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Urban Sprawl of Towns in NCR Sub-Region of Haryana: A Geographical Perspectives

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ABSTRACT

Urban sprawl refers to the uncontrolled expansion of urban areas into surrounding rural and agricultural lands, often resulting in fragmented development, environmental degradation, and infrastructure stress. In the National Capital Region (NCR) of Haryana, rapid urbanization, driven by industrialization, population migration, and improved connectivity, has significantly altered the urban landscape. This transformation has led to the conversion of agricultural land into built-up areas, increased pressure on natural resources, and challenges in urban planning. Understanding the pattern and extent of urban sprawl is crucial for formulating sustainable development policies that balance urban growth with environmental conservation and infrastructure development. The study analyzed urban sprawl patterns in Class-I towns of Haryana's NCR over a 30-year period, identifying key drivers, and assessing impact on land use, infrastructure, and environmental sustainability, providing insights into urban governance and resource management.The study used secondary data sources like topographical maps and satellite imagery to analyze urban sprawl changes over time. The study uses Geographic Information System techniques to analyze urban expansion in Class-I towns in Haryana's NCR, revealing high growth in Gurugram, Faridabad, Sonipat, Panipat, and Rohtak. The study highlights the negative effects of unchecked urban expansion, including agricultural loss, increased surface runoff, heat island effects, traffic congestion, inefficient waste management, and water scarcity. The study underscored the necessity of integrated urban planning, suggesting smart growth policies, mixed land-use zoning, and sustainable transport for balanced urban expansion. Overall, the research provided critical insights for policymakers, urban planners, and local authorities to manage urban sprawl effectively while promoting socio-economic and environmental sustainability.

Keywords: Urban Sprawl, Land Use Change, NCR Haryana, Sustainable Planning

INTRODUCTION

Urban sprawlwas a defining characteristic of contemporary urbanization, referred to the uncontrolled expansion of cities and towns into peripheral rural areas. This phenomenon was particularly evident in rapidly developing regions, where industrialization, population growth, and infrastructure development fueled horizontal urban growth (Seto et al., 2010). In India, the National Capital Region (NCR) witnessed intense urban sprawl over the past few decades, significantly altering the spatial and demographic landscape of its constituent towns. Haryana, a key sub-region of the NCR, experienced rapid urbanization, with Class-I towns expanding far beyond their historical cores due to increased migration, economic opportunities, and improved transportation networks (Chauhan & Kumar, 2020).

Urban expansion in Haryana's NCR sub-region was primarily driven by industrial growth, infrastructural investments, and improved connectivity to Delhi and other metropolitan areas. Towns such as Faridabad, Gurugram, Sonipat, and Panipat transformed into major economic and residential hubs, attracting a diverse population that sought employment and better living conditions (Kumar et al., 2023). The development of expressways, metro rail networks, and national highways further accelerated this expansion, leading to a shift from compact urban centers to sprawling, decentralized urban landscapes (Pramanik et al., 2021). However, while urban growth facilitated economic development, it also resulted in unregulated land-use changes, encroachment on agricultural land, and environmental concerns (Singh et al., 2022).

The consequences of urban sprawl in Haryana’s NCR towns were multi-dimensional, affecting land use, socio-economic structures, and environmental sustainability. One of the most significant impacts was the loss of agricultural land, as fertile farmlands were increasingly converted into residential, commercial, and industrial zones (Verma, 2019). This not only affected food security and rural livelihoods but also contributed to ecological imbalances, including the

reduction of green cover and increased surface runoff. Additionally, the lack of planned urban infrastructure led to challenges such as traffic congestion, water scarcity, and inadequate waste management (Jain, 2017).
The transformation of urban morphology due to sprawl created fragmented and inefficient urban systems, making it difficult for local governments to provide adequate services and amenities to residents. Remote sensing and GIS-based spatial analysis aided in mapping urban expansion trends, enabling policymakers to identify growth areas and implement necessary interventions for sustainable urban policies (Narain, 2017).

Moreover, scholars emphasized the importance of planned urban expansion, integrating smart growth strategies such as mixed land use, public transport-oriented development, and the preservation of open spaces (Ewing, 2017). While several government policies, including master plans and green belt regulations, were introduced to control sprawl, their effectiveness remained limited due to weak enforcement and increasing land demand (Sharma, 2022).

This study aimed to analyze the spatial growth patterns of Class-I towns in Haryana's NCR from 1991 to 2021 using satellite imagery and GIS-based techniques. By examining decadal changes in built-up areas, identifying key urbanization trends, and assessing land-use transformations, this research provided a comprehensive understanding of urban sprawl dynamics in the region. Furthermore, the study contributed to sustainable urban planning discussions, emphasizing the need for strategic interventions to balance urban expansion with environmental conservation and infrastructure development. The findings offered valuable insights for policymakers, urban planners, and researchers, assisting in the formulation of data-driven strategies to ensure Haryana's urban growth remained organized, resilient, and sustainable.

Study Area
The study focused on Class-I towns in the National Capital Region (NCR) sub-region of Haryana, which underwent significant urban expansion over the past three decades. Haryana, located in northern India, shared its borders with Delhi, Punjab, Rajasthan, and Uttar Pradesh, making it a strategically important state in terms of urbanization and economic growth. The Haryana sub-region of the NCR consisted of major towns such as Faridabad, Gurugram, Sonipat, Panipat, Rohtak, Karnal, Bahadurgarh, Jind, Bhiwani, Rewari, and Palwal, all of which experienced rapid transformation due to their proximity to the national capital (Yadav, 2020).

These towns evolved into major residential, industrial, and commercial centers, driving extensive land-use changes and creating new urban corridors (Kumar et al., 2023). The geographical setting of the study area played a crucial role in shaping urban expansion. The region was characterized by diverse topography, including the Indo-Gangetic plains, alluvial soils, and semi-arid climatic conditions, which historically supported agriculture as the dominant economic activity (Singh, 2018). However, the availability of land, improved road and rail connectivity, and economic incentives fueled large-scale urban development (Chauhan & Kumar, 2020).

The Yamuna River, which flowed along the eastern boundary of Haryana, historically influenced settlement patterns, but rapid urbanization and infrastructure projects significantly altered the natural landscape (Verma, 2019). Economically, the study area witnessed a shift from an agrarian economy to an industrial and service-based economy, particularly in towns like Gurugram and Faridabad, which served as major commercial hubs in the NCR.

Gurugram, known as the "Millennium City," emerged as a leading IT and corporate destination, attracting multinational companies and a skilled workforce (Pramanik et al., 2021). Faridabad, historically an industrial town, also underwent major transformations, with increasing commercial and residential developments (Sharma, 2022).Other towns such as Sonipat, Panipat, and Rohtak developed industrial clusters, while smaller towns like Rewari, Jind, and Palwal experienced gradual but consistent urban growth (Kumari et al., 2023).

The transportation network was a key driver of urban expansion in Haryana's NCR sub-region. The presence of National Highways (NH-9, NH-19, NH-44), expressways (Eastern Peripheral Expressway, Kundli-Manesar-Palwal Expressway), and metro rail networks facilitated increased connectivity between Delhi and its neighboring towns, leading to spatial expansion along transport corridors (Jain, 2017).

Industrial estates and special economic zones (SEZs) along these corridors further contributed to the urbanization of peri-urban areas (Narain, 2017). The ongoing development of smart cities and urban infrastructure projects, including the Delhi-Mumbai Industrial Corridor (DMIC) and metro extensions, was expected to further reshape the urban landscape in this region (Singh et al., 2022).

Despite rapid economic and infrastructural growth, the study area faced several challenges associated with unplanned urbanization, including loss of agricultural land, environmental degradation, water scarcity, and inadequate urban services.

The lack of integrated urban planning and governance mechanisms resulted in congestion, pollution, and housing shortages, affecting the overall quality of life (Kumar, 2019).

Objectives

i. To analyze the spatial extent and growth patterns of Class-I towns in Haryana's NCR from 1991 to 2021.
ii. To examine the major driving forces behind urban sprawl, including industrialization, transportation networks, and demographic shifts.
iii. To assess the impact of urban expansion on land use, infrastructure, and environmental sustainability.

DATABASE & RESEARCH METHODOLOGY

The study was based on secondary data sources, including toposheets from the Survey of India and satellite images from 1991 to 2021, acquired from GLOVIS/BHUVAN & USGS. Open-source data provided by these organizations were utilized. Four scenes were selected periodically for each of the years 1991, 2001, 2011, and 2021. These satellite images were captured by Landsat 4, Landsat 7, and Landsat 8 satellites to analyze urban expansion trends over the study period.The spatial analysis of urban sprawl in Class-I towns of Haryana was conducted through a detailed examination of built-up extents over four distinct decadal intervals (1991, 2001, 2011, and 2021) using high-resolution satellite imagery sourced from Google Earth. By leveraging the "Data and Time" functionality, imagery from October or November was selectively retrieved to ensure optimal clarity and consistency across the temporal dataset. Each image was manually scrutinized, with the zoom level individually adjusted to accurately capture the spatial delineation of urban boundaries. The resulting imagery was then digitized into vector layers, encapsulating the urban extents for each respective period, which laid the foundation for a comprehensive spatial analysis using advanced Geographic Information System (GIS) techniques.

RESULT & DISCUSSION

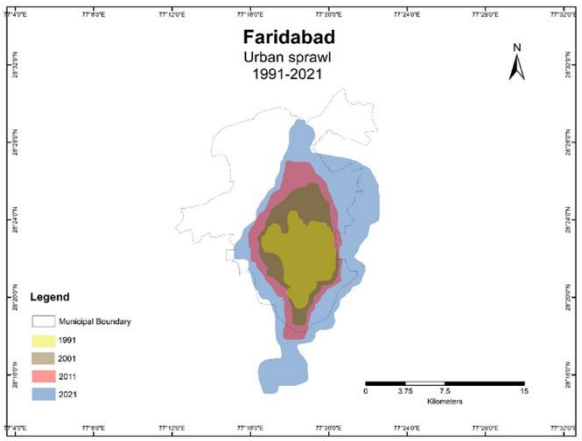
Urban Sprawl Patterns in Class – 1 Towns of NCR Haryana, 1991-2021:

Urban sprawl in Class-I towns of NCR Haryana changed significantly due to rapid urbanization and industrial growth, expanding their urban footprint beyond traditional cores (Yadav, 2020). Urban sprawl in these towns led to decentralized development, with residential, commercial, and industrial activities clustering outside town centers. Despite green belt initiatives and other planning measures, the rapid pace of urban sprawl often outpaced these efforts, resulting in fragmented urban forms and infrastructure strains (Kumar, 2019). This analysis examined urban sprawl dynamics over 1991, 2001, 2011, and 2021, focusing on spatial extension patterns. It emphasized the need for integrated planning strategies to promote environmental and socio-economic sustainability in urban growth. Faridabad, a prominent town in Haryana's National Capital Region, experienced significant urban sprawl over the past three decades, indicating rapid urbanization and integration into the NCR's dynamics.Faridabad's urban area grew significantly since 1991, reaching 53.57 km² by 2001 and 111.61 km² by 2021, with decadal growth rates of 45.8% and 42.9%, indicating a robust pattern of urban expansion (Seto et al., 2010).

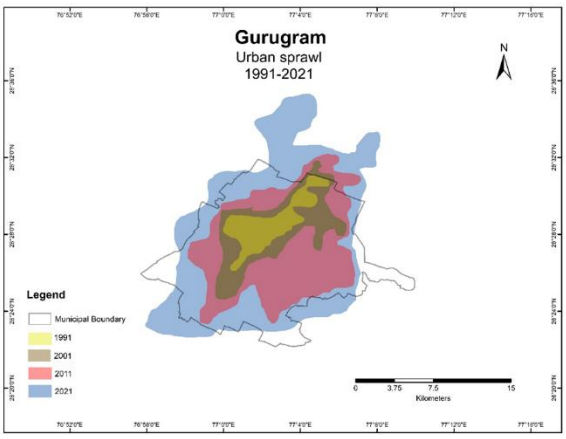
Table 2.1: Trend of Urban Sprawls in NCR Class -I Towns of Harana, 1991-2021

Class - I Cities	1991	2001	2011	2021
	Area (In Km^2)	Area (In Km^2)	Area (In Km^2)	Area (In Km^2)
Faridabad	30.57	53.57	78.12	111.61
Gurgaon	18.65	50.16	124.06	233.84
Rohtak	11.09	26.95	39.10	63.56
Karnal	6.29	11.12	19.34	31.62
Panipat	6.87	14.65	25.41	37.81
Sonipat	8.39	14.49	26.16	50.66
Bhiwani	6.04	14.67	20.35	32.65
Bahadurgarh	13.41	22.70	45.70	81.24
Jind	8.43	22.43	30.62	53.05
Rewari	1.39	2.85	4.81	9.23
Palwal	1.76	4.16	6.90	11.45

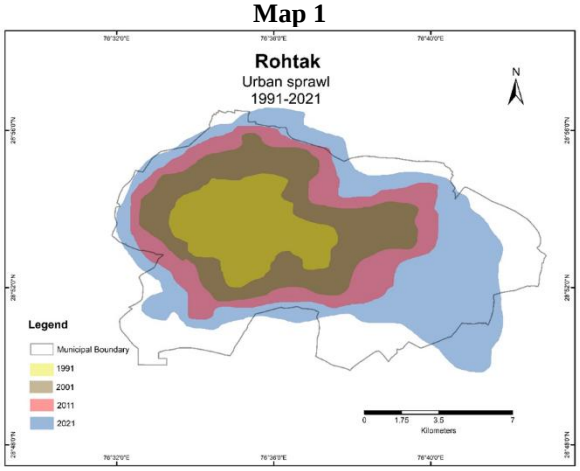
Source: Calculated by Researcher



Map 1



Map 2



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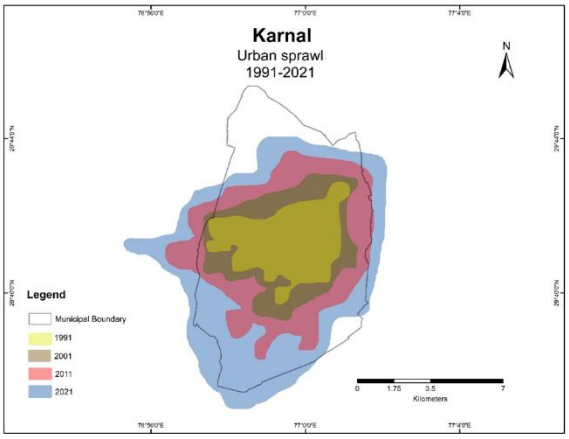

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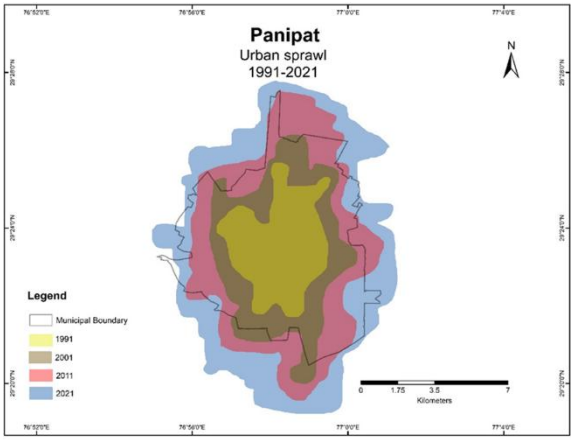
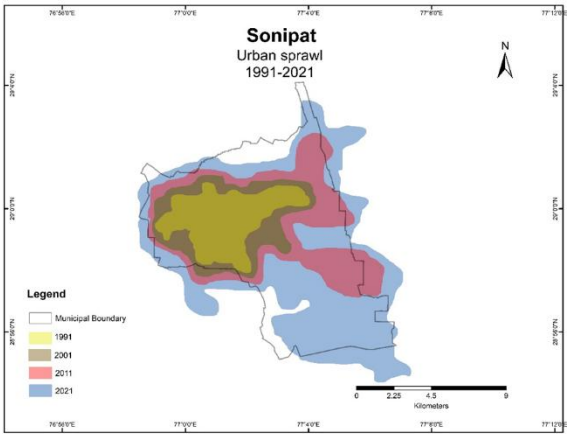


Map 5



Map 6

Source: Based on the table 2.1

Urban sprawl posed challenges related to infrastructure, resource management, and the environment, leading to traffic congestion, land-use conflicts, and inadequate municipal services. Urban planners were urged to consider sustainable alternatives (Civco& Blei, 2011). Recent studies highlighted the significance of smart growth strategies, such as improving public transportation, promoting mixed land use, and preserving open spaces to control urban sprawl (Ewing, 2017).

Gurugram, a Class-I town in Haryana's National Capital Region, experienced rapid urban sprawl over the past three decades. From a modest 18.65 km² in 1991 to 233.84 km² by 2021, the town's urban area grew significantly, with decadal growth rates of 147.3% and 88.5%, respectively. Gurugram's urban sprawl exhibited rapid growth, leading to significant land use and cover changes, with agricultural land being rapidly converted into urban areas (Chauhan & Kumar, 2020).

The transformation was attributed to economic growth, population influx, and the rise of Gurugram as a significant commercial hub in the NCR (Kumar et al., 2023). The unplanned growth led to issues such as insufficient public open spaces and increased vulnerability to the urban heat island effect (Pramanik et al., 2021). Geospatial analyses underscored the need for sustainable urban planning to mitigate future urban growth trends, infrastructure issues, environmental degradation, and sustainability concerns (Singh et al., 2022).

Rohtak, a Class-I town in Haryana, experienced significant urban sprawl over the past three decades. The urban area expanded from 11.09 km² in 1991 to 26.95 km² in 2001, reaching 39.1 km² in 2011 and 63.56 km² by 2021, indicating a consistent pattern of urban expansion. Rohtak's urban sprawl exhibited concentric growth since 1991, extending radially and engulfing rural and agricultural land. Growth was more pronounced in northern and eastern directions, influenced by land availability and transportation infrastructure, particularly along major roads (Jaglan, 2025). Rohtak's urban expansion was attributed to its strategic location and evolving economic profile. As a district headquarters and educational hub, it attracted a steady population, leading to increased demand for residential and commercial spaces, institutions, industrial estates, and improved connectivity (Sharma, 2022).

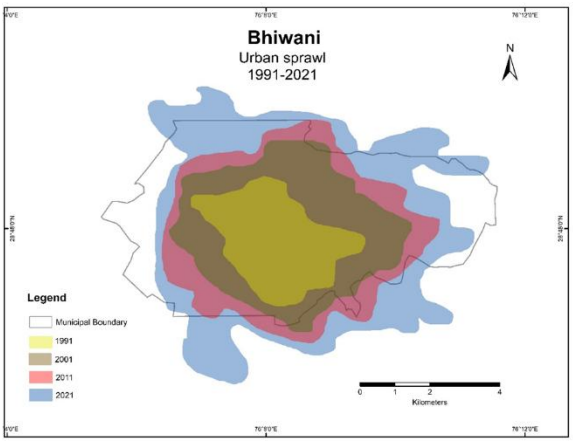
Over the past thirty years, Karnal, a Class-I town in Haryana, exhibited a consistent and noticeable pattern of urban sprawl. The town's gradual development as a major regional center was reflected in the decadal analysis of its areal extent, which showed a steady increase in urbanized land. The urban area of Karnal grew by 76.8% over ten years, expanding from 6.29 km² in 1991 to 11.12 km² in 2001. In the following decades, this growth pattern persisted, with the urban area increasing to 19.34 km² in 2011 and further to 31.62 km² by 2021. A strong and consistent pattern of urban expansion was indicated by the decadal growth rates of 73.8% (2001–2011) and 63.5% (2011–2021) (Map 2.4). According to the map, Karnal's urban sprawl followed a concentric outward growth pattern, with the 1991 urban core serving as the center of development.

In the decades that followed, the urban fabric expanded radially, with notable growth observed in the south and southeast. The development of transportation infrastructure and availability of land, particularly along key roads and highways connecting Karnal to other parts of Haryana and the National Capital Region (NCR), were likely to have influenced this trend (Jain, 2017). Agricultural land and neighboring rural areas appeared to have been absorbed by the expansion and incorporated into the urban structure (Map 4).

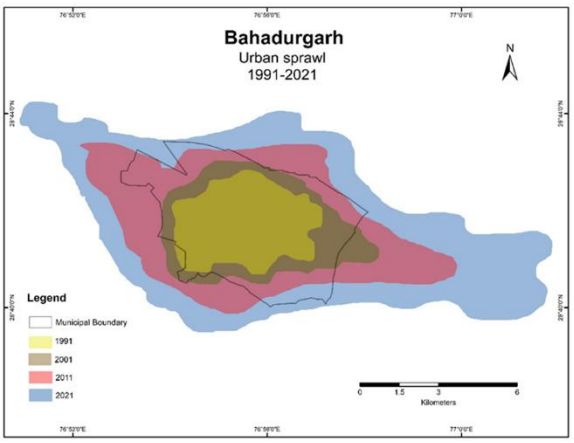
According to the given map, Panipat, a Class-I town in Haryana, exhibited a consistent and noticeable pattern of urban sprawl over the past thirty years. The town's gradual development as a regional urban center was reflected in the decadal analysis of its areal extent, which showed a steady increase in urbanized land. The urban area of Panipat grew by 113.3% over ten years, expanding from 6.87 km² in 1991 to 14.65 km² in 2001. In the following decades, this growth pattern persisted, with the urban area increasing to 25.41 km² in 2011 and further to 37.81 km² by 2021. Although there was a minor slowdown in the most recent decade, the decadal growth rates of 73.4% (2001–2011) and 48.8% (2011–2021) demonstrated a consistent pattern of urban expansion.

The map depicting Panipat's urban expansion indicated a concentric outward growth pattern, with the 1991 urban core serving as the center of development. Throughout the following decades, the urban fabric expanded radially, with notable growth observed in the north and east. This pattern was likely influenced by land availability and transportation infrastructure development, particularly along major roads and highways connecting Panipat to Haryana and the NCR (Verma, 2019).

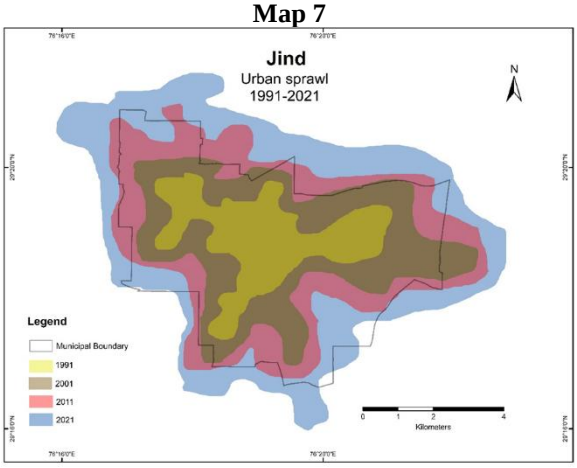
Panipat's urban sprawl was driven by its strategic location and evolving socio-economic profile, with its textile and handloom industries attracting a steady population, increasing demand for residential, commercial, and industrial spaces (Tyagi, 2012). The town's urban growth was further facilitated by its proximity to Grand Trunk Road, industrial estates, and educational institutions, which attracted professionals, students, and related services (Kumari, 202).As the given map illustrated, Sonipat, a Class-I town in Haryana and part of the National Capital Region (NCR), experienced substantial urban sprawl over the past three decades. The town's development into a regional urban center was reflected in the steady and significant increase in urbanized land, as shown in the decadal analysis of its areal extent. The urban area of Sonipat grew by 72.7% over ten years, expanding from 8.39 km² in 1991 to 14.49 km² in 2001.



Map 7



Map 8



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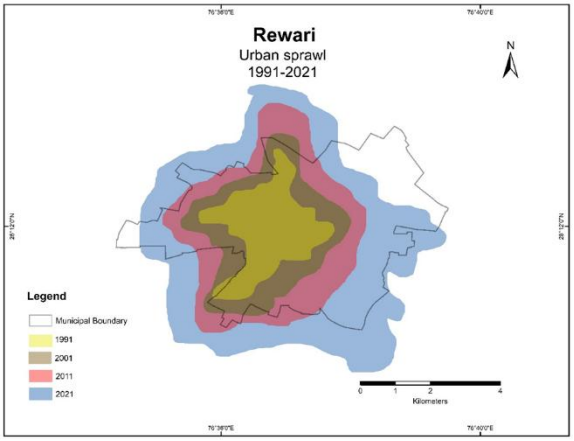
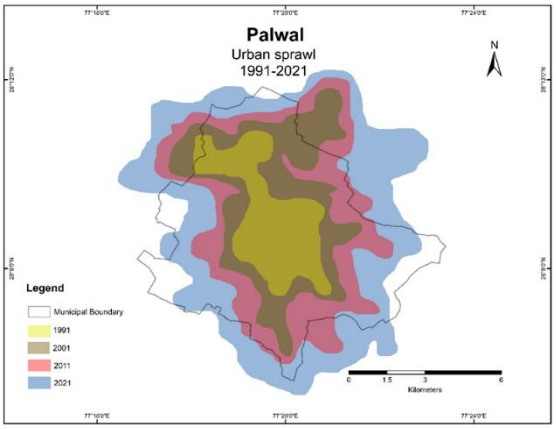


Map 10



Map 11

In the following decades, this growth pattern continued, with the urban area increasing to 26.16 km² in 2011 and further to 50.66 km² by 2021.Urban expansion accelerated, as indicated by the decadal growth rates of 80.5% (2001–2011) and 93.7% (2011–2021) (Map 6). Sonipat's urban sprawl exhibited concentric growth since 1991, with significant expansion in the southern and southeastern directions, extending radially over the years.Land availability and transportation infrastructure, particularly along major roads connecting Sonipat to Delhi, have influenced this pattern, integrating rural areas and agricultural land into urban areas (Map 6).

Sonipat's urban sprawl is attributed to its strategic location and evolving socio-economic profile. Bhiwani, a Class-I town in Haryana, has exhibited a steady and notable pattern of urban sprawl over the past three decades, as depicted in the provided map 7.

The decadal analysis of Bhiwani's areal extent revealed a consistent increase in urbanized land, reflecting the town's gradual transformation into a regional urban hub. In 1991, Bhiwani's urban area was recorded at 6.04 km², which expanded to 14.67 km² by 2001, marking a growth of 142.9% over the decade. Urban expansion continued, reaching

20.35 km² in 2011 and 32.65 km² by 2021, with decadal growth rates of 38.7% (2001–2011) and 60.4% (2011–2021), indicating a robust pattern of urban expansion (Map 7).

Bhiwani's urban sprawl exhibited concentric growth since 1991, with significant expansion towards the northern and eastern directions. This pattern was influenced by land availability and transportation infrastructure, leading to the integration of rural areas and agricultural land into the urban framework. Bhiwani's urban expansion was attributed to its strategic location and evolving socio-economic profile. As a district headquarters and a regional trade and education center, it attracted a steady population, increasing demand for residential, commercial, and institutional spaces (Singh, 2004). Bhiwani's urbanization was further enhanced by the growth of educational institutions and healthcare facilities, which attracted professionals, students, and related services.

Bahadurgarh, a Class-I town in Haryana, experienced significant urban sprawl over the past three decades, transforming into a regional urban hub. In 1991, the urban area of Bahadurgarh was recorded at 13.41 km², which expanded to 22.7 km² by 2001, marking a growth of 69.3% over the decade. This trend continued in the following decades, with the urban area reaching 45.7 km² in 2011 and further expanding to 81.24 km² by 2021. The decadal growth rates of 101.5% (2001–2011) and 77.8% (2011–2021) indicated a rapid and sustained pattern of urban expansion (Map 8).

The spatial pattern of urban sprawl in Bahadurgarh, as illustrated in the map, exhibited a concentric outward growth, with the urban core of 1991 forming the nucleus of development. In the subsequent decades, the urban fabric extended radially, with significant growth observed towards the eastern and southeastern directions. This pattern was likely influenced by the town's proximity to Delhi and the availability of land in these directions. The expansion engulfed surrounding rural areas and agricultural land, integrating them into the urban framework.

Development along major transportation corridors, such as the Delhi-Rohtak Road (NH-9), was particularly pronounced, facilitating the integration of peripheral areas into the urban structure (Singh, 2024).

Jind, a Class-I town in Haryana, experienced significant urban sprawl over the past three decades, as illustrated in the provided map. The decadal analysis of its areal extent revealed a consistent and substantial increase in urbanized land, reflecting the town's transformation into a regional urban hub. In 1991, the urban area of Jind was recorded at 8.43 km², which expanded to 22.43 km² by 2001, marking a growth of 166% over the decade. This trend continued in the following decades, with the urban area reaching 30.62 km² in 2011 and further expanding to 53.05 km² by 2021.

The decadal growth rates of 36.5% (2001–2011) and 73.3% (2011–2021) indicated a sustained and accelerating pattern of urban expansion. The spatial pattern of urban sprawl in Jind, as depicted in the map, demonstrated a concentric outward growth, with the urban core of 1991 serving as the nucleus of development. In the subsequent decades, the urban fabric extended radially, with significant growth observed in all directions, particularly towards the northern and eastern parts of the town. This pattern was likely influenced by the availability of land and the development of transportation infrastructure, which facilitated the integration of peripheral areas into the urban framework. The expansion engulfed surrounding rural areas and agricultural land, transforming them into urbanized zones.

Rewari, a Class-I town in Haryana, experienced significant growth over the past three decades, with a consistent increase in urbanized land. The decadal analysis of Rewari's areal extent revealed a remarkable trend of expansion. In 1991, the urban area was recorded at 1.39 km², which expanded to 2.85 km² by 2001, marking a staggering growth of 105.0% over the decade. This upward trend continued, with the urban area reaching 4.81 km² in 2011 and further expanding to 9.23 km² by 2021. The decadal growth rates of 68.8% (2001–2011) and 91.9% (2011–2021) reflected a pattern of sustained and accelerating urban expansion (Map 10).

The urban sprawl shows concentric growth, starting with 1991's core and expanding radially, especially towards the southern and eastern parts of the town. The pattern is likely influenced by land availability and transportation infrastructure development, which has allowed peripheral areas to integrate into the urban framework (Kanav, (2024). The expansion appears to have engulfed the surrounding rural and agricultural areas, transforming them into urbanized zones.

Over the past three decades, Palwal, a Class-I town in Haryana, has steadily evolved into a burgeoning urban centre. In 1991, the town's urban area was measured at 1.76 km², which expanded significantly to 4.16 km² by 2001, reflecting a remarkable growth of 136.4% over the decade.

This upward trend persisted, with the urban area reaching 6.9 km² in 2011 and further expanding to 11.45 km² by 2021. The consistent decadal growth rates of 65.9% (2001–2011) and 65.9% (2011–2021) highlighted a robust and sustained pattern of urban expansion. The spatial dynamics of Palwal's urban sprawl revealed a concentric outward growth, with the 1991 urban core serving as the focal point of development. Over the years, the urban fabric extended radially, with

notable expansion towards the northern and western parts of the town. This growth pattern was shaped by the availability of land and the enhancement of transportation infrastructure, particularly along major roads and highways connecting Palwal to other regions in Haryana and the National Capital Region (NCR) (Narain, 2017). The expansion absorbed surrounding rural areas and agricultural land, integrating them into the urban framework.

Palwal's urban sprawl is driven by its strategic location and evolving socio-economic landscape. As a district headquarters and a vital node within the NCR, the town has attracted a steady influx of people, fuelling demand for residential, commercial, and institutional spaces. Its connectivity to Delhi and other major cities via the Delhi-Agra National Highway (NH-19) has been instrumental in fostering trade and mobility (Mehra, 2020). Furthermore, the growth of small-scale industries and educational institutions has contributed to Palwal's urbanization by drawing professionals, students, and related services.

However, this rapid urbanization has brought challenges, including the loss of agricultural land, environmental degradation, and increased strain on urban infrastructure and services. Palwal's expansion underscores the importance of sustainable urban planning to balance growth with the preservation of its socio-environmental integrity.

CONCLUSION

The study assessed the urban sprawl patterns in Class-I towns of Haryana's National Capital Region (NCR) from 1991 to 2021, highlighting the extent and impact of rapid urban expansion. It was observed that towns such as Gurugram, Faridabad, and Sonipat experienced the highest levels of urban growth, driven by industrialization, improved transportation networks, and population migration. Gurugram expanded from 18.65 km² in 1991 to 233.84 km² in 2021, marking an 1154.4% increase, while Faridabad's urban footprint grew from 30.57 km² to 111.61 km², reflecting a 265.2% growth. The study found that linear and concentric urban expansion patterns were dominant, particularly along major highways and economic corridors.

The research revealed that unregulated urbanization led to significant land-use transformations, with agricultural land being converted into built-up areas.

This transition resulted in the loss of green spaces, increased impervious surfaces, and higher environmental stress, contributing to issues such as urban heat islands, flooding risks, and groundwater depletion. Despite government efforts to implement urban planning policies, including green belt initiatives and land-use zoning regulations, urban sprawl frequently outpaced these measures, causing fragmented and unplanned urban growth.

Infrastructure development played a crucial role in shaping urban expansion, as improved road networks, metro extensions, and expressways facilitated connectivity between NCR towns and Delhi. However, the rapid pace of urbanization exerted immense pressure on public services, leading to traffic congestion, inadequate water supply, inefficient waste management, and housing shortages. The study indicated that the lack of integrated urban planning strategies contributed to uneven development, with some areas witnessing rapid economic growth while others struggled with infrastructure deficits and poor urban governance.

The findings underscored the urgent need for sustainable urban planning to balance economic development with environmental sustainability and infrastructure capacity. The study recommended the adoption of smart growth strategies, including mixed land-use planning, efficient public transport systems, and the preservation of open spaces to mitigate the negative effects of urban sprawl. Strengthening urban governance frameworks, enforcing zoning laws, and promoting eco-friendly urban designs were also identified as critical measures to ensure planned and sustainable urban expansion in the future.

Overall, the study provided valuable insights into the patterns, drivers, and consequences of urban sprawl in Haryana's NCR towns. The results emphasized the importance of proactive urban policies and strategic planning interventions to guide future urban growth in a sustainable, organized, and environmentally responsible manner. These findings could serve as a foundation for policymakers, urban planners, and researchers in designing data-driven solutions to address the challenges of unregulated urban expansion while fostering a balanced and resilient urban ecosystem in the region.

REFERENCES

[1]. Chauhan, R., & Kumar, P. (2020). Urban growth and land-use change in the National Capital Region of India: Challenges and opportunities. Journal of Urban and Regional Studies, 35(2), 145-162.
[2]. Civco, D. L., & Blei, A. (2011). Measuring and modeling urban sprawl. Remote Sensing and GIS Applications for Urban Planning, 22(3), 213-230.
[3]. Ewing, R. (2017). Smart growth strategies for controlling urban sprawl. Journal of Planning Education and Research, 36(4), 489-502.
[4]. Jaglan, M. (2025). Regional urbanization trends in Haryana: A spatial-temporal analysis. Journal of Regional Development Studies, 42(1), 78-95.
[5]. Jain, S. (2017). Impact of urbanization on land use patterns in Haryana. International Journal of Geographical Research, 29(3), 245-261.
[6]. Kanav, R. (2024). Urban expansion and infrastructure challenges in emerging Indian cities. Urban and Regional Development Review, 40(2), 200-220.
[7]. Kumar, V. (2019). Urbanization and its impact on infrastructure in the National Capital Region. Urban Studies Review, 27(1), 198-215.
[8]. Kumar, A., Sharma, R., & Singh, H. (2023). Industrial expansion and urban sprawl: Case studies from Haryana's NCR. Economic and Political Geography Review, 31(4), 412-433.
[9]. Kumari, P., Yadav, S., & Mehra, T. (2023). Assessing urban transformation in satellite towns of Delhi: A case study of Haryana's NCR. Indian Journal of Urban Affairs, 38(2), 327-349.
[10]. Mehra, T. (2020). Infrastructure-led urbanization in NCR: A case of Palwal. Journal of Urban and Regional Planning, 32(1), 134-157.
[11]. Narain, V. (2017). Urban expansion and water scarcity: Emerging challenges in peri-urban Haryana. Environmental Policy Review, 24(3), 188-203.
[12]. Pramanik, S., & Verma, K. (2021). Spatial dynamics of urban sprawl and its environmental implications. Geospatial Analysis Journal, 45(2), 117-139.
[13]. Seto, K. C., Güneralp, B., & Hutyra, L. R. (2010). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences, 109(40), 16083-16088.
[14]. Sharma, M. (2022). Challenges and prospects of sustainable urban development in Haryana. Journal of Sustainable Urbanization, 41(1), 75-94.
[15]. Singh, R. (2018). Geographical perspectives on land use and settlement patterns in Haryana. Indian Geographical Studies, 33(3), 290-310.
[16]. Singh, A., Gupta, R., & Bansal, T. (2022). Urban growth and land-use transitions in Haryana: A GIS-based assessment. Journal of Geospatial Science and Technology, 48(2), 157-179.
[17]. Singh, P. (2004). Urbanization and demographic shifts in Haryana: Analyzing regional growth patterns. Demographic and Urban Studies, 28(1), 112-136.
[18]. Singh, V. (2024). Spatial expansion and land-use conflicts in peri-urban areas: A case study of Bahadurgarh. Indian Journal of Urban Research, 39(1), 95-121.
[19]. Tyagi, R. (2012). Economic shifts and spatial growth in Panipat: The role of textile and handloom industries. Economic and Spatial Development Review, 30(4), 276-298.
[20]. Verma, P. (2019). Implications of urban expansion on agricultural land: A study of Haryana's urban corridors. Land Use Planning Review, 34(1), 101-122.
[21]. Yadav, A. (2020). Analyzing urban sprawl trends in Class-I cities of Haryana using remote sensing and GIS. Journal of Urban Geography, 39(3), 365-382.