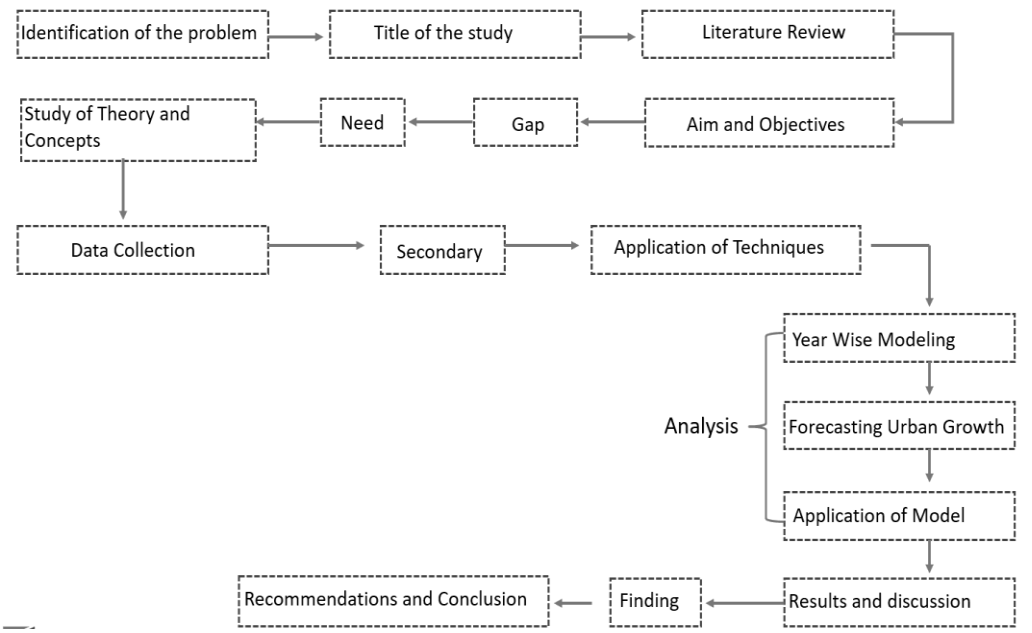
city is economically flourishing as an emerging Information Technology, electronics, and textile hub. The establishment of GIFT City (Gujarat International Finance Tec-City) has also reinforced its position as a financial and business hub. With good connectivity to major cities such as Ahmedabad (only 23 km away) and well-planned road infrastructure, Gandhinagar provides effortless commuting possibilities. According to the 2011 Census, Gandhinagar had a population of 292,000, indicating its well-planned growth and consistent development as a key urban hub

3.0 Methodology

Figure 5: Schematic Representation of Methodology Followed in the Study



4.0 Literature Review

Urban sprawl has become a central theme in urban studies, especially in rapidly developing countries like India, where urban growth often outpaces planning frameworks. The phenomenon is characterized by the unplanned expansion of cities into rural hinterlands, leading to inefficient land use, ecological disruption, and social disparity. Scholars such as Angel (2011) emphasize that urban sprawl is largely driven by increasing demand for residential and commercial space, fueled by population growth and economic expansion. This is particularly true for Tier-2 Indian cities, which are transitioning into key economic hubs amid rising rural-to-

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urban migration (Sharma, 2019). Research by Sudhira *et al.* (2004) and Singh (2018) highlights the multifaceted impact of urban sprawl, including the degradation of agricultural land, loss of green cover, stress on water resources, and exacerbation of infrastructure deficits. Socioeconomic consequences such as informal settlements and service inequality in peri-urban areas further illustrate the adverse effects of unmanaged growth. These findings underscore the urgency of adopting tools and frameworks that can better monitor and manage urban expansion.

A notable methodological advancement in the study of urban sprawl is the use of Geographic Information Systems (GIS) and Land Use/Land Cover (LULC) analysis. GIS facilitates spatial and temporal monitoring of urban growth patterns, providing crucial data to assess land-use transitions and predict future expansion. Herold *et al.* (2003) and Jat *et al.* (2008) demonstrated the effectiveness of GIS in capturing urban sprawl in Indian cities like Jaipur, where significant encroachment into agricultural zones was detected. Similarly, studies in cities such as Surat and Indore (Verma, 2020) reveal rapid, uncoordinated expansion, illustrating a pan-Indian pattern in Tier-2 cities.

Further, Bharath *et al.* (2012) stress the relevance of predictive modeling using tools like Cellular Automata (CA) and CA-Markov models, which allow researchers and planners to forecast urban growth by simulating various land-use scenarios based on historical data. These models are especially critical for Tier-2 cities, where formal planning often lags behind ground realities. Thematic reviews of the literature cluster urban sprawl research into four domains: LULC analysis, sprawl measurement through indices like Shannon's entropy, exploration of socioeconomic and environmental drivers, and urban growth modeling. The paper under review aligns well with this framework, integrating LULC analysis with spatial metrics and socio-environmental insights to develop a comprehensive understanding of urban expansion in Tier-2 cities. However, despite this body of work, a significant research gap remains. Most empirical studies and planning initiatives are concentrated on Tier-1 cities, leaving Tier-2 cities under-researched and underrepresented in policy frameworks. This study addresses that gap by employing a comparative GIS-based approach to analyze sprawl in cities like Nashik, Gandhinagar, and Thiruvananthapuram. The novelty lies in examining these mid-sized cities not only as passive growth recipients but as active nodes shaping India's urban future

5.0 Results

After conducting an exhaustive literature review of 1,319 research publications on urban development simulation and management were evaluated both qualitatively and quantitatively; the majority of these studies used the use of geographic information systems (GIS) to analyze changes in land use and land cover (LULC). Of these, 126 research examined LULC data to comprehend urban sprawl, while 98 studies focused on prediction models. With only ten publications, LUCC research lacked compactness. The main focus of 782 papers was the use of AHP in GIS to urban land use planning and suitability evaluations. Using remote

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sensing and regional analysis, 41 of these projects addressed urban sprawl without exposing the threat of GIS, demonstrating its significance in planning and preventing urban invasion. Urban sprawl has been a major area of research worldwide, particularly in emerging countries where cities are growing at previously unheard-of speeds. According to (Angel, 2011) the desire for more residential and commercial space, population growth, and economic development are the main causes of urban sprawl. In India, migration from rural to urban regions is a significant element in the fast growth of metropolitan areas, particularly in Tier-2 cities. These cities are changing from being important regional centers to major economic hubs, which is putting a lot of strain on the infrastructure and causing major changes in land use (Sharma, 2019).

Table 2: Paper Studied

Sr. No.	Keywords	Number of Papers
1	Forecast AND Urban growth simulation AND Urban sprawl AND GIS	98
2	GIS AND LU/LC AND Urban Sprawl AND Urbanization	126
3	Growth patterns AND Land Use/Cover Change (LUCC) and GIS AND compactness	10
4	Urban Development AND land suitability AND planning AND urban sprawl AND Land use change AND GIS	262
5	GIS-AHPAND land suitability AND planning AND urban sprawl	782
6	GIS; Land Use/Cover Change (LUCC) AND Regional Comparison AND Remote Sensing AND Urban Sprawl	41

Source: Scopus

The effects of urban expansion on the environment and socioeconomics are widely known. Uncontrolled urban expansion, according to (Sudhira, 2004), has several detrimental effects, including the loss of green space and agricultural land, increased pollution of the air and water, and stress on nearby ecosystems. In addition, the unplanned urbanization of rural regions worsens socioeconomic inequality and upends traditional livelihoods. According to (Singh, 2018)peri-urban informal communities frequently lack access to essential utilities like power, water, and sanitary facilities, making it difficult for local governments to provide enough infrastructure. Land Use and Land Cover (LULC) datasets and Geographic Information Systems (GIS) are widely used to quantify and evaluate urban sprawl. According to (Herold, 2003) GIS-based spatial analysis offers important insights into how cities expand over time. Researchers may follow changes in land cover and quantify urban expansion by classifying diverse land uses, such as residential, commercial, agricultural, and forest regions, using satellite-based LULC data. When (Jat, 2008)used GIS to analyze urban sprawl in Jaipur, India, they discovered that the city has greatly grown into the rural and agricultural areas. Cities like Surat and Indore have shown similar tendencies of unchecked expansion (Verma, 2020). Future urban growth models are increasingly crucial for forecasting sprawl and designing sustainable development

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policies. The use of spatial models that forecast future urban growth based on existing population patterns, economic conditions, and land-use regulations is highlighted by (Bharath, 2012), Urban planners in Tier-2 cities, where the infrastructure is frequently ill-prepared to manage increasing urbanization, depend heavily on these models. By taking proactive steps based on GIS-based analysis, sprawl's negative consequences may be lessened, encouraging balanced and sustainable urban growth.

Table 3: Thematic Literature

Theme	Description	Number of Paper
Land Use/Land Cover (LULC) Analysis	Utilizing remote sensing to analyze LULC changes is a foundational tool for understanding urban expansion. Researchers can track spatial changes and urbanization over time by categorizing satellite images into types like built-up areas, vegetation, water bodies, and agricultural land.	12
Measuring Urban Sprawl	Metrics like Shannon's entropy and landscape metrics provide insights into the structure of urban sprawl, helping to assess spatial patterns, fragmentation, and dispersion, which are key to understanding the intensity and extent of sprawl.	58
Drivers and Impacts of Urban Growth	Identifying the key drivers, such as population growth, economic factors, and policy decisions, sheds light on urban sprawl's causes. Recognizing these drivers is essential for managing and mitigating the environmental and societal impacts of rapid urbanization.	12
Urban Growth Modeling and Prediction	Predictive models, such as Cellular Automata (CA)-Markov and regression-based analyses, allow researchers to forecast urban growth patterns. These models utilize historical data and identify growth drivers to anticipate future urban expansion and guide proactive planning.	6

Understanding urban sprawl and its mechanisms is necessary for future city growth management to be successful. Unchecked urban growth into "natural" areas compromises land management, environmental protection, and socioeconomic stability. Once again, because of the speed at which cities are growing, particularly in developing nations, GIS and remote sensing have become essential tools for tracking and analyzing the trends and mechanisms of urban sprawl. The existing research is arranged in four —Land Use/Land Cover (LULC) Analysis, Measuring Urban Sprawl, Drivers and Impacts of Urban Growth, and Urban Growth Modeling and Prediction—each of which focuses on a distinct facet of managing urban sprawl, according to a thematic literature review on the chosen topic. In this research work, urban growth trends in Tier-2 Indian cities are evaluated using both GIS analysis and LULC change over time as a result of social, industrial, and migratory changes. The analysis of five cities—Kochi, Surat, Indore, Nagpur, and Udaipur—reveals evidence of occupancy expansion and its related effects, which include poor management of the growth, resource depletion, environmental degradation,

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and social issues. This research can help guide more sustainable and effective city development by highlighting frequently overlooked features of Cities.

6.0 Conclusion

According to the research, unplanned urban sprawl—the ease with which older Tier-2 cities grow—poses a threat to sustainable urbanization during periods of controlled resettlement. For this reason, policy directives must be clear, balanced, and proactive. Growth management and the requirement for equality in urban development depend heavily on the usage of GIS and LULC data. These results urge actions to improve Tier-2 Cities' sustainability, which is a crucial component of India's urbanization problem.

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