



Urban transformation in the National Capital Territory of Delhi, India: The emergence and growth of slums?



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ABSTRACT

In the 20th and 21st centuries, the world has experienced rapid urbanization and slum proliferation. Slum residents form a significant portion of urban populations and contribute to the development of cities. However, due to their highly concentrated consumption and waste production patterns, slums endure and exacerbate, among other things, environmental degradation. To date, our understanding of slums in Indian cities has been primarily based on census data and evidence from remote sensing images. These data do not yet provide spatial slum dynamics over time and are limited to static and statistical representation. In addition to the obsolescence of spatial data, the non-availability of consistent socio-economic data leads to data integration problems. Therefore, new approaches that consider the scarcity of data and the choice of analytical techniques are needed; planners without advanced technical training should also be able to easily apply these approaches. This study provides a comprehensive approach to examine the urban transformation of the National Capital Territory of Delhi (NCT-Delhi), India, from 1971 to 2011. Combining data from multi-temporal remote sensing images, census population statistics, slum enumeration and the provision of essential services, these investigations reveal a previously undocumented rapid increase in built-up areas outside municipal boundaries. The findings confirm the spatial shift of slums from the city center towards the periphery. The analysis provides a revealing insight: the emergence and growth of slums are outcomes of the prevailing urban planning environment, the limited success of adopted policies and the government's inability to foster growth.

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1. Introduction: urban growth and sustainability in India

In the 20th and 21st centuries, the world has experienced rapid urbanization and slum proliferation (e.g., Davis, 2007). Only 13% of the world's population lived in urban areas during industrialization in 1900 (UN, 2012), and most of those people lived in slum settlements. By 2050, the global urban population is projected to increase to 6.3 billion, and Indian urban areas will contribute 0.9 billion to that number (UN, 2012). The global urban slum population is projected to increase by 27 million annually from 2000 to 2020 (UN-Habitat, 2002a). In India, 104 million people will live in urban slums by 2017 (Dash, 2013), and most of this increase will occur in small cities (Bihardays, 2013), which are under-resourced and under-serviced with managerial and planning capabilities that are experiencing increasing stress (UNEP, 2007).

Against the background of predicted growth, scarce resources, and limited institutional capacity to respond to such growth, this study provides an approach to study the spatial urban transformation in the context of the emergence and growth of slums in South Asian cities. However, this study's purpose is not to model the slums but to capture spatial urban transformation. This research attempts to provide insights into how the shifting of slums and municipal boundaries affects the process of including and excluding slums in the city's development. More specifically, what role urban planning and the judiciary play in the shifting of the slums? How do adopted policies influence the slums' emergence and growth? Answering these questions will contribute to a better understanding of slum dynamics.

Since the 16th century, slums have been the only large-scale, low-income housing solution (UN-Habitat, 2003). Slums are settlements where the poor live who contribute in building cities, and the presence of these settlements implies that the city in which they are located is economically successful (Glaeser, Kahn, &

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Rappaport, 2008; Ramanathan, 2005). In fact, slums are an integral productive economic agent of the urban economy (PRIA, 2014). Nevertheless, public authorities rarely recognize and address slums as integral or equal parts of the city (Sliuzas, Mboup, & Sherbinin, 2008). Slum settlements with highly concentrated consumption and waste production patterns endure and exacerbate environmental degradation.

In general, UN-Habitat defines slums as settlements in which inhabitants have inadequate housing and essential services¹; they are characterized by (i) insecure residential status, (ii) inadequate access to safe water, (iii) inadequate access to sanitation and other infrastructure, (iv) poor-quality housing, and (v) overcrowding (UN-Habitat, 2002b; UN-Habitat, 2006). UN-Habitat (2008) has since placed cities under the 'slum cities' category, which indicates that urban services in those cities are inadequate for rich and poor alike.

The recent development trend indicates that more than 70% of growth occurs outside the formal planning process as sprawl, and 30% of the urban population lives in slums (FIG, 2010). As developments sprawl, local authorities find it more difficult to provide essential services due to the increased cost of infrastructure provisions (Ewing, 2008; Pallagst, 2007). Similar development trends have been identified not only in old Indian megacities but also in incipient megacities (Taubenböck, Wegmann, Roth, Mehl, & Dech, 2009).

In Indian metropolises, only 70%–80% of urban households have sanitation facilities, and untreated water is discharged indirectly into rivers, lakes and ponds. Consequently, 90% of the water supply is polluted (Maiti & Agrawal, 2005; Pandey, Singhal, Jaswal, & Guliani, 2006). In incipient megacities (e.g., Ahmedabad, Bangalore, Hyderabad and Pune), the fresh water supply is limited to only 2–3 h a day (Maiti & Agrawal, 2005; Pandey et al., 2006). This situation is known as "shock urbanization" (Rode et al., 2008), i.e., urbanization in which growth outpaces the provision of infrastructure. Unless massive investments are made to significantly improve urban infrastructure and living conditions, most cities in India will be in a state of major crisis in the coming years (Mukhopadhyay & Revi, 2009; Sankhe et al., 2010; Vaidya, 2009; WB, 2013).

Our understanding of Indian city slums is primarily based on census data (CGDR, 2011; MoHUPA, 2010) and evidence from remote sensing (RS)-based geographic information systems (GIS) analyses. Census statistics do not provide information on the spatial distribution, patterns or the scale of development. Recent studies that are based on GIS and earth observation (EO) have been successful in analyzing slums in detail, but they are limited to statistical and static physical representations (e.g., Baud, Sridharan, & Pfeffer, 2008; Das, Choudhury, Shobhana, Bhakhar, & Vaghela, 2014; Hofmann, Strobl, Blaschke, & Kux, 2008; Taubenböck & Kraff, 2014). In addition to the obsolescence of spatial data, the non-availability of consistent socio-economic data leads to data integration problems (Toutain & Gopiprasad, 2006). Consequently, few studies (e.g., Roy, Lees, Palavalli, Pfeffer, & Sloot, 2014) have attempted to examine and understand slum dynamics with respect to socio-economic factors.

Due to the scarcity of reliable census data, the failure to recognize the importance of spatial factors in national, regional and local resource development, the lack of frameworks for integrated analysis, and the lack of qualitative and quantitative models (Kim, 2008; Nangia, 2009), new approaches to spatial planning are needed to link urban development with infrastructure (Todes, 2008). In addition, the adopted methodologies should consider the scarcity of data and the choice of analytical techniques, which

planners without advanced technical training can easily apply (FIG, 2010).

An improved understanding of slum dynamics with respect to municipal boundaries and the provision of essential services remains critical for urban policymaking due to the lack of adequate data and intricate analytical techniques. Therefore, using census data, RS imagery and simple statistical techniques, the proposed research aims to provide a comprehensive approach to examine how municipal boundaries, the provision of essential services and population growth influence slum dynamics in the National Capital Territory of Delhi (NCT-Delhi). A related objective is to identify a general pattern of growth that may be applicable to other Indian cities. The present research specifically aims to investigate the links between the following factors:

- (i) The expansion of built-up areas (BUAs) and municipal boundaries
- (ii) BUAs outside municipal boundaries and slums
- (iii) Population and slum growth
- (iv) The provision of essential services and slums

To this end, the paper is divided into six sections. The introduction is followed by a description of the urban environment of the study area and a presentation of the data used and the methodology adopted for the analysis. The fourth section explains the key findings; the fifth section discusses and interprets slum dynamics; and the sixth section concludes.

2. Study area: the status of urban growth in NCT-Delhi

The National Capital Region of Delhi (NCR-Delhi) was planned by establishing evenly distributed sub-centers throughout the region to reduce the influx of migrants to NCT-Delhi. The goal was to facilitate the decentralization of economic activities and housing development to designated satellite towns that were located 25–30 km away (DDA, 1962). However, the recent works of Jain (2013) and Jain, Siedentop, Taubenböck, and Sridharan (2013) have identified sprawl in the NCR-Delhi. In addition, the policies adopted to guide regional growth have had limited success (Jain & Siedentop, 2014).

NCT-Delhi is the administrative center and, after Mumbai, the second-largest financial capital of India. It has dual status as a city and a state. Geographically, it is sandwiched between two states, as depicted in Fig. 1. NCT-Delhi's rapid growth and development attract poor unskilled migrants who seek employment. Despite lessening from 1971 to 2001, migration contributed approximately 40% of the total growth in NCT-Delhi in 2001. In the same year, more than 40% of the migrants in slums were employed in unskilled and semi-skilled activities (NCRPB, 2008), thus contributing to the GDP.

In 2011, NCT-Delhi became the largest urban agglomeration in India, with 23 million residents (Shrinivasan & Chhappia, 2011), 1.7 million of whom lived in slums (CoI, 2013). Due to faulty planning and poor implementation, small cities near Delhi (e.g., Khurja and Bulandshahr) have developed into slums; the consequences for small cities are severe because their population growth is projected to occur primarily in the form of slums (Bihardays, 2013). Thus, both NCT-Delhi and small cities that neighbor the capital face enormous challenges in integrating these slums.

3. Data and methodology

3.1. Data limitation for the analysis

Data access poses a serious challenge to spatial analysis in Indian urban regions due to the lack of available data and the high

¹ Essential services include housing provisions and connections to piped water supply and sewer lines.

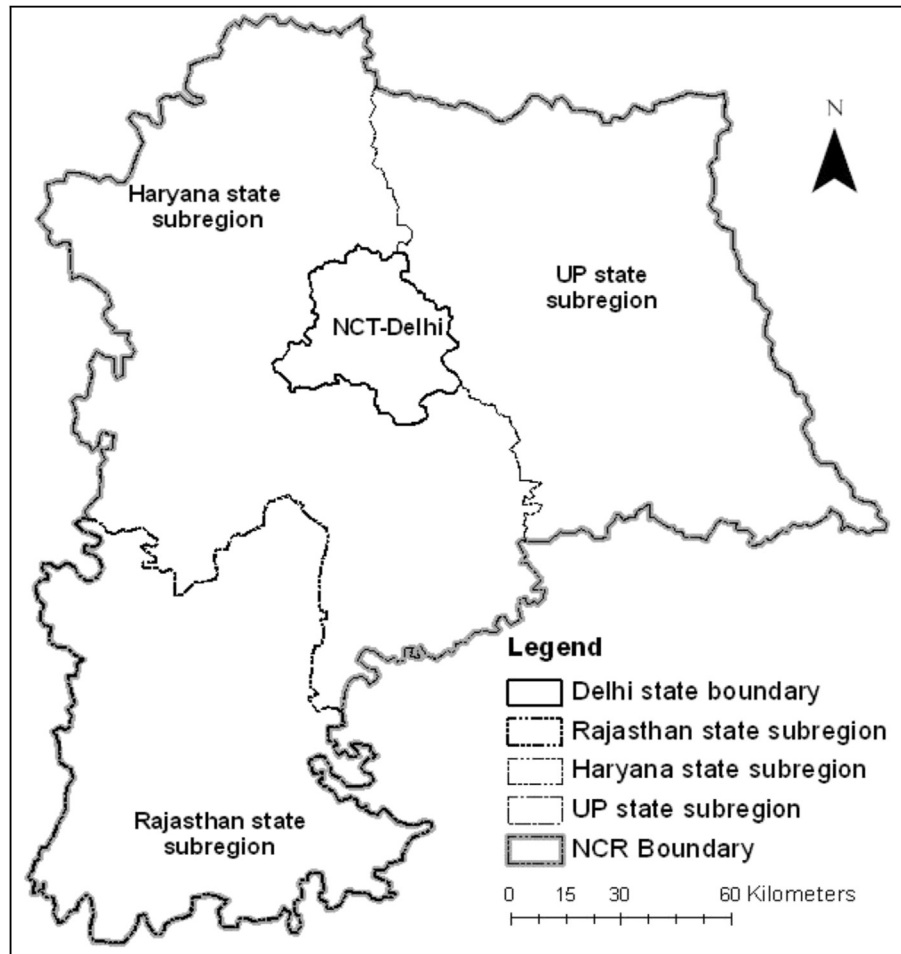


Fig. 1. Location of the National Capital Territory (NCT) Delhi in relation to other states in the National Capital Region (NCR) Delhi. Note: Uttar Pradesh (UP).

costs associated with analyzing such large landscapes. Examining slum dynamics is a complex process because it involves both temporal and spatial components that require high quality and unique time-series data for analysis. To achieve the research objectives, RS images from Landsat sensors and the TerraSAR-X sensor (for 1977, 1999, and 2010) were used to model the spatial dynamics of BUAs using the methodology introduced by Taubenböck et al. (2012). The BUAs outside municipal boundaries were used as proxies to examine slum dynamics.

The study suffered from a lack of records and databases of digitized municipal boundaries. To map the spatial dynamics, Indian census data on the municipal boundaries for five years—1971, 1981, 1991, 2001 and 2011—were digitized. The Municipal Cooperation Boundaries (MCBs) used for the analysis includes Municipal Corporation Delhi, Cantonment area and New Delhi Municipal Corporation. The census municipal boundaries for different time series were first geo-referenced to align them to the same coordinate system as that of the RS images; they were later digitized. During the digitization process, some discrepancies could not be resolved.

In addition, measuring slums is difficult due to the lack of an agreed-upon definition for these urban settlements and the subjective nature of the definitions that do exist. In India, the different definitions that respective states and national organizations, such as the Census of India (CoI) and the National Sample Survey Organization (NSSO), have adopted complicate the process of identifying urban slums. For example, the CoI defines slums as residential

areas in which dwellings are unfit for human habitation due to dilapidation; overcrowding; faulty building design and arrangement; narrow or faulty street arrangement; a lack of ventilation, light, or sanitation facilities; or any combination of these factors, which are detrimental to safety and health (CoI, 2011). Because this definition is subjective and not quantifiable, different survey officials have interpreted it differently. Consequently, a discrepancy has developed between the CoI and the NSSO with respect to estimated slum populations. According to the CoI, India had 60.5 million slum dwellers in 2011, whereas the NSSO reported the urban slum population to be 40.4 million in 2012 (Varma, 2014). Furthermore, state governments adopt definitions based on the respective states' Slum Acts, not on the definitions of the CoI or the NSSO (MoUPA, 2010). To eliminate discrepancies in the analysis, the examination of slum dynamics was based on the availability of zone (district²) level data on essential services, such as housing, sanitation and water supply.

3.2. Methodology adopted for the research

The analysis consisted of two main steps: First, to examine the relationship between the BUAs and municipal boundaries (see Fig. 2), a dataset was created that consisted of digitized municipal

² The census of India divides the nation into states; states consist of districts; districts consist of tehsils; and tehsils consist of towns (wards) and villages.

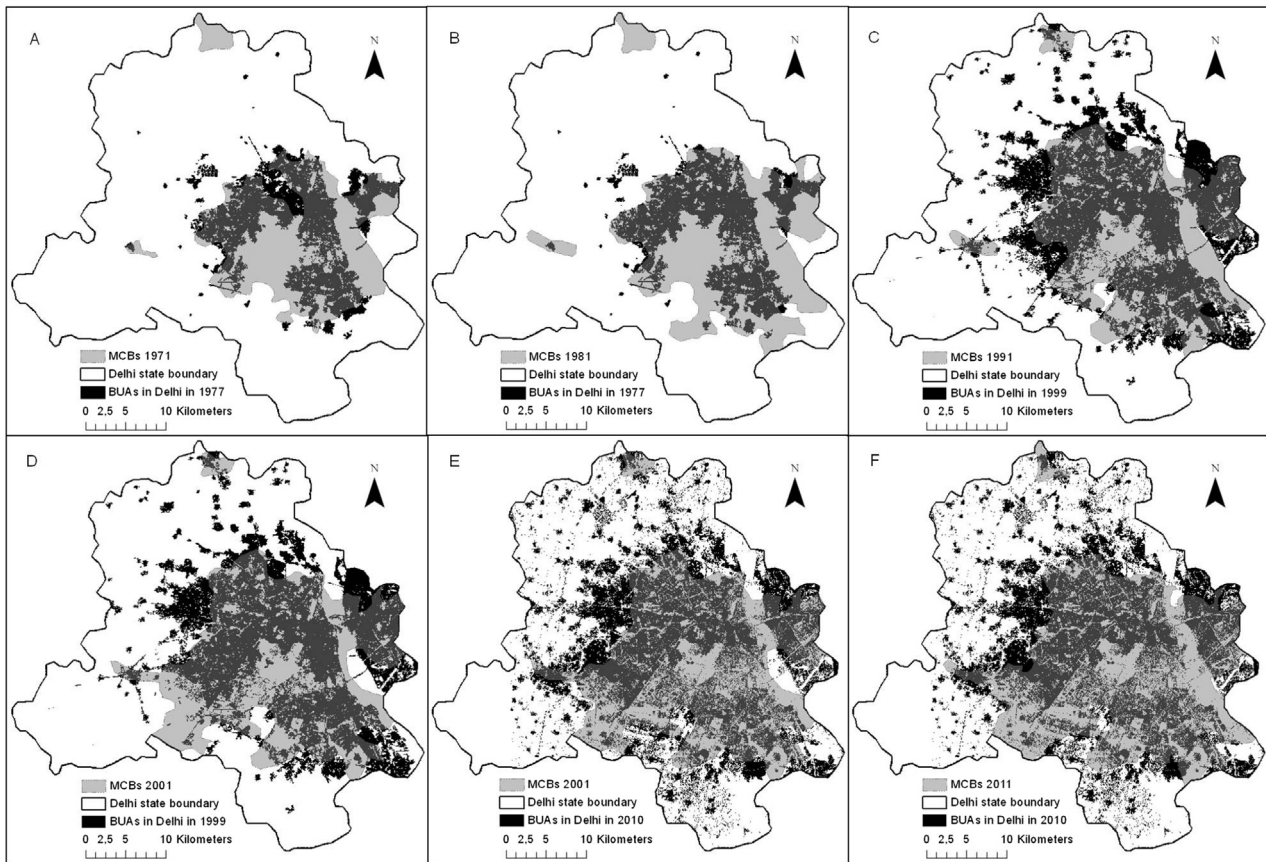


Fig. 2. Spatial dynamics of the municipal boundaries in NCT-Delhi from 1971 to 2011. Note: Built-Up Areas (BUAs); Municipal Corporation Boundaries (MCBs).

boundaries for different time periods. Based on the municipal boundaries, the BUAs were extracted for the different years. Compared with those for 1977 and 1999, the BUA for 2010 was extracted from a different sensor. Thus, the 2010 RS image does not cover all of NCT-Delhi. To overcome this spatial limitation and the resulting discrepancy, the ratio of the total area of NCT-Delhi to the area not included in the RS image was calculated. Six percent of the total area of NCT-Delhi was not covered in the 2010 data. This ratio was used to calculate the BUA in the omitted portion for 2010.

The census population for NCT-Delhi from 1971 to 2011 was obtained from the CoI, whereas the provision of essential services (e.g., housing, water supply and sanitation) was obtained from the Government of NCT-Delhi (GNCT-Delhi) for 2006 and 2013. The enumeration of essential services from [GNCT-Delhi \(2006\)](#) was based on a public perception survey conducted in 2004, whereas the [GNCT-Delhi \(2013\)](#) data were based on the 2011 census. These figures were available for nine zones or census districts (north, northeast, northwest, south, southwest, east, west, New Delhi and the center).

For the period from 1971 to 2011, the data on slum distribution in NCT-Delhi were obtained from [CGDR \(2011\)](#). Unfortunately, the distributions were only available for five zones (north, south, east, west and central). Except for the zone names, no clear descriptions were given in the report. Thus, to facilitate the analysis with a similar breakdown of zones, population and essential services were approximately mapped to five slum zones. These five zones contained the following districts: (i) the 'north' consisted of the northwest and north; (ii) the 'east' consisted of the northeast and east; (iii) the 'center' consisted of the center and new Delhi; (iv) the 'south' consisted of the south and one tehsil of the southwest

(Vasant Vihar); and (v) the 'west' consisted of the southwest and west (minus Vasant Vihar). This division comprised the second step of the analysis.

The RS-extracted BUAs for 1977, 1999 and 2010 were plotted against the municipal boundaries from 1971, 1981, 1991, 2001 and 2011, as represented in [Fig. 2](#). The black patches represent the BUAs outside municipal boundaries; the dark gray patches represent the BUAs within municipal boundaries; and the light gray areas represent the municipal jurisdictions. The Yamuna River separates the eastern part of Delhi from the rest of NCT-Delhi.

4. Main findings of the research: establishing the link

The investigation that was conducted to analyze the urban transformation of NCT-Delhi from 1971 to 2011 identified linkages between the following factors:

- (i) The expansion of the BUAs and municipal boundaries
- (ii) BUAs outside municipal boundaries and slums
- (iii) Population and slum growth
- (iv) The provision of essential services and slums

4.1. The expansion of the BUAs and municipal boundaries

The analysis results in [Table 1](#) confirm that 20%, 35% and 42% of the BUAs in NCT-Delhi in 1977, 1999 and 2010, respectively, were outside their MCBs. The visual analysis in [Fig. 2](#) further illustrates that as the BUAs outside the MCBs expanded, the boundaries were extended in subsequent census counts. Although the MCBs in NCT-

Table 1

The growth of Built-up areas (BUAs) and absolute and relative rates of change in NCT-Delhi.

	BUAs-1977 and MCBs-1971	BUAs-1999 and MCBs -1991	BUAs-2010 and MCBs -2001
BUAs in Delhi	157	473	544
BUAs within the MCBs	125	309	313
BUAs outside the MCBs in %	20	35	42
Absolute rate of change	1977–1999	1999–2010	
BUAs within the MCBs in %	1.47	0.02	
BUAs outside the MCBs in %	4.13	0.41	
Relative rate of change	1977	1999	2010
BUAs within the MCBs in %	100	247	251
BUAs outside the MCBs in %	100	513	721

Note: BUAs in square kilometers; Municipal Corporation Boundaries (MCBs).

Delhi have been elastic for decades to incorporate growth, the development outside the MCBs has been rapid. The findings in [Table 1](#) confirm this development, revealing higher absolute rates of BUA change outside MCBs compared with BUA change within MCBs. Additionally, the relative spatial extent of the BUAs outside the MCBs has increased rapidly compared with the BUAs within the boundaries.

For example, for 1977–1999 and 1999–2010, the absolute rates of change for the BUAs within the MCBs were 1.47% and 0.02%, respectively, whereas outside the MCBs, the rates were 4.13% and 0.41%. The observed higher absolute rate of change for 1977–1999 could be the result of comparing a longer time period (22 years, 1977–1999) with a shorter one (11 years, 1999–2010). If the spatial extent in 1977 is assumed to be 100%, then the relative rates of change within the MCBs in 1999 and 2010 were 247% and 251%, respectively, whereas outside the boundaries, these rates were 513% and 721%. Therefore, this investigation has established a trend of growth beyond municipal boundaries, with a more rapid growth rate outside the MCBs than within them.

4.2. BUAs outside municipal boundaries and slums

[Table 2](#) lists the BUAs outside their MCBs for 1977, 1999 and 2010, alongside slums for 1981, 2001 and 2011. The results generally demonstrate increasing BUAs with corresponding increases in slums in all five zones.

A distinct trend of stagnation of BUAs outside municipal boundaries was identified in the eastern and the central zone since 1999. This finding can be interpreted as the result of the limited possibility of further development in these zones, as they had been predominantly built up by 1999; [Fig. 2 \(C, D, E and F\)](#) confirms this interpretation. In addition, extension of the municipal boundaries in 1981 incorporated the BUAs outside the municipal boundaries in the center since 1991. The 1990's construction of the Delhi Rapid Transit System and the Commonwealth Games Village (Sports Complex) resulted in major demolition in the center and some parts of the eastern zone. Slums were evacuated from these zones.

Table 2

Built-up areas (BUAs) outside the Municipal Corporation Boundaries (MCBs) and slum growth in NCT-Delhi.

	North	East	Center	West	South
BUAs-1977 outside the MCBs-1971	13	6	3	4	6
No. of slums in 1981	39	48	48	73	77
BUAs-1999 outside the MCBs-1991	62	26	0	42	33
No. of slums in 2001	67	87	61	132	127
BUAs-2010 outside the MCBs-2001	90	26	0	50	53
No. of slums in 2011	68	87	61	133	128

Note: BUAs in km².

The demolition of slums in the center explains the low number of slums in this zone between 2001 and 2011. The stagnation of slums in the eastern and central zones from 2001 to 2011 further affirms that development was limited in these zones due to the lack of open public undeveloped land.

In general, slums proliferate on available open public land because regulating such large landscapes is difficult. In addition, areas outside municipal jurisdictions are not under municipal control. Consequently, these areas are accessible to the urban poor for squatting. [Table 2](#) illustrates a high number of slums in the western and southern zones between 2001 and 2011. This is confirmed by [Fig. 2 \(C and D\)](#), which indicates a large amount of undeveloped land outside the municipal jurisdictions in these zones. These undeveloped areas could have served as a catalyst for slum proliferation in these zones.

The analysis corroborates the emergence of slums alongside the increase in BUAs outside the MCBs over these decades, thus establishing a positive link between BUAs outside the MCBs and the corresponding increase in slums. The stagnation of slums in the center and their increase towards the periphery were also observed.

4.3. Population and slum growth

[Fig. 3 \(A and B\)](#) shows the spatial dynamics of population and slum growth in NCT-Delhi from 1971 to 2011. [Table 3](#) lists the population and slum growth from 1971 to 2011 in the five zones. In general, the results indicate an increasing trend in population and slum growth. The distinct pattern observed for the center has been explained in previous paragraphs of this section.

The observed results in [Table 4](#) imply high rates of population change in all five zones in 1971 and 1981 and between 1981 and 1991, whereas a slow rate of population change occurred in the remaining years. A similar trend of high and low rates of change was observed for the slums in all five zones. Thus, the similar trend of population and slum rates of change accentuates the positive link between increased population and slum growth.

In summary, slum growth generally matched population growth in all zones. In addition, the slums stagnated in the center and increased in the peripheral zones.

4.4. The provision of essential services and slums

[Fig. 4](#) reveals that essential services (e.g., sanitation and water supply) were delivered to less than 40% of the population in 2004. Housing availability was identified to be a maximum of 48% in the northern zone and a minimum of 40% in the west. In [Table 3](#), the results of the 2001 slum analysis reveal the greatest number of slums located in the west, which had minimal housing availability in 2004. Additionally, fewer slums were identified in the north, which had maximum housing availability. Although housing availability nearly doubled in all zones in 2011, it remained low in the west and the south compared with the north and the east. [Table 3](#) confirms greater numbers of slums in the west and the south compared with the north and the east. Therefore, the housing availability tends to have resulted in lower or higher numbers of slums.

[Table 3](#) indicates stagnation in slums since 1991, with a minimal increase from 2001 to 2011. [Fig. 4](#) illustrates that between 2004 and 2011, the supply of essential services doubled. The number of slums increased rapidly until 1991, and stagnation was observed from 2001 to 2011. This trend implies a link between the supply of essential services and slum growth in NCT-Delhi, which tends to have stagnated because of the improved delivery of essential services.

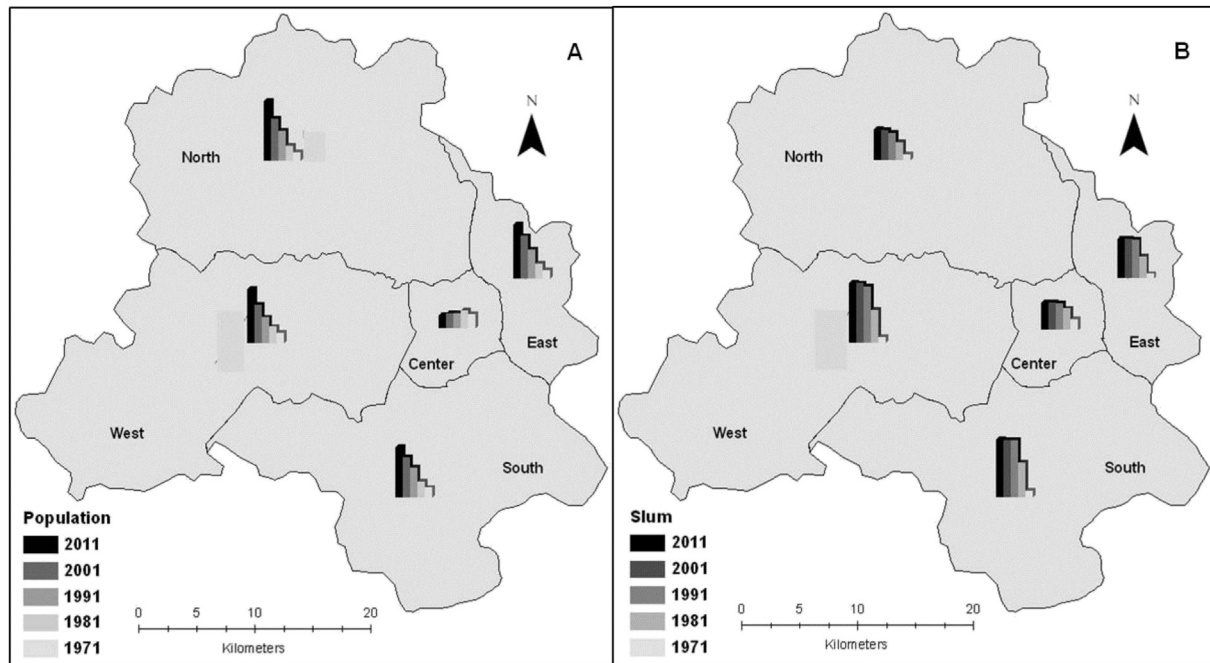


Fig. 3. Population and slum spatial dynamics from 1971 to 2011 in NCT-Delhi.

5. Discussion: rationale for the emergence and growth of slums

In general, the findings of the analysis have established that, since 1970, substantial urban development in NCT-Delhi has occurred outside municipal boundaries with a simultaneous limited extension of municipal boundaries. This change, coupled with population pressures and the limited provision of essential services, seems to have resulted in the emergence and growth of slums. These findings have also established the stagnation of slums in the center and their increase towards the periphery.

The transformation in NCT-Delhi is not unique; cities in other emerging countries and developed countries have experienced similar processes. However, due to its transformation, NCT-Delhi's urban agglomeration is projected to increase to 33 million by 2025 (UN, 2012), adding approximately one million inhabitants each year. Determining how the government will provide for this increase is crucial for NCT-Delhi urban development. Successful urbanization requires the integration of slums into cities, as these settlements house poor unskilled migrants who contribute to the

development of these cities. With the provision of essential services and targeted interventions, slums can be fully integrated into cities (Gill, Goh, & Lall, 2011). This integration can only be achieved with the continuous evolution of institutions and infrastructure (WDR, 2009), and although this process will take time, it can be achieved in decades rather than centuries.

The emergence and growth of slums in the NCT-Delhi in the backdrop of the institutional environment can be summarized as outcomes of the following factors: (i) the prevailing urban planning environment, (ii) the influence of the adopted policies and (iii) the urban government's inability to deliver essential services. These factors will be discussed in the following paragraphs.

5.1. Urban planning environment

Indian urban planning is a dynamic process of informality, i.e., a state of deregulation and an ever-shifting relationship between legal and illegal or authorized and unauthorized developments (Roy, 2009). In Delhi, the retention of modern, large-scale, prestigious buildings that are not aligned with the master plan of the city, along with slum demolition and the pushing of slums to the peripheries, reflects this informality (Ramanathan, 2006). For instance, land use changes along the bank of the Yamuna River, which is a non-urbanizable zone experienced the developments,

Table 3
Population (in millions) and slum growth in NCT-Delhi from 1971 to 2011.

	North	East	Center	West	South
1971					
Population	0.62	0.62	0.99	0.71	0.71
No. of slums	12	9	24	13	15
1981					
Population	1.09	1.08	1.30	1.18	1.12
No. of slums	39	48	48	73	77
1991					
Population	2.18	2.11	1.11	1.86	2.16
No. of slums	61	85	59	124	126
2001					
Population	3.08	3.07	1.08	2.79	2.89
No. of slums	67	87	61	132	127
2011					
Population	4.35	3.95	0.92	3.91	3.66
No. of slums	68	87	61	133	128

Table 4
Population and slum rates of change in NCT-Delhi from 1971 to 2011.

	North	East	Center	West	South
Population					
1971–81	0.75	0.76	0.31	0.65	0.59
1981–91	1.00	0.95	−0.14	0.58	0.93
1991–2001	0.41	0.46	−0.03	0.49	0.34
2001–2011	0.41	0.29	−0.15	0.40	0.27
Slums					
1971–81	2.25	4.33	1.00	4.62	4.13
1981–91	0.56	0.77	0.23	0.70	0.64
1991–2001	0.10	0.02	0.03	0.06	0.01
2001–2011	0.01	0.00	0.00	0.01	0.01

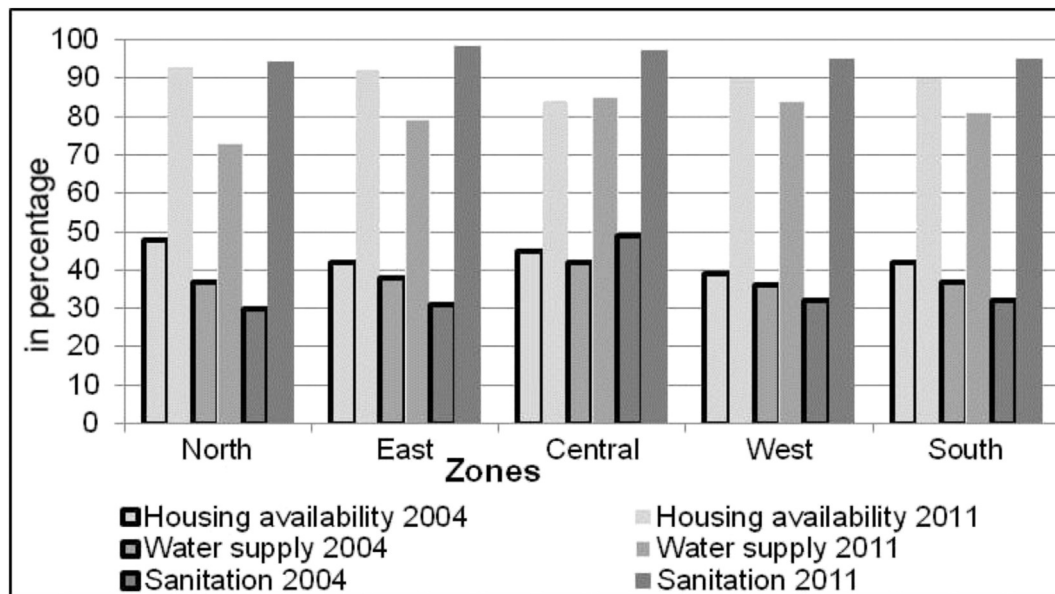


Fig. 4. Essential services in NCT-Delhi in 2004 and 2011.

such as Pushta colony (a slum colony), Akshardam Temple (the world's largest and most "modern" Hindu monument), the Commonwealth Games Village, the Information Technology Park, and a Delhi Mass Rapid Transit System depot, which violate the zoning regulations. Among the above-listed developments, only the slums were evacuated under a court order because they were not consistent with the Delhi government's aim of becoming a "World Class City". Another violation was the construction of India's largest shopping mall complex on Delhi's protected "ridge area" in Vasant Kunj (Ghertner, 2008); however, slum dwellers were evicted from the natural reserve because authorities claimed that the reserve areas were the lungs of the capital (Dupont, 2007).

In recent decades, the judiciary has undermined the fundamental right of shelter to the poor and slum residents, denying the state's obligation to provide resettlement alternatives for evicted families (Dupont, 2008, 2011a; Dupont & Ramanathan, 2008). As a result, more families have been evicted than re-located, which has increased homelessness and created different types of slum problems (Dupont, 2013; 2014). A major portion of the land from which slum dwellers have been evicted (on the pretext of public interest) is vacant (Dupont, 2014). The price of the vacated land is higher, thus it has been used to build high-end residential areas, shopping malls, office complexes and/or new roads (Dupont, 2011b; 2014).

Since the beginning, the Delhi Master Plan has reiterated its objective of decongesting Delhi and making it clean and green. As part of this process, polluting industries and slums in central Delhi have been pushed towards the periphery. This shift, coupled with the economic liberalization of the 1990s, increased the demand for real estate and large complexes with gated communities and multinational corporations (Shaw & Satish, 2007). These complexes were built on urban peripheries, as they required large amounts of land, which was available only at the peripheries. Consequently, the peripheries have been characterized as having dual structures, with pseudo-islands of prosperity surrounded by slums. In recent years, non-functional and ineffective rehabilitation measures and the municipalities' lack of willingness to provide infrastructure to distant settlements to avoid delivery costs have resulted in the degeneration of the urban periphery (Kundu, 2007).

Traditional planning practices, such as single-use zoning and low floor area ratio (FAR), in NCT-Delhi have resulted in a low-rise,

horizontal spread (Jain, 2013), as planners in India keep buildings low to avoid a strain on the infrastructure. Such horizontal expansion increases municipalities' infrastructure delivery costs, simultaneously raising the costs of living, which fosters the development of informal settlements (Glaeser, 2011). In addition, fiscal measures, such as Transfer Development Rights and increased FAR to accommodate the urban poor, have not provided necessary improvements. Instead, the initial horizontal slums have resulted in vertical slums (Javed, 2014). For example, in Delhi's slum rehabilitation, approximately 13,000 urban poor have been densely packed in multistory blocks on 18% of the land, and the balance (82%) has been allocated to 700 purchasing clientele, a commercial mall and shops, leaving the remainder for roads and other infrastructure (Khosla, 2013). Regulations and incentives that provide affordable housing and charge development impact fees would have helped the urban poor attain housing and generated the revenue to provide essential services. The prevailing implementation and regulation environment seems to have limited the available affordable housing for the urban poor.

5.2. Influence of the adopted policies

Since independence, both central and state governments have taken several initiatives to integrate slums into the cities, including the following: (i) the 1956 Slums Areas (Improvement and Clearance) Act, (ii) the formation of development authorities under the Third Five Year Plan (1961–1966), (iii) the founding of the Housing and Urban Development Corporation in 1970, (iv) the Environmental Improvement of Urban Slums in 1972–73, (v) the Integrated Urban Development Plan in the Fifth Five Year Plan (1974–78), (vi) the 1976 Urban Land (Ceiling and Regulation) Act, (vii) Valmiki Ambedkar Awas Yojana in 2001, and (viii) Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005.

The aim of Delhi's large-scale land acquisition and disposal policy was to supply affordable housing to low-income and economically disadvantaged populations; in reality, this policy favored high- and middle-income residents. The plot allocation was intended to be 50%, 30% and 20% for low-, middle- and high-income residents, respectively, but the actual numbers in 1982 were 20%, 21% and 47% (Acharya, 1987; Ravindra, 1996). Recently, from 2007

to 2008, the low-income housing target was 26,486 units. However, by 2008, only 6600 houses had been built (MoHUPA, 2009). The Indian ministry's report also acknowledged that the housing shortage for economically disadvantaged populations and low-income groups has not been addressed (MoHUPA, 2006). In addition, the JNNURM and the sub-mission Basic Services to the Urban Poor aimed to ensure housing for the economically disadvantaged, but the facility could only be used by those with security of tenure (Mahadevia, 2006), which the urban poor lack; therefore, the mission will not reach half of the population.

In general, it can be concluded that the adopted initiatives to provide for housing for the urban poor have had limited success due to (i) insufficient funding for infrastructure, (ii) some initiatives that were limited to certain segments of society and did not reach all of the urban poor, and (iii) the government's failure to utilize funds for the development of the urban poor (Dupont, 2011a; Javed, 2014).

Consequently, the lack of statutory housing provision implementation (Dewan, 2003) and the acute shortage of affordable housing have resulted in the growth of squatter and illegal settlements (Dupont, 2011a; 2013; Ramanathan, 2006). In addition, the greatest hindrance to the development of low-income housing is land availability. Although some land has already been designated for the development of low-income housing, it is not utilized effectively. This ineffective land use is due to inefficient land management and the lack of coordination between planning authorities at the state and local levels (Mahadevia, Joshi, & Sharma, 2009).

The descriptions above help confirm that when city authorities do not emphasize adequate housing in urban development processes, squatter housing becomes the only solution for the urban poor. The provision of adequate urban housing implies the provision of urban infrastructure services, including modern sanitation, piped drinking water and proper drainage (Ling, 2005), which are central to sustainability (UN Habitat, 2012). Therefore, by fulfilling the urban poor's needs for essential services, cities hosting slums can become sustainable (Ling, 2005; Mahadevia, 2002).

5.3. The urban government's inability to deliver essential services

The observed trend of urban development outside municipal boundaries indicates the weak empowerment of rural governing bodies. For instance, strict regulations and growth controls push growth into jurisdictions with little or no control (Ewing, 2008; Mills, 2006). A similar effect has been observed in NCT-Delhi, where the Municipal Corporation of Delhi (MCD) has the authority to control development, regulate land use and deliver essential services. Rural governance falls under Gram Panchayats, which do not have the right to control development but are responsible for rural development and the provision of services (e.g., drinking water, sanitation, underground water drainage and schools). This weak empowerment of Gram Panchayats to control development pushes the growth pressure from the city center to peripheral rural areas, which is particularly advantageous due to the lack of development control and low land prices in these areas.

Some developments (e.g., multinational corporations and gated communities) outside municipal boundaries have been successfully receiving 24-hour water supply and electricity by paying high prices (Shaw, 2005). These developments are equally responsible for the urban environment's degradation because they are not connected to the trunk infrastructures. For instance, in the gated communities in Delhi, solid waste management systems are either insufficient or nonexistent (Singh, 2013), and residents rely on

water tankers and groundwater from bore wells, which are illegal (Khandekar, 2013). This situation raises the following question: Should all developments outside municipal jurisdictions that are not properly connected to main trunk infrastructures, whether rich or poor, be classified as slums?

The municipal authority is responsible for delivering essential services (e.g., water, drainage and sanitation), but is limited within municipal jurisdictions. Any development outside the purview of a municipality lacks these essential services due to limited municipal revenues, which is a result of the following:

- (i) There is limited collection of property taxes, which are the municipal bodies' main revenue sources. For instance, in Delhi from 2006 to 2007, only 18% of the municipal revenue was collected from property taxes because property taxes were assessed at 30% less than market value and because of limited collection (Mathur, Thakur, Rajadhyaksha, & Bahl, 2009).
- (ii) Basic services are considered social goods; therefore, the government provides these services to users at no charge or at nominal prices (Savage & Dasgupta, 2006).
- (iii) Finally, the majority of collected revenue is used to pay the municipal authority's staff salaries (GNCT-Delhi, 2006).

The already slow delivery of essential services is exacerbated by the local authorities' deficient revenues, which make them dependent on the national and state governments for funding. Therefore, municipalities' unwillingness to bear the cost of extending services to distant settlements (Kundu, 2007) has increased the disparity in the availability of essential services between the center and the periphery and between the areas under municipal jurisdiction and those outside municipal jurisdiction. Because of the lack of funding and the unprecedented pace of growth, development has surpassed the delivery of essential services, which has incapacitated the institutional structure.

6. Conclusion

There is a growing call from researchers to examine sustainability in terms of essential service provisions for the urban poor (Ling, 2005; Mahadevia, 2002). This study provides comprehensive insight into the urban transformation of NCT-Delhi. Specifically, it reveals a previously undocumented rapid increase in BUAs outside municipal boundaries. And confirms the spatial shift of slums from the city center towards the periphery complying with the results of several studies by Dupont (2014; 2011a; 2011b). These investigations indicate that the emergence and growth of slums are outcomes of the prevailing urban planning environment, the limited success of adopted policies and the government's inability to provide for growth.

The primary limitation of this study was the lack of detailed spatial data linked to census data. Although the ability to classify types of urban slum morphology and to locate slums using EO data (e.g., Taubenböck & Kraff, 2014) will support future analysis, new EO sensors must allow for higher geometric and thematic detail without cost limitations for large areas. Despite limited data, the present study provides a methodology for studying the spatial dynamics of slums and thus advances the understanding of what drives the emergence and growth of slums in South Asian cities.

There are clear signs that the growth of the urban slum population will accelerate in the near future, thus significantly affecting urban environments and challenging urban sustainability. Therefore, there is a need to develop and implement more robust urban strategies that explicitly consider the delivery of essential services for the urban poor.

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