Urban Sustainability and Population Dynamics: A Geographical Study of Varanasi as a Smart City

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Abstract—Urban sustainability has emerged as a critical concern in the era of rapid urbanization, particularly in developing countries where demographic pressures are reshaping cities. This paper examines the relationship between population dynamics and sustainable urban development in Varanasi, a historic city recently designated as part of India's Smart Cities Mission. The study highlights how population growth, migration, density variations, and demographic heterogeneity directly influence urban morphology, resource demand, and socio-environmental challenges. While Smart City initiatives in Varanasi aim to modernize infrastructure, improve governance, and preserve cultural heritage, their effectiveness depends on integrating demographic realities into planning and implementation. A geographical perspective underscores that sustainability must encompass three interrelated dimensions: environmental, social, and economic. Varanasi's growing population has intensified pressures on housing, sanitation, waste management, and the River Ganga, while also creating opportunities for labor supply and economic vitality. The uneven spatial distribution of population further contributes to socio-spatial inequalities between the congested urban core and under-serviced peri-urban areas. The findings suggest that technological interventions alone cannot achieve sustainability unless accompanied by inclusive governance, environmental conservation, and equitable access to basic services. The study concludes that the future of Varanasi as a Smart City lies in harmonizing population dynamics with sustainability goals through integrated planning. By balancing heritage conservation, social justice, and environmental protection with modern infrastructure, Varanasi can transition into a city that is not only technologically "smart" but also resilient, inclusive, and sustainable.

Keywords: Urban sustainability, population dynamics, Smart City, Varanasi, geographical perspective

I. INTRODUCTION

Urban centres are the engines of economic growth, cultural exchange, and technological innovation; yet, they are also sites of immense demographic pressure, environmental degradation, and social inequality. As the twenty-first century unfolds, the concept of **urban sustainability** has gained prominence as a framework to balance rapid urbanisation with ecological preservation, social equity, and economic viability (Tan & Taeihagh, 2020). **Population dynamics**—the patterns of growth, density, migration, and demographic composition—play a decisive role in shaping the sustainability trajectory of cities. The interaction between population trends and urban development is particularly significant in countries like India, where cities are expanding at unprecedented rates. Within this context, Varanasi, one of the world's oldest continuously inhabited cities and recently designated as a **Smart City** under India's Smart Cities Mission, presents an ideal case for geographical inquiry (Das et al., 2024). The city embodies the complexities of managing modern urban growth, while also preserving its rich historical, cultural, and religious significance.

Varanasi, located on the banks of the River Ganga in Uttar Pradesh, is not only a spiritual and cultural hub but also a city undergoing major urban transformations. Current estimates place Varanasi's population at approximately 1.75 million as of 2025 (Census 2011, 2025). This population growth, driven by natural increase and rural-to-urban migration, has created both opportunities and challenges. On the one hand, a growing population fosters economic vibrancy, increases labour supply, and stimulates markets. On the other hand, it exerts pressure on infrastructure, housing, sanitation, transportation, and waste management systems. Designated as a Smart City, Varanasi is expected to exemplify sustainable urban development through the integration of digital technology, thoughtful planning, and inclusive governance. However, without integrating population dynamics into sustainability strategies, technological or infrastructural interventions risk deepening disparities rather than resolving them (Tan & Taeihagh, 2020).

Urban sustainability, in a geographical sense, goes beyond green technologies and carbon footprint reduction. It is also concerned with spatial equity, balanced resource distribution, and improving the quality of life for all socio-economic groups. Population growth and distribution influence land-use change and urban morphology—especially in Varanasi, where unplanned settlements, riverbank encroachments, and congestion in the city core reflect demographic pressures. Migration, driven by education, pilgrimage, trade, and employment, contributes to demographic complexity—underscoring the need for inclusive urban policies grounded in geographical understanding (Planning Tank, 2025).

Demographic change is not uniform across space. In Varanasi, central wards suffer high density, while peripheral zones expand rapidly, often lacking basic infrastructure. The old city, located along the Ganga, accounts for approximately 31 per cent of the population and 38 per cent of the city's GDP, despite covering only 7 per cent of the area—an indicator of stark spatial disparities (Press Information Bureau, 2016). Smart City initiatives, if focused only on urban core modernisation, risk leaving peripheral and marginalised populations behind.

Environmental sustainability is also closely tied to population trends. The Ganga is severely polluted by untreated sewage, industrial effluents, and ritual waste—a situation exacerbated by demographic growth. Smart City strategies in Varanasi aim to address these issues through riverfront development, modern sewage treatment, and innovative waste systems (Elets News Network, 2018). Nevertheless, their success depends on aligning interventions with demographic realities.

Furthermore, the **social dimension of sustainability** is profoundly shaped by population dynamics. Varanasi's populace includes long-term residents, migrants, students, pilgrims, and foreign visitors—each with distinct needs and urban impacts. Influxes from rural Uttar Pradesh and Bihar swell informal settlements, straining sanitation, healthcare, and education systems—highlighting the need for equitable spatial planning (Planning Tank, 2025).

The **Smart City designation** for Varanasi brings attention, investment, and technological innovation—but also risks becoming superficial. While projects like ghat beautification and intelligent transportation enhance the city's image, sustainability remains elusive unless residents in informal areas are provided with housing, health, and education facilities. Population dynamics thus become pivotal to assessing whether the Smart City vision will be inclusive or merely cosmetic.

A geographical study of Varanasi offers broader insight into urbanisation trends in the Global South. The city is a microcosm of challenges facing rapidly growing historic cities—where tradition, identity, and modernisation collide. Lessons from Varanasi can inform sustainability strategies in other medium-sized Indian cities. Geographical tools, such as spatial analysis, demographic mapping, and socio-environmental assessment, are indispensable for understanding and managing the complex interplay between population growth and sustainable urban development.

In sum, the relationship between population dynamics and urban sustainability is a critical area in contemporary geography, especially under India's Smart Cities Mission. Varanasi—rich in heritage, spirituality, and transforming—provides a compelling case for analysing how demographic realities shape sustainable urban futures. Its experience reflects the tension between heritage preservation and modernisation, population growth and environmental stress, social equity and infrastructure development. This paper aims to analyse Varanasi's population growth, distribution, and migration from a geographical perspective, evaluating their implications under the Smart City framework. Through this, it contributes to understanding how population dynamics must be integrated into urban sustainability strategies to build cities that are not only smart but also resilient, inclusive, and truly sustainable.

II. CONCEPTUAL FRAMEWORK OF SUSTAINABLE URBAN DEVELOPMENT

The concept of sustainable development gained global prominence with the publication of the Brundtland Report (1987), which defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development [WCED], 1987). Translated into urban contexts, sustainability implies building cities that are socially inclusive, economically productive, and environmentally resilient.

Internationally, frameworks such as the United Nations Sustainable Development Goals (SDGs)—especially Goal 11: Sustainable Cities and Communities—emphasise access to safe housing, efficient transportation, reduced pollution, preservation of cultural heritage, and inclusive urban governance (United Nations, 2015). Similarly, UN-Habitat's New Urban Agenda (2016) advocates compact, connected, and integrated urban planning that addresses both growth and sustainability. In India, the policy emphasis on sustainable cities is reflected in flagship programmes such as the Smart Cities Mission (2015), the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), the Swachh Bharat Abhiyan, and the Namami Gange project for river conservation. These initiatives aim to strike a balance between infrastructural development, ecological restoration, and social inclusion (Ministry of Housing and Urban Affairs [MoHUA], 2020).

For a heritage city like Varanasi, sustainable urban development presents a unique dual challenge: conserving its cultural and spiritual identity while enhancing infrastructure, livability, and resilience. This requires context-sensitive planning that respects the historical neighbourhoods, ghats, and weaving clusters, while addressing the contemporary needs of housing, transportation, sanitation, and pollution control.

III. DEMOGRAPHIC PROSPECTS AND URBANISATION TRENDS IN VARANASI

Demography is central to understanding prospects and challenges for sustainable urban development. Varanasi has experienced consistent population growth over the past three decades, though the rate of increase has slowed in recent years.

The data reveal three critical demographic transitions:

Rapid Urban Expansion (1991–2001): Varanasi experienced a decadal growth rate of nearly 30%, reflecting high fertility rates and migration inflows, mainly from the surrounding rural districts of Uttar Pradesh and Bihar. This period coincided with the liberalisation of India's economy, when cities emerged as magnets for labour mobility.

Moderate Growth (2001–2011): The growth rate slowed to 22.6%, but the absolute population gains remained significant. Expansion of higher education, healthcare, and pilgrimage-driven tourism fueled urbanisation, while peri-urban areas absorbed rural migrants (Gupta & Singh, 2017).

Table 1: Population Growth of Varanasi Urban Agglomeration (1991–2025)

Year	Population (Urban Agglomeration)	Decadal Growth Rate (%)
1991	929,270	27.4
2001	1,201,815	29.3
2011	1,473,371	22.6
2021	1,720,000 (estimated)	16.8
2025	1,826,010 (projected)	6.17

Source: Census of India (1991, 2001, 2011); World Population Review (2021); Author's projection for 2025.

Slowing Growth (2011–2025): Projections suggest a further slowdown to 16.8% by 2021 and below 10% by 2025. This reflects national demographic transitions—declining fertility rates, saturation of urban capacity, and rural-to-urban migration diversifying toward tier-II and tier-III cities.

IV. INFRASTRUCTURE DEVELOPMENT: PROGRESS AND GAPS

Infrastructure forms the backbone of sustainable urban development. Reliable access to electricity, water, sanitation, housing, and transport not only enhances the quality of life but also facilitates economic productivity and social inclusion. In Varanasi, infrastructure development has witnessed significant progress under the **Smart Cities Mission** and various state and central government schemes; however, gaps persist that threaten the long-term sustainability of the initiatives.

The data demonstrate that Varanasi performs relatively better than the state average in most infrastructure indicators but lags behind national averages, particularly in sanitation and road density.

Electricity Access: With 92.4% household electrification, Varanasi has benefitted from the *Saubhagya Yojana* and state-level rural electrification programs (MoHUA, 2020). However, supply quality remains inconsistent, with frequent outages in peri-urban areas. Sustainable urban development requires not only universal access but also the integration of renewable energy to reduce dependence on coal-based power.

Water Supply: Only 65.1% of households have access to tap water, below the national average of 76.3%. The Ganga remains the principal source, but its pollution undermines the provision of safe water. AMRUT projects are underway to expand piped water coverage, yet leakage, contamination, and inequitable distribution persist (NMCG, 2021).

Table 2: Comparative Infrastructure Indicators (Varanasi vs Uttar Pradesh vs India)

Indicator	Varanasi	Uttar Pradesh	India
Households with electricity (%)	92.4	87.2	96.8
Households with Tap Water (%)	65.1	58.4	76.3
Households with Sanitation (%)	72.5	63.8	85.0
Road Density (km per 1000 pop)	5.6	4.2	8.1

Source: Census of India (2011); MoHUA (2020); Varanasi Smart City Development Corporation (VSCDC, 2021).

Sanitation: Approximately 72.5% of households have access to toilets, higher than the Uttar Pradesh average but still significantly below the national figure of 85%. Open defecation persists in slums and peri-urban belts despite the Swachh Bharat Mission. Wastewater treatment capacity covers only a fraction of sewage generated, leading to direct discharge into the Ganga (CPCB, 2020).

Transport Infrastructure: With a road density of 5.6 km per 1000 population, Varanasi lags behind India's urban average of 8.1. Congestion in the city core, narrow medieval streets, and unregulated traffic contribute to chronic mobility challenges. Initiatives such as the *Varanasi Ring Road*, *Ropeway Project*, and *Ganga Cruise services* represent innovative steps, but they require systemic integration with public transportation and pedestrian-friendly planning (Sharma & Tiwari, 2021).

V. INFRASTRUCTURE AND SUSTAINABILITY

Varanasi's infrastructure trajectory highlights three interlinked challenges: **heritage-sensitive urban renewal, equitable service provision, and environmental resilience**. On the one hand, Smart City interventions have modernised parts of the city, with projects such as intelligent traffic management, LED street lighting, and underground cabling. On the other hand, marginalised areas, especially informal settlements, remain underserved. Without targeted interventions, urban inequality will deepen.

From a sustainability perspective, water and sanitation are the most pressing challenges. A city situated on the banks of the Ganga cannot be considered sustainable if untreated sewage continues to flow into the river. Similarly, transport reforms need to prioritise low-carbon solutions—such as public transport, cycling, and pedestrian pathways—rather than car-centric expansion.

The theoretical framework of **urban political ecology** (Swyngedouw & Heynen, 2003) is particularly beneficial in this context. It explains how unequal power relations shape access to infrastructure and environmental services. In Varanasi, resource allocation often favours central areas frequented by tourists and pilgrims, while peripheral communities remain marginalised. Achieving sustainable development requires rebalancing these inequalities.

Economic Dimensions of Urban Development

Economic vitality is an essential dimension of sustainable cities. Varanasi's economy is shaped by its **tourism industry, silk weaving sector, tertiary services, and educational institutions**. However, challenges such as informalization, unemployment, and uneven growth patterns complicate the prospects.

Tertiary Sector Growth: The data highlight the dominance of the service sector in Varanasi, which contributes over 56% to the city's economy, surpassing both the state and national averages. Education, healthcare, trade, and tourism constitute the backbone of this sector. The expansion of higher educational institutions, such as Banaras Hindu University, has created a skilled labour force, enhancing the prospects of knowledge-based industries.

Tourism as an Economic Driver: With over 6 million annual tourist arrivals, Varanasi is among India's most visited cities. Religious tourism, cultural tourism (encompassing music and arts), and increasingly international tourism fuel local commerce.

However, the dependence on pilgrimage tourism makes the economy vulnerable to shocks, as evidenced by the COVID-19 pandemic, during which tourist inflows collapsed (Saha, 2021).

Table 3: Economic & Social Indicators (Varanasi vs Uttar Pradesh vs India)

Indicator	Varanasi	Uttar Pradesh	India
Tertiary Sector Share (%)	56.4	49.8	54.3
Workforce Participation Rate (%)	34.5	32.1	37.5
Per Capita Income (₹ current)	79,840	70,200	94,566
Annual Tourist Arrivals (millions)	6.1	22.1	185.0

Source: MoSPI (2019); UP Directorate of Economics & Statistics (2020); Ministry of Tourism (2021).

The Banarasi silk weaving industry remains an iconic part of the city's identity and economy, employing nearly 200,000 people directly or indirectly. However, it faces challenges from power loom competition, cheap imports, and a lack of modernisation (Gupta & Verma, 2019). Sustainable development requires reviving this sector through skill upgradation, branding, and eco-friendly production practices.

Employment and Informality: Workforce participation at 34.5% is below the national average, indicating low female labour force participation and high levels of informal employment. Informal workers dominate the construction, street vending, transport, and hospitality sectors, often lacking job security and social protection.

Per Capita Income: At ₹79,840, Varanasi's per capita income is higher than the state average but significantly below the national level. This reflects its intermediate urban economy status—more developed than many towns in Uttar Pradesh, but lagging behind metropolitan centres.

VI. THEORETICAL PERSPECTIVE

Environmental challenges in Varanasi resonate with the **ecological modernisation theory** (Mol & Sonnenfeld, 2000), which argues that technological and institutional innovations can reconcile economic growth with environmental protection. Programmes like Namami Gange exemplify this approach. However, without deep structural reforms—such as decentralising waste management, enforcing stricter emission norms, and expanding green infrastructure—ecological modernisation may remain superficial.

VII. SOCIAL DIMENSIONS OF URBAN SUSTAINABILITY

Urban sustainability cannot be achieved without addressing social justice, equity, and inclusiveness. In Varanasi, social dimensions are shaped by its historical diversity, caste dynamics, gender inequalities, and the needs of vulnerable populations such as migrants and slum dwellers.

Table 4: Social Indicators in Varanasi (2011–2020)

Indicator	Varanasi	Uttar Pradesh	India
Literacy Rate (%)	77.0	69.7	74.0
Female Literacy (%)	70.4	63.4	65.5
Slum Population (% of urban)	19.8	24.1	17.4
Human Development Index (HDI, est.)	0.621	0.596	0.645

Source: Census of India (2011); UNDP India (2019); Varanasi District Human Development Report (2020).

VIII. INTERPRETING SOCIAL INDICATORS

Education: Varanasi's literacy rate of 77% is above both state and national averages, reflecting the presence of premier educational institutions such as Banaras Hindu University. Female Literacy at 70.4% is higher than the state average, but it still indicates a gender gap that constrains women's empowerment and labour force participation (Jha, 2019).

Slum Population: Nearly one-fifth of Varanasi's urban population resides in slums, which is slightly below the state average but above the national figure. These settlements face deficits in sanitation, drinking water, housing, and healthcare, perpetuating cycles of poverty and vulnerability (UN-Habitat, 2018).

Human Development Index (HDI): With an estimated HDI of 0.621, Varanasi fares better than the average for Uttar Pradesh but lags behind the national index of 0.645. Inequalities in income, health, and education persist, particularly across caste and gender lines.

IX. CONCLUSION

The study of *Urban Sustainability and Population Dynamics: A Geographical Examination of Varanasi as a Smart City* highlights that population growth is both a driver of urban vibrancy and a significant source of challenges for sustainable development. Varanasi's demographic expansion—fueled by natural growth, migration, and its role as a cultural and religious hub—has shaped its urban morphology, pressured its infrastructure, and intensified environmental concerns, particularly regarding the River Ganga (Das et al., 2024). While the Smart City Mission has introduced opportunities for modernisation through digital governance, infrastructural renewal, and heritage conservation, its success ultimately depends on integrating demographic realities into planning (Tan & Taeihagh, 2020).

From a geographical perspective, sustainability in Varanasi requires addressing the uneven spatial distribution of population, reducing socio-spatial inequalities, and ensuring that the benefits of modernisation extend beyond the urban core into peripheral and marginalised settlements (Planning Tank, 2025). Environmental sustainability, particularly waste management and river pollution control, must be aligned with population growth patterns (Elets News Network, 2018). Equally important is the social dimension—improving housing, health, education, and employment opportunities for all residents, including migrants and informal settlers.

Thus, the future of Varanasi as a Smart City hinges not only on technological advancements but also on creating inclusive, equitable, and resilient systems that respond to population dynamics. The case of Varanasi demonstrates that urban sustainability in historic cities cannot be achieved solely through infrastructure—it must emerge from a balanced integration of heritage conservation, demographic realities, environmental protection, and social justice. This synthesis will ensure that Varanasi evolves into a city that is not just "smart," but also sustainable and inclusive.

X. KEY RECOMMENDATIONS

1. **Inclusive Urban Planning** – Extend Smart City interventions to peri-urban areas and slums to reduce socio-spatial inequalities (Press Information Bureau, 2016).
2. **Sustainable Waste & Water Management** – Prioritise sewage treatment, solid waste recycling, and Ganga riverfront conservation to align population growth with environmental goals (Elets News Network, 2018).
3. **Affordable Housing & Services** – Provide housing, health, and education facilities to informal settlers and migrants to enhance overall social well-being (Planning Tank, 2025).
4. **Balanced Heritage & Modernisation Strategy** – Protect cultural assets while integrating modern infrastructure for long-term sustainability (Das et al., 2024).
5. **Population-sensitive Governance** – Incorporate demographic projections into Smart City planning to anticipate future demands on transport, energy, and public services (Tan & Taeihagh, 2020).

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