GeoJournal (2022) 87 (Suppl 4):S797–S819
https://doi.org/10.1007/s10708-021-10570-8

Urban growth and quality of life: inter-district and intra-district analysis of housing in NCT-Delhi, 2001–2011–2020

Madhuri Sharma · Rajesh Kumar Abhay

Accepted: 12 December 2021 / Published online: 7 January 2022

Abstract One out of three people in India is urban. In 2011, there were about 53 urban agglomerations larger than 1 million population as against only 35 in 2001. Much of this urban expansion has been occurring in the country's largest metropolises including the National Capital Territory of Delhi which has expanded horizontally and vertically both. This has also added to overall decline in its already dilapidated housing stock and quality of life. Delhi, a historical hub for regional, national, and international commerce, and a place for the socio-political elites, has failed to provide basic life amenities to its average citizens. This research critiques the (un)sustainable elements of Delhi's urbanization and concomitant decline in basic amenities pertaining to quality-of-life by examining the growth and expansion of its urban-built-up areas during 2001–2011–2020 and provides nuanced insights into its 'livability' by examining select quality-of-life attributes. The LANDSAT imageries for 2010 and 2020 are used to measure NDB-Index that assesses its built-up area and change, which are later corroborated with Census household data to examine change in its 'livable' and 'dilapidated' housing structures. Significant sub-regional disparity exists in the availability of good and livable homes, with almost 20–30% of several districts still without drinking water source inside premises. However, significant progress is also noted for basic amenities like lighting, latrine and bathing facilities, and majority of Delhi's built-up area has expanded along newer developments and transportation corridors. This calls for goal-oriented strategic interventions by policymakers to help achieve the SDG-11 on Sustainable Cities.

Keywords Urban Agglomerations · National Capital Territory of Delhi (NCT-Delhi) · Dilapidated · Life Amenities · LANDSAT Imageries

M. Sharma (✉)
Department of Geography, University of Tennessee, 416 Burchfiel Geography Building, 1000 Phillip Fulmer Way, Knoxville, TN 37996, USA
e-mail: msharma3@utk.edu

R. K. Abhay
Department of Geography, Dyal Singh College, University of Delhi, New Delhi 110 003, India
e-mail: rkabhay@dsc.du.ac.in

Background context

Local–global economy and urbanizing world

Having access to decent quality housing is a major problem among the vulnerable communities across the world, However, this crisis affects the poor and the low-income communities far worst in the developing countries as its largest urban areas are over-stressed due to uncontrolled and unsustainable levels of rural–urban migration, driven by the urban economic hubs. While urban centers in developing economies provide

various means of livelihoods (Mitra, 2004, 2006; Sharma, 2017), such regions do not necessarily have the residential infrastructure to provide decent quality housing to all of its residents. In general, a developing economy like India is notoriously famous for its exorbitant housing prices, way beyond affordability by its middle-class population (Edelman & Mitra, 2006; Mitra & Murayama, 2009). In India, on average, a house costs almost 30–35 times the average salary of a household whereas in USA, an average house costs about 5–7 times a household's income (co-authors' research interviews in Delhi). Most people move from rural to urban areas in search of a better quality of life, since urban areas provide a range of social and economic development opportunities for human lives (Jiboye, 2009; Mitra, 2006; Sharma, 2017). A house, thus, plays a key role in a human's life as it fulfills the second most important of the basic needs for humans, immediately following food (Ezeanah, 2021). Having access to adequate housing is also a basic human right (Kothari et al., 2006).

The total share of global urban population has been on the rise since the end of World War I, counting about 50% in 2015, and the United Nations estimates that by 2035, this share will exceed 62.5% (UN-HABITAT, 2020). Such rapid urbanization is met with huge challenges, especially due to the limited and premium land in urban cores, which eventually poses limitations to providing quality and affordable housing to average people. The precarity of fast urbanization through lack of affordable quality homes are also felt across many cities in Africa, South Asia, and Latin America as well. Significant shares of low and middle class people in these cities suffer from housing shortage, poor availability, sub-standard quality of housing, proliferation of urban villages and shanty towns, thence forcing humans to live amidst piles of solid waste, that pose constrained access to health facilities, poor air quality, degraded and limited access to public transportation, and the like (Bah et al., 2018; Ellis & Roberts, 2016; Mathur, 2013; Sharma, 2017; Tiwari et al., 2016; United Nations, 2020).

Research concerning urban expansion and housing quality in other parts of the developing world also suggests that often it is the poorest and the vulnerable minorities who occupy the least quality and environmentally unsafe residential spaces. In many developing regions, the poorest often build shanty towns and kutcha/temporary housing on the hillside slopes that lack basic life amenities, such as running water, fresh air, adequate ventilation, and sanitation, transportation linkages and other infrastructure that can provide improved quality of life (Davis, 2011; Jochem et al., 2018). Davis (2011), for example, discusses the fast expansion of squatter settlements on the hillsides of *Rio de Janeiro* (Brazil)—a global city where socio-economic polarization has been on the rise, with such residential spaces now reaching unsustainable levels, posing risks to lives and the environment. Likewise, Jochem et al. (2018) explore extreme levels of urban poverty among the residents on the difficult hillside areas of Afghanistan—an area for inhabiting the poor, the minorities, and the political refugees. The co-author's field-based professional work experience with the deprived and poorer communities in India's hilly regions also suggests that the hillsides generally comprise the dwellings of the marginalized communities—the scheduled tribes and the hill people in the Eastern and the Western Ghats, the Himalayas and in the Northeastern corridors of the Himalayas, including the seven-sister states. This is largely due to continued negligence by the governing administrators and the politicians, along with the physical and financially difficult processes in building transportation and related infrastructure in these hilly and difficult terrains of India. In the richest economies of the world, however, hillside residential locations have been the homes of the rich and the famous so they can claim their exclusive '*rights to the view*' by building on such spaces (Kellogg, 1977). Almost all Hollywood stars have their mansions on the Malibu Hills and in the Hollywood hills of Southern California. Thus, while the wealthy have numerous choices when buying or building homes (Anantakrishnan, 2018), the poor are left with limited choices since the only lands where they can build are generally allotted by the government, and in the process of negotiations and/or informal encroachments through squatters, generally the lowest and the most undesirable locations get converted into urban villages—slums (co-author's research interview in Delhi).

Regarding informal settlements, scholars also suggest that the urban squatters in developing countries are the eventual spatial manifestations of post-Fordist economic and industrial restructuring that changed the urban economy in the first world, but its socio-economic consequences were felt in the developing world. The post-Fordist neoliberal policies created a

distinct type of urban economy—the *new economy*—that affected the developed and the developing countries alike, by creating stringent core-periphery dynamics within each country and globally such that the poorest economies had to sustain a far greater share of the first world's neoliberal policy's consequences (Florida, 2017). In India, the poorest and the most vulnerable, including many middle-income population, still can't afford anything beyond the undesirable squatters of the Dharawi—Asia's largest slum (Anantakrishnan, 2018). This is because of the grab of the premium lands in big cities of India by the richest developers and builders, and the highly corrupt political and administrative system that has made land and homes unaffordable for the common people..

Urban economy and the spatial manifestation of sub-standard housing

Urban economy has significant potential to uplift a country's economy and raise the standard of living for its citizens (Mitra, 2004, 2008). Cities generate over 80% of global GDP even though they cover only 3% of the Earth's total land area (UN-HABITAT, 2020). It is well-known that the growth of cities and urban areas have a potential to improve the overall quality of lives of people (Mitra, 2006, 2008). A city provides opportunities for social and diversity inclusiveness, improved education, and health infrastructure, and serves as center of economic innovation and growth that reduces poverty, while also providing space and opportunities for political, religious, and cultural inclusiveness and prosperity (Edelman and Dupont & Mitra, 1995; Mitra, 2006; Sharma, 2017). At the same time, though, urban areas are unable to provide housing for all the people who move to urban locations with the hopes of creating a better future for themselves and their families (Edelman & Mitra, 2006; Kundu, 2016; Sharma, 2017). Due to unaffordable housing and lack of overall economic well-being, lower-income and poverty of the migrants, people continue to live in poor quality and sub-standard housing, often falling in the 'dilapidated' category of housing that comprise the largest shares in slums (Mitra, 2004). Slums, in general, lack in the availability of basic public amenities such as safe water, sanitation, electricity and the like (Kumar, 2016). This situation persists in many global cities such as Beijing, Mumbai, Benin, Kolkata, and the Latin American cities (Dey, 2020; Ezeanah, 2021; Junhua, 1997; Magalhães, 2016; Sundaram, 1985). It is estimated that almost 26 percent of South Asia's urban population lives in slums, accounting to almost 30 million households, comprising of low, low-middle and middle-income households (Ellis & Roberts, 2016). These slums are largely the spatial manifestations of unauthorized and substandard settlements with restricted potentials for social-economic mobility (Sharma, 2017). Millions of people living in such sub-standard dwellings further hinder overall commercial and economic investments through infrastructure development and otherwise (Sundaram, 1985)—all of which recreate cycles of concentrated poverty in developing economies.

Today, housing affordability remains a global challenge as it virtually affects all (UN-Habitat, 2020). The cities, especially in developing economies, are growing and expanding, encompassing their commercially and economically expanding land use patterns (Dey, 2020; Ezeanah, 2021; Sundaram, 1985). Like other parts of the world, cities in developing countries like India too are transforming and growing rapidly (Dupont, 2004) and facing similar issues (Dey, 2020; Sharma, 2017; Sundaram, 1985). Delhi has been experiencing a shortage of housing along with poorer and dilapidated housing stock (Malhotra, 2016; Planning Department, 2019). This occurs due to a lack of continued investment in the built structure, mostly due to low income and lack of assets of the dwellers. Since its naming as the Capital in 1912, Delhi has grown and expanded significantly, acquiring the status of the second largest metropolitan area of India, with rapid urbanization along with its large share of the poorest, the oldest, and the most dilapidated housing stock. Delhi, being the Capital and the administrative center, is also notorious for its political lack of will-power toward improving quality of housing for the common people. This has pushed the city's population toward its old and dilapidated housing structures in its oldest central geographic locations—most of which are extremely congested, without access to roads or even streets. These parts endow the poorest infrastructure, with almost non-existent public amenities. Expensive housing, poor implementation of housing schemes, lack of enough affordable housing, lack of responsible financing, and scarcity of public facilities, etc. have collectively aggravated these problems (Malhotra, 2016). Thus,

sustainable solutions for providing adequate and safe housing, associated amenities, as well as conservation of old structures are critical steps toward sustainable urbanization and holistic growth (Bah et al., 2018; Ceranica et al., 2017; Hagbert & Femenías, 2016; Magalhães, 2016; Montaner, 2020; Turner et al., 2019).

Recently, people have started building and residing in the surrounding areas of Delhi such as Gurugram (earlier Gurgaon), NOIDA and Faridabad. Housing quality in these newly expanded geographic spaces are relatively newer, better, available at lower prices than in central/old Delhi and are linked to the city and commercial districts and workplaces by roads and metro railways. Gurugram, for example, is now one of the wealthiest suburbs of Delhi, which contributes toward 45% of the total property taxes and revenues in the whole state of Haryana (Goldstein, 2015). In Faridabad, several new high quality housing societies have developed for the senior citizens and the retired. The facilities provided in these newly developed communities are all available within proximity to serve the needs of the old and the ageing population (Sharma & Sen, 2016). Purchasing good quality homes, especially in an expensive city like Delhi is a very difficult process. Land acquisition followed by arranging for basic services such as water, electricity, waste collection, streets, etc. can be daunting, especially when one thinks of keeping it affordable. Besides, limited access to housing finance, particularly for low and low-to-middle income groups, exacerbates the gap between housing availability and affordability (Roychowdhury & Puri, 2017). In India, however, for the Economically Weaker Sections (EWS) and the Lower Income Groups (LIG) of population, various affordable housing schemes have been initiated by the government (Malhotra, 2016).[1]

Quality of life amidst urbanization-induced housing crises

Urbanization[2] in India has largely been propelled by rural–urban migration, induced by urban-centric economic opportunities promoted by the local and national governments (Mitra & Murayama, 2009; Mitra, 2004, 2006; Sharma, 2017). This phenomenon has created a huge demand for housing in cities and urban areas which has added to overcrowding, and unaffordable high rents, leading to the proliferation of slums in numerous big and mid-sized cities/metropolises (Edelman & Mitra, 2006; Onibokun, 1972). Globally, there has been a shortage of homes in low- and mid-income countries of the world (Bah et al., 2018; UN-Habitat, 2020), and out of the total housing stock that exists, most of them are very old and/or are becoming old and getting fast dilapidated.[3] In India, such dilapidated housing settlements lack safety features, provide sub-standard and inadequate quality and quantity of shelter, and are often clustered spaces of unhealthy environments, which also lack overall safety with low-to-limited physical, social, and mental/emotional well-being of its residents (Malhotra, 2016). Often in the slums and urban villages of Indian cities, people build on homes that are already quite old and in dilapidated condition, deemed unsuitable for human life (Dey, 2020; Sundaram, 1985). Such homes have been identified as unfit based on the perceptions of individuals (Census of India, 2001; Ezeanah, 2021), and are considered as *high-risk* settlements that are vacant, sometimes abandoned and/or in poor condition. In the absence of affordable housing, particularly to a large segment of low-to-middle class population in developing economies, at least one in four dwellers lives in dilapidated houses or in the slums (Ellis & Roberts, 2016). Delhi, the Capital City of India, is no stranger to enormous share of its population who are migrants from near and far rural areas, trying to meet their ends meet in this large city, eventually settling down in sub-standard habitations that they call home (Mitra, 2004, 2006; Mitra & Murayama, 2009; Sharma, 2017).

To assess quality of housing and its impacts on residents' lives, scholars have used a multitude of

[1] EWS category includes households earning Rs. 100,000 or less whereas the LIG households' income range within Rs. 100, 001to Rs. 200,000 per annum.

[2] The Indian census defines urbanization as a process wherein towns and cities with 5000 for more people reside in urban areas while meeting other criteria as specified in the Census (Census of India, 2011).

[3] Dilapidated literally means decayed or in a deteriorated shape. This happens due to lack of repairs on older structures and continued investments in the built housing infrastructure, as people in the developing economies often struggle with low income, and they don't have disposable income to spend on housing repairs.

qualitative measures to examine living conditions and quality of services in their dwellings. For example, Hanmer et al. (2000) found that housing quality was determined by the provisioning of infrastructural services which provided sustainable amenities toward improved living environments without compromising the livelihoods of local people. Neilson (2004), on the other hand, suggested five criteria for improving housing quality. They suggested that a house must follow the acceptable standards, free from serious/poor shape in terms of built structure, is energy competent, has modern services, and is healthy, safe, and secure. The urban slums are very congested and are built generally in the oldest and most dilapidated parts of inner-city areas (Pucher et al., 2005). These residents suffer from congestion, derelict housing, poor availability of public amenities, pollution, unsafe water, poor sanitation, and the like—all of which significantly restrict their physical, socio-economical, cultural, and emotional wellbeing. Quality of life implies not only a person's overall wealth status and employment status; instead, it also implies a community's broader environment, access to health and educational infrastructures, overall housing conditions, and its physical suitability to human life, and residents' wellbeing and levels of satisfaction (Peck & Stewart, 1985). The quality of housing in an area affects the physical wellbeing of people, whereas decent living conditions while staying within affordable costs is critical to the emotional wellbeing of its dwellers (Okewole & Aribigbola, 2006). These authors, indeed, used both quantitative and qualitative parameters to assess the quality of housing—quantitative assessment included the structural, economic, and social indicators of housing whereas qualitative measures included subjective assessment of quality of life (Okewole & Aribigbola, 2006).

To sum up, our review of relevant literature finds abundance of research focused on housing supply shortage, availability of public amenities, slum upgradation, solutions for sustainable urbanization, and the like. However, there is dearth of good research on dilapidated housing, their spatio-temporal patterns, and how might they affect people's quality of life. This paper fulfills this gap by providing critical insights into the spatial expansion of such dilapidated housing and its change over time in the National Capital Territory of Delhi. Our study specifically addresses these aspects of dilapidated housing and makes an important contribution to the academic knowledge by highlighting the ever-expanding urban dilapidation from a spatio-temporal lens in NCT-Delhi. In addition, we also examine the associated quality of life amenities in these census housing to better understand the overall quality of life of Delhi's residents. By taking this amenities-based detailed approach to studying inter and intra-district patterns and change in its overall quality of life, we fill in a critical gap in academic scholarship on urban sustainability and quality of life in a city of one of the fastest growing economy of the world—Delhi in India—that is home to more than 16 million people, 40 percent of whom still reside in its *urban villages*—a term used by the academic elites to refer to Delhi's slums. Thus, the major objectives of this paper include: (1) to analyze the trends of urbanization from 1901 to 2011 and its spatial patterns at the district level, (2) to examine the urban sprawl and growth of built-up area, using the LANDSAT imageries for 2010 and 2020,[4] (3) to investigate the growth and change in the quality of life of the residents of NCT-Delhi by assessing the share of its residents who live in the livable housing versus the dilapidated, (4) to examine the change in the availability and access to various quality-of-life amenities for the residents in these sample households, and finally (5) to suggest policy interventions that can improve the quality of housing and eventually the life of Delhi's residents.

Research design

The study area and scale of analysis

We chose NCT-Delhi for this analysis due to its national and global significance as a political and economic hub in the fastest growing region of the world. It contributes to the country's economy through significant shares of total employment and tax revenues. According to the Master Plan of Delhi, Delhi is

[4] Please note we use the 2020 satellite imagery data to measure the most recent built-up land use in Delhi so that it can somehow explain and correlate with the latest population expansion-based enumerations from the Census 2011. Due to Covid-19, the latest 2021 has been delayed and may take more time to be completed and be available for public use. Thus, to show the decadal change, we used imageries from 2010 and 2020 both, to emphasize on the expansion and its degree of change.

a major center for wholesale markets dealing with textiles, stationery, iron and steel, auto parts and modern technology. There are 32 planned Industrial Estates in NCT-Delhi. The National Capital Territory of Delhi spreads across 1483 sq km (572.59 sq miles) (District Census Handbook, 2011), and is bordered by the State of Uttar Pradesh (toward the east, across River Yamuna), and surrounded by the State of Haryana toward its north, west and south. While the City of Delhi inhabits more than 11 million people, the second largest in India after Mumbai, the population of NCT-Delhi is about 16.8 million (Census of India, 2001), with only 2.5% of this total population being rural (0.4 million) and the rest 97.5% being urban (16.4 million). Delhi is also densely populated with 11,320 persons/sq km, that also marks some of the most dilapidated urban slums and residential communities being analyzed in this paper. Delhi also has an unfavorable sex ratio of 868 females for every 1000 males and low labor participation rate of 33.28%, despite an overall literacy rate of 86.2% (District Census Handbook, 2011). We choose the districts and the sub-districts as the scale of analysis for this study. According to the Census of 2011, Delhi contains nine districts—North, East, South, West, North-East, North-West, South-West, Central Delhi and New Delhi, which are further divided into 27 sub-districts, locally known as *Tahsils* (Fig. 1: Top row). The forthcoming 2021 Census[5] will add two additional districts—the South-East district and the Shahdara district, thus making a total of 11 districts. This study focuses on these 9 districts and 27 sub-districts (tahsils) of NCT-Delhi, based on Census 2011 definition.

Data sources and methodology

Data at this scale is gathered from the Indian Census—the most reliable and publicly available source of data. The Census collects data at the household level—known as 'Census House' once every ten years. The Census of India (2001) defines a 'Census house' as "a building or part of a building used or recognized as a separate unit because it has a separate main entrance from the road or common courtyard or staircase." It may be occupied or vacant and may be used for residential or non-residential purposes or both. These data are clubbed together at the sub-district level which is a viable unit of analysis for studying the quality of housing quality in NCT-Delhi.

To address our research objectives, we use the Census based secondary data and remote sensing images to measure the built-up area as well as the quality of life of its residents. The secondary data is collected from various sources such as the Census of India (2001), District Census of Handbook for NCT-Delhi (2011 and earlier census years) census tables which provide data on houses, households amenities, and the assets, etc. for Delhi. We use Forest Survey of India (FSI, 2019), USGS (United States Geological Survey) for remote sensing data in the form of satellite imageries. The collected data is cleaned and organized to create a comprehensive dataset for the entire study area. Census of India provides detailed data on various aspects of housing condition, its ownership, available amenities, and their status. Data on trends and patterns of urbanization are easily available from the census at the district and sub-district scales. Spatial patterns of urbanization are tabulated at the district level for the 2001 and 2011 censuses and are illustrated with the trend line graph, bar charts, graphs, tables, and choropleth maps. The household level data is also collected for analyzing the status of the quality of housing and household amenities. The Census of India has classified all census houses into three categories: good, livable, and dilapidated. Data on these three categories is collected from the Census, and their spatial distribution patterns are mapped at the district level for the years 2001 and 2011—illustrating the livable and dilapidated houses. Various choropleth maps show the sub-regional variations among the livable and dilapidated housing across the NCT-Delhi.

Researchers have employed different techniques to compute and map housing-types and built-up area at various scales. For example, Dey (2020) used the *dilapidation index* to examine the structural conditions of housing from the perspectives of residents and their behavioral analysis. Others have used the *normalized built-up index* method to map the urban built-up area (e.g., Bhatti & Tripathi, 2014; He et al., 2010). This

[5] The Census of 2021 in India has been delayed significantly due to the pandemic, and hence the final date of compilations and publicly available release date of the latest data is still unknown. This makes it difficult for us to conduct this analysis using the 2021 Census. However, we feel that the change pattern shown in this paper is a critical guideline to our future planning measures.

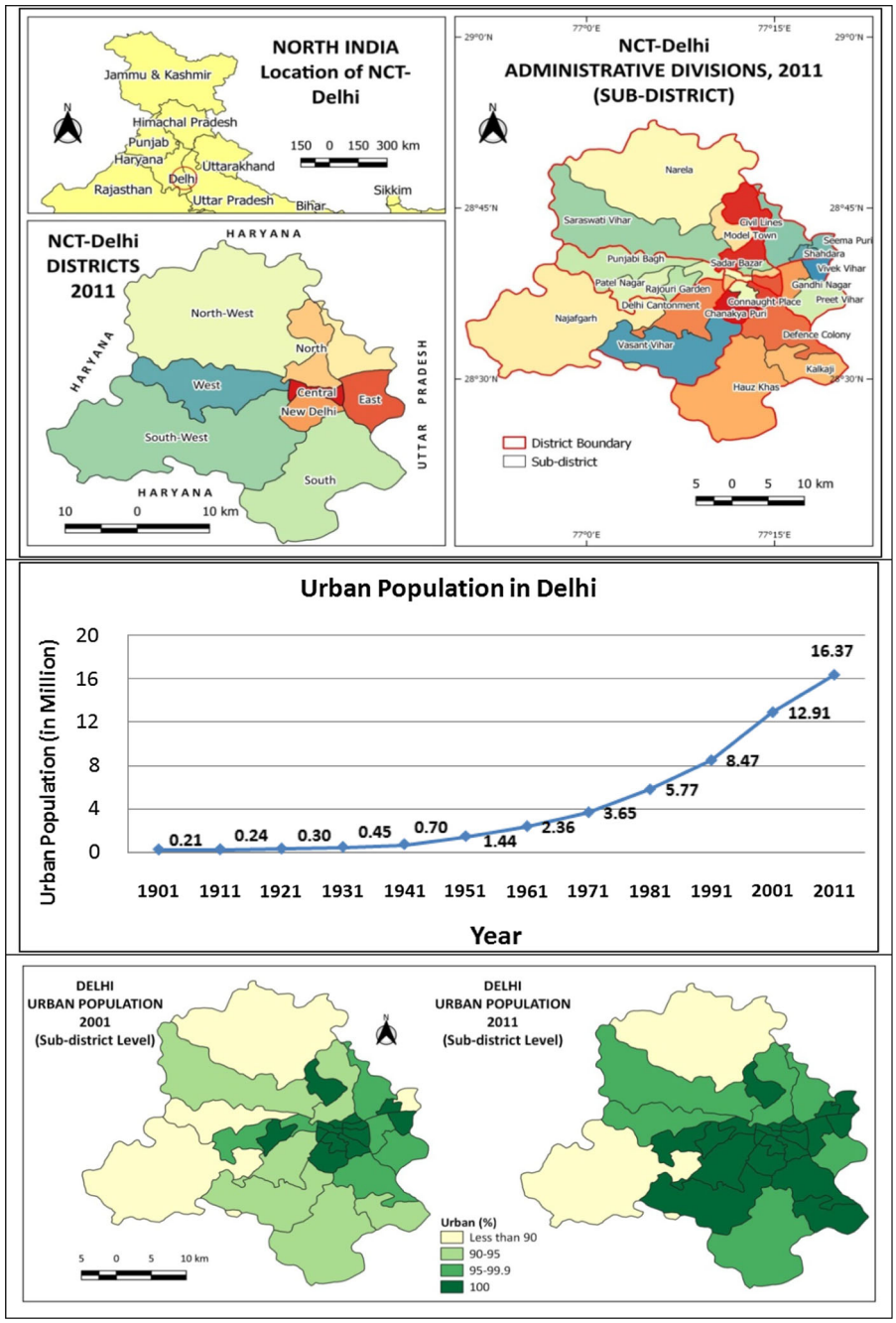


Fig. 1 Study area (top), trend of urbanization (middle) and its district-based urbanization (bottom) in NCT-Delhi, India. *Source*: Census of India, Delhi, 2011 and previous years

method is one of the most precise in extracting the urban built-up area. Jain and Dimri (2016) used several indicators to finalize the built-up area in Delhi, such as the built-up density, population density, patch density, and edge density to show urban sprawl based upon remote sensing and spatial metrics approaches. Scholars have highlighted the benefits of using remote sensing satellites imageries in analyzing the spatial extent and growth of urban *built-up* areas. They are available for periodic times and represent a synoptic

view of the urban environment and its growth and change (He et al., 2010). Several transformation methods are available to analyze urban growth. NDBI (*Normalized Difference Built-up Index*) is one very popular technique, introduced long ago by Zha et al. (2003) to map urban built-up areas. Other image classification methods like supervised and unsupervised classification techniques involve several steps to achieve results, and yet those suffer from accuracy issues. As such, for our analysis, we use the popularly used NDBI method to measure and map the built-up areas, given its simplicity in computation and accessibility to non-technical audience in terms of the story it tells. We use various bands of data, as illustrated in Eq. (1) below, based on band combinations. The NDBI is computed using the following notation where SWIR represents the short-wave infrared band and NIR is near-infrared band.

$$\text{NDBI} = \frac{\text{SWIR} - \text{NIR}}{\text{SWIR} + \text{NIR}} \quad (1)$$

In this study, we use NDBI data for 2010 and 2020,[6] downloaded from the United States Geological Survey (USGS) of LANDSAT-8 at 30 m spatial resolution. Using Eq. (1), NDBI is calculated and analyzed to address the objectives of this study. The NDBI value ranges between -1 and $+1$, with negative values representing land use categories such as waterbodies, and positive/higher values representing built-up areas. NDBI value for vegetation is low. We use the QGIS 3.14 open-source GIS software for mapping our analytical findings. Once we complete the assessment of built-up area's growth and expansion, we then move forward with simple descriptive statistics and graphical analytical measures to examine change in the availability of various quality of life indicators at the inter- and intra-district level for both Census, 2001 and 2011. Based on the facts and figures available in the data, we present our findings through visual graphs and maps, later substantiated by major highlights of the most important findings in the following sections.

[6] We use NDBI data for 2010 and 2020 because that the closest approximation to the latest ground-level built-up area estimation. While the Census 2021 may take several years before it is released to the public, nevertheless our multi-step attempt to explain the urban built-up area spawl along with quantitative analysis of 2001–2011 change quality-of-life amenities in the census households of NCT-Delhi is the best methodological approach toward addressing our research objectives.

Results and discussion

Urbanization trends in Delhi

Since independence, Delhi has grown tremendously in its spatial spread-out as well as overall population, currently at 16.8 million, of which 16.3 million (97.5%) is urban (Census of India, 2011). Since its designation as the 'Capital' by the British Empire in 1912, the population of Delhi increased from 0.24 million (1911) to 1.44 million (1951) (Dupont, 2004). During 1901–1951, the urbanization of Delhi was gradual, with less than 1 million added every decade; since 1951, however, its urbanization speed exploded dramatically (Fig. 1). Though the 1950s and 1960s added approximately 1 million urban people, since 1981, it has added more than 2 million urbanites every decade up until 1991. During 1991–2011, however, NCT-Delhi has had an extraordinary growth of urban population, accounting to more than 4 million and 3 million in the Census of 2001 and 2011, respectively, with an overall increase of 4.3% in its total urban population (Table 1) during 2001–2011. Also interesting to note is that out of the nine districts in NCT-Delhi, those with the highest shares of urban growth include North-East (7%), South (6.7%) and South-West (6.5%) whereas the North-West, North, and West districts experienced an urban growth of about 4%; Central and New Delhi districts were already saturated at 100% during both decades (Table 1). New Delhi and Central districts are in the central parts of the city, that also encompass some of the most urbanized, elite built constructions, and is home to the administrative official headquarters. In 2001, out of the 27 sub-districts, 12 sub-districts were completely urban whereas by 2011, 19 sub-districts became fully urbanized (Fig. 1: Bottom-row).

According to the 2001 Census, the urban population ranged from 87.2% in North-West district to 100% in the districts of New Delhi and Central (Table 1). Out of 27 sub-districts, 12 sub-districts were 100% urbanized (Fig. 1: Bottom-row) and 4 sub-districts had urbanization of less than 90%. These sub-districts included Narela (North-West district), Punjab Bagh (West), Najafgarh (South-West district) and Seema Puri (North-East). During 2011 Census, the urban population ranged from 93.7% in North-West district to 100% in Central Delhi and New Delhi district (Census of India, 2011). However, there still existed

Table 1 District-wise urban population in the NCT-Delhi, 2001–2011 (in percent). *Source*: Census of India, District Census Handbook-Delhi, 2001 and 2011

S. no.	District	2001	2011	Increase
1	North-West	90.7	94.1	3.4
2	North	94.0	98.0	4.0
3	North-East	92.0	99.0	7.0
4	East	98.8	99.8	1.0
5	New Delhi	100	100	0.0
6	Central	100	100	0.0
7	West	95.9	99.7	3.8
8	South-West	87.2	93.7	6.5
9	South	92.9	99.6	6.7
Total	NCT-Delhi	93.2	97.5	4.3

wide variations in urbanization at the sub-district levels. Narela at 79.2% urbanization and Najafgarh at 89.5% urbanization rates were still less than 90% urbanized, and these were also the largest sub-districts in terms of areal spread (Fig. 1). During 2001–2011, 7 more sub-districts became fully urbanized, indicating micro-level intra-sub-district levels of rapid urbanization.

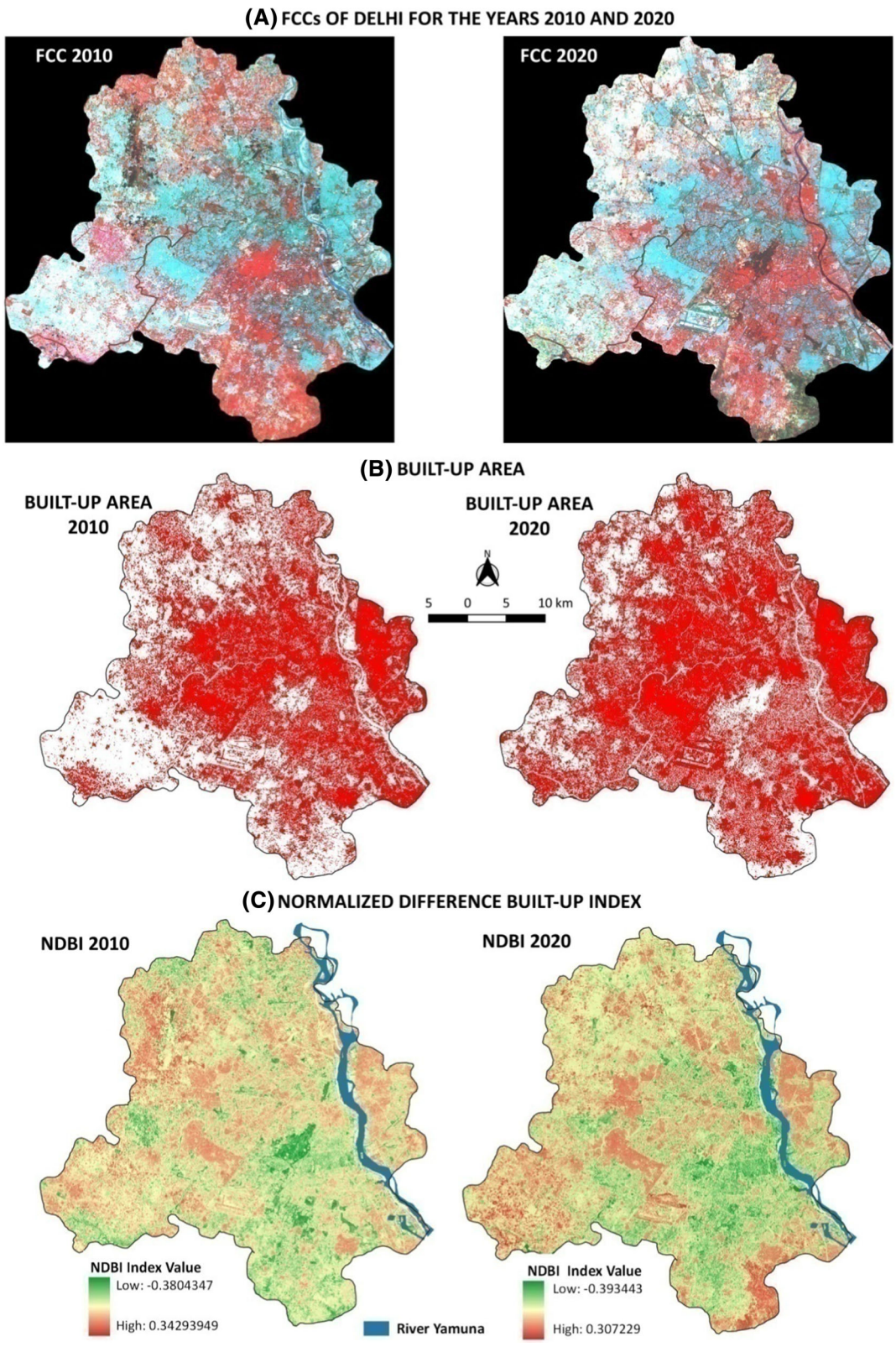
Also, we found that in 1961, the total built-up area was about 22.26% (325.3 sq km), which almost doubled to 42.16% (624.3 sq km) during 1961–1991. During the last 20 years (1991–2011), out of a total geographical area of 1,483 sq km, urbanization encompassed a total of 924.7 sq km. Simultaneously, the total urban population also increased from 93.2% (2001) to 97.5% (2011). This sprawl has been very rapid and can be attributed to the planning of Delhi, along with development of satellite towns such as Gurugram, NOIDA, Ghaziabad and Faridabad and its further extension as the NCR (National Capital Region)—all of which have been largely propelled by NCT-Delhi's growing significance as an important center of attraction for global outsourcing and IT industry (Mehta et al., 2012; Stitt, 2003).

Urban sprawl of built-up area in Delhi, 2001–2011

We also analyzed the growth and change in total built-up area in NCT-Delhi, using the widely used NDBI, and the False Color Composite (FCC) images (Fig. 2A) for the years 2010 and 2020 to explore spatial correlation across these decades. As noted in the methodology section, the NDBI is the index of analysis used in this study for measuring built-up areas. In our analysis, the highest positive value of + 0.307 was obtained for Delhi in 2020, whereas it was + 0.342 in 2010, thus corroborating significant change in total built-up area which is illustrated in the maps as well.[7] The built-up land has been highlighted using the supervised classification techniques during the period to extract the built-up land area (Fig. 2B) and further supported by NDBI. The NDBI is a binary image wherein higher positive values indicate built-up and barren lands (He et al., 2010). Thus, it becomes easy to extract a map of built-up areas, as shown in Fig. 2C. Figure 4B suggests that the urban sprawl is the highest toward the south and south-west direction. This urban sprawl can be attributed to the development of National Highways (NH) No. 8 and 24, passing through the south-west and the south direction respectively—connecting Gurugram and Faridabad—two newly developed satellite cities (see Stitt (2003)'s documentary on Delhi's outsourcing industry).

The patches of built-up land are also visible toward the north direction, particularly in Narela sub-district, which is located on the way to NH-1 linking Amritsar in the State of Punjab. These developments have been quite rapid during 2010–2020. The above discussions also reveal that the transport corridors had strongest association with the built-up areas. Besides, the built-up urban development has reached its maximum level in the trans-Yamuna region whereas the areas in and around Dwarka sub-city (South-West district) and Rohini (in North-West district) are still showing urban

[7] Please note that the Normalize Difference Built-up Index value ranges between − 1 and + 1, with negative values representing land use categories such as waterbodies, whereas positive/higher values represent built-up areas. NDBI values for vegetation is low. Thus, the NDBI technique is a simple and yet a very useful statistic for analyzing the urban built-up areas. We want the readers to understand that the highest or lowest values in NDBI does not imply the increase or decrease in the built-up areas. Instead, it shows the density and intensity of built-up area. Value of the pixels closer to the highest NDBI values imply high built-up density and vice-versa. The figure clearly explains that the built-up has increased with more density over the specified time period (e.g., the brown color in the figure which is becoming darker, suggesting that the built-up areas are becoming denser/closer, especially in South Delhi, and Southwest Delhi, when compared over time).


(A) FCCs OF DELHI FOR THE YEARS 2010 AND 2020
FCC 2010
FCC 2020
(B) BUILT-UP AREA
BUILT-UP AREA 2010
BUILT-UP AREA 2020
N
5 0 5 10 km
(C) NORMALIZED DIFFERENCE BUILT-UP INDEX
NDBI 2010
NDBI 2020
NDBI Index Value
Low: -0.3804347
High: 0.34293949
River Yamuna
NDBI Index Value
Low: -0.393443
High: 0.307229

◀**Fig. 2** NDBI in Delhi, 2010 and 2020. *Source*: Based on LANDSAT data downloaded from USGS

growth (Jain et al., 2016). These urban developments are occurring at the cost of agricultural land located in the peripheral areas of Delhi. Transportation roads and other auxiliary networks of city roads and metro, etc. have played a major role in the transformation of land-use/land cover of NCT-Delhi since the start of the twenty-first century.

Spatial patterns of housing quality and housing structure in NCT-Delhi

According to the 2011 Census, there were 3.3 million census houses in Delhi as against 2.5 million in 2001 (Table 2). During this decade, the capital city experienced a multifold increase in the total number of households. Migration from surrounding states has played a major role in exploding Delhi's population (Dupont & Mitra, 1995; Mitra, 2004, 2006; Sharma, 2017). There is an overall increase of 0.8 million households in the first decade of the century. The quality of housing is measured based on the perception of the respondents and is classified as good, livable, and dilapidated (Census of India, 2001). Overall housing quality has improved, even though there has been a decline in the livable quality of houses (5.2%) as well as the dilapidated houses (2.6%) (Table 2). The Census (2011) estimates that in Delhi, the number of housing in the dilapidated condition is now less than 0.1 million. However, a visual introspection of livable versus dilapidated housing in Delhi's districts and sub-districts provides a very different view (Fig. 3) wherein the spatial sprawl of dilapidated houses has indeed increased to far greater extent that those in livable conditions.

Spatial patterns of livable housing

The spatial patterns of the livable and dilapidated houses at the district level are illustrated in Fig. 3A–D. In 2001, the highest percentage of livable housing was found in the North-East (44.75%), followed by North district (43.31%); it was the lowest in East Delhi district (26%) along with West (33.5%) and South-West (32.5%) districts (Fig. 3A). The spatial pattern of livable houses in 2011 suggests that the maximum number of livable quality of houses are in the Central district (39.3%), followed by North-West and North district (Fig. 3C). Out of these, the Central district is fully urbanized. This suggests that the North-West district is added into the category of maximum percentage of livable houses in 2011 (more than 35%; Fig. 3C), making the entire north and north-western parts of Delhi more livable in comparison to the rest of the city. It can be attributed to this regions' higher shares of home ownership. In north and north-west Delhi, approximately one-fourth its total population lives in rented house (Planning Department, 2019) whereas rest own it. The rental landlords usually don't invest in improving the quality of these houses, and since most of the landlords live away from these houses, tenants are forced to take the responsibility of dealing with housing-repairs and other related problems (Kumar, 2016). Tenants mostly invest on the available public facilities and continue to live in those livable housing, without making substantive investments toward its structural improvement. However, important to note is that the overall percentage of livable quality of houses has declined during the period 2001–2011, with its share at 37% in 2001 compared to only 31% in 2011. This is how the spatial expansion of districts show a higher percentage of livable housing, but the overall average is low.

This aspect of the *livability* of housing is also analyzed at the sub-district level (Fig. 3E). There are 12 sub-districts with less than 30% livable houses whereas 6 sub-districts have more than 40% of their houses as livable. Mostly, the south-western and south-eastern parts of NCT-Delhi have a lower percentage of houses as livable. The livable housing percentage ranges from a maximum in Pahar Ganj sub-district (45.6%) in Central district to the lowest percentage in Parliament Street (18.5%) in New Delhi district. Pahar Ganj is located near New Delhi railway station, characterized with high population density, congested housing, with slums and poverty around in patches (Kumari & Punia, 2017). It is very difficult to reconstruct or even renovate homes in these locations due to very high cost of labor and limited sources of income as most people belong to middle income group. Parliament Street sub-district, located in New Delhi district, is one of the most developed areas of the city, surrounded by Chanakya Puri, and Connaught Place sub-district has higher percentage of good housing than livable and dilapidated.

Table 2 Livable and dilapidated houses in NCT-Delhi, 2001–2011. *Source*: Census of India (2001, 2011a)

Year	Total Census Households	Good	%	Livable	%	Dilapidated	%
2001	2,450,817	1,422,525	58.0	897,197	36.6	131,095	5.4
2011	3,313,904	2,181,500	65.8	1,039,572	31.4	92,832	2.8
Change	+ 863,087	+ 758,975	+ 7.8	+ 142,375	− 5.2	− 38,263	− 2.6

Spatial patterns of dilapidated housing

Fig. 3B, D illustrate the overall patterns of dilapidated housing in NCT-Delhi at the district level for the years 2001 and 2011. During 2001, two districts—North and surprisingly, New Delhi were found to have the highest percentage of dilapidated quality of housing, at 8.5% and 9%, respectively (Fig. 3B). It is surprising because these are the upscale areas of the city. In contrast, New Delhi district has some of the oldest constructed structures, developed way back during the British Raj, and are in and around the upscale areas of the city. Renovation and other construction activities are not frequent due to which dilapidation is high. In 2001, North-East and East districts had the least number of houses in 'dilapidated' category because of their being on the outskirts of the city, known as 'Jamuna Paar' (i.e., across the river Yamuna), and new construction was a continuous process. Therefore, the percentage of livable and dilapidated housing was low here

The spatial extent of dilapidated housing also extended into the Central and North-West districts (more than 3%) along with North and New Delhi districts in 2011 (Fig. 3D). Important to note here is that two districts—New Delhi and Central districts—are completely urbanized and have a higher percentage of dilapidated quality of housing. Central Delhi is the oldest part of the city with historical significance, densely populated, and highly congested. Narrow streets, restricted movement of large vehicles, higher cost of labor and other required materials and developed markets are the major factors posing constraints in the process of reconstruction and renovation of houses in this area. This raises an important question about the process of urbanization in Delhi, and whether it is on the right track of sustainable growth. However, the overall percentage of dilapidated housing has decreased in NCT-Delhi, from 6% in 2001 to 2.9% in 2011—a significant progress. Sub-district patterns of dilapidated housing in 2011 also explain that 14 sub-districts (almost half of the total) have more than 3% of their total housing stock in dilapidated condition (Fig. 3F). Only 6 sub-districts have less than 2% dilapidated housing, and these are in the outskirts of the city. Thus, overall higher urbanization and higher dilapidation scenario have emerged along with simultaneous growth and existence of core-periphery variations—an important finding from this spatial analysis.

Quality of life: spatial patterns of housing structure and household amenities in NCT-Delhi 2011

Housing structure in NCT-Delhi, 2011

To further highlight the quality of life of Delhi's households, and its residents, we dug deeper into various quality of life indicators for the census households in NCT-Delhi. We had access to major variables such as housing structure, sources of drinking water, bathing and latrine facilities inside the premises, and lighting source. Accordingly, we conducted various types of change analyses, percentile, and histogram analyses, as well as choropleth maps to illustrate the spatial patterns of major attributes. These steps provided deeper insights into the degrees to which basic amenities of life were inaccessible to a significant share of population even in the 2011 Census. Though we understand that by 2021 the likelihood of these amenities must have improved somehow, nevertheless, the access to these amenities in 2001 and 2011, and the change therein provides interesting insights into people's lives.

The census defines the housing-types based on the type of material used in the construction of the walls and roofs. According to the Census of India (2001), permanent houses are made of wall and roof with permanent building materials like stone packed with mortar, metal, asbestos sheets, bricks, concrete and

hand or machine-made tiles. In temporary houses, wall and roof are made of temporary material like grass, thatched leaves, bamboo, etc., and sometimes plastic, polythene, mud, unburnt brick, or wood. Further, in semi-permanent category, the walls or roofs are either made of permanent material and the other is made of a temporary material. In serviceable temporary housing, wall is made of mud, un-burnt brick, or wood whereas non-serviceable housing incorporates wall made of grass, thatched leaves, bamboo, plastic or polythene. Thus, the housing structure is an important aspect of people's homes, and overall wellbeing of its residents. As noted in Fig. 4, we find that the housing structure, classified as low, average and higher levels are based on the cut-off levels of 35th and 65th percentile values, and the mapped patterns suggest that the southwest (attributed to the fact of expanding Dwarka sub-city) and northeastern districts have far greater shares of homes that are permanent structures, whereas the central and northern districts fall below the 35th percentile in terms of permanent structures (Fig. 4A). Accordingly, these spatial patterns correlate strongly with the structures falling in semi-permanent categories, although few additional districts get added to the above 65th percentile category in the central-eastern regions of Delhi—which also house some of the most densely populated slums of Delhi. Digging further deep into the temporary, serviceable, non-serviceable and unclassified categories of housing structure, we find that significant share of housing in western, southeastern, and northeastern parts of Delhi are below 35th percentile in terms of 'serviceable' category. Likewise, a significantly higher share of household structures in northern, central and central-eastern parts of Delhi are non-serviceable. Many of these are the oldest settlements in Delhi, with very narrow inaccessible roads, which makes it enormously difficult for renovations to be conducted, hence making them more unlivable with time.

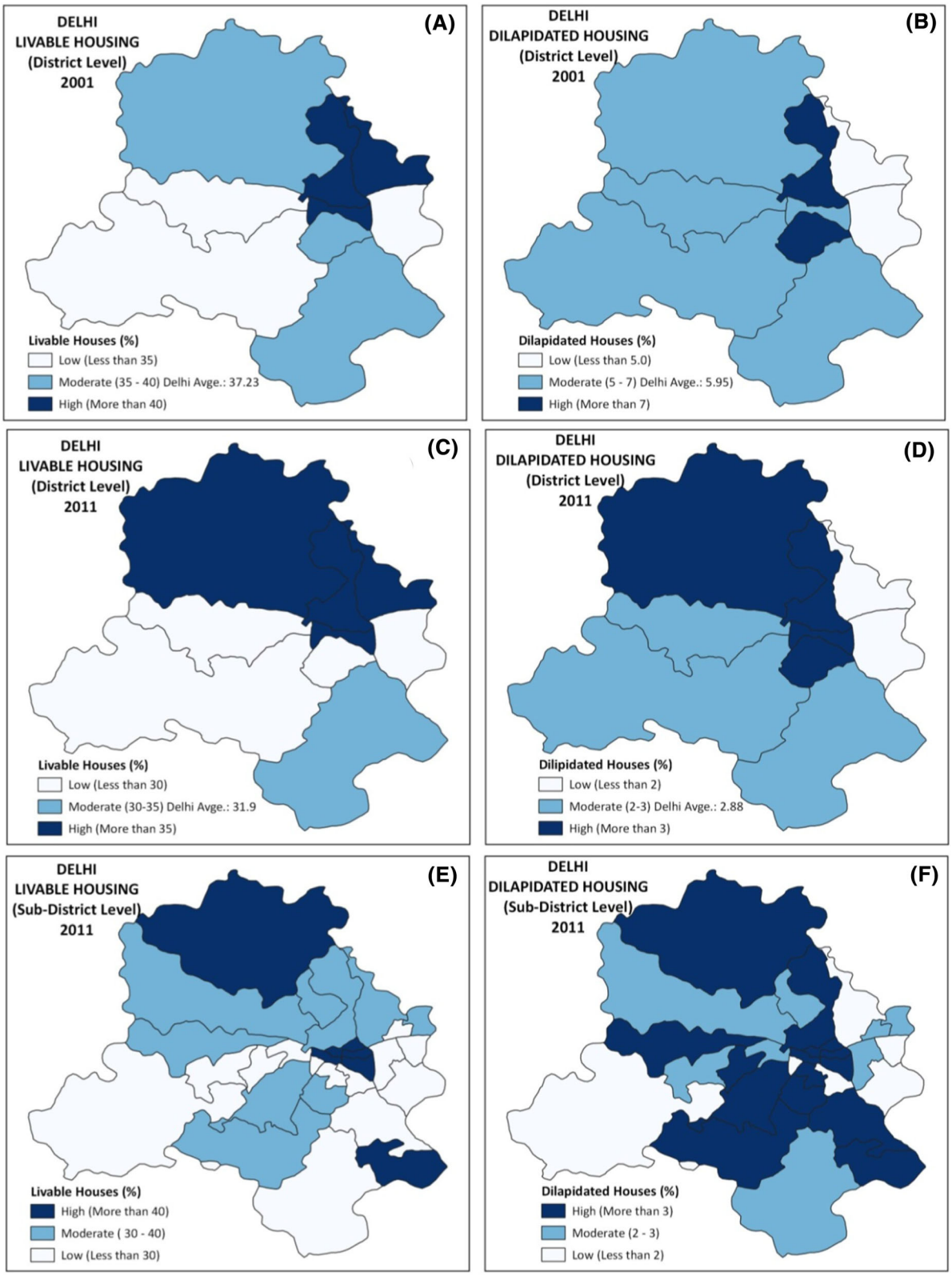
Figure 5 provides insights into the percentile/frequency distribution and the associated histograms for total housing structure and related attributes in NCT-Delhi in 2011. These details rather provide the alarming reality of Delhi's housing structure as the slightly normal curve appears only for the semi-permanent (Top-Right) and unclassified (Bottom-Right) categories; for all other types of structure, the histograms represent a significant share of housing that are toward the lower-end of the spectrum rather than the average or the positive side. These figures, thus, highlight a rather uncomfortable reality about the housing structure in several districts of NCT-Delhi.

Household amenities in NCT-Delhi, 2011

As obvious from Fig. 6A, a significantly higher share of households in Delhi have treated sources of water available inside their premises, with almost patches of orange dominating in more than 75% of Delhi's households (Fig. 6C, households below 35th percentile) and a significant share of households do not have drinking water source located inside their premises, and much of these are in the northern half of NCT-Delhi (Fig. 6C), though the scenario of this attribute is generally not bad, as one could conclude that almost more than half of all households have drinking water source available inside their premises.

Household amenities in NCT-Delhi in 2001, 2011 and change

Figure 7 illustrates the spatial distribution of below average (less than 35th percentile), average and above average (above 65th percentile) households with various household amenities that are critical to maintaining quality of life. These include the presence of bathing and latrine facilities inside the household premises and main source of lighting for its residents. These are considered as basics amenities for decent quality of living, and especially in a fast sprawling and densely growing Delhi, not having access to these basic amenities can pose health and safety concerns to its residents. The maps (Fig. 7: Left-A, B) suggest that a significantly higher share of homes in north and south-central parts have no latrines inside their premises. This is due to higher concentration of rural areas and slums which use mobile/temporary toilets, respectively. Figure 7: Left-C, D illustrate the grim reality of various households wherein they depend on public latrine or open-space defecation in several households. Public and open spaces are the alternative sources of latrine for those households not having access to any types in-house latrines. Approximately 20% households in Delhi do not have latrine facility and they use public spaces like sides of drains, rivers, roads, vacant lots, and agricultural fields for necessary ablutions. They are mostly the slum residents or the homeless labors such as rickshaw pullers, labor,


DELHI
LIVABLE HOUSING
(District Level)
2001
(A)
Livable Houses (%)
Low (Less than 35)
Moderate (35 - 40) Delhi Avge.: 37.23
High (More than 40)
DELHI
DILAPIDATED HOUSING
(District Level)
2001
(B)
Dilapidated Houses (%)
Low (Less than 5.0)
Moderate (5 - 7) Delhi Avge.: 5.95)
High (More than 7)
DELHI
LIVABLE HOUSING
(District Level)
2011
(C)
Livable Houses (%)
Low (Less than 30)
Moderate (30-35) Delhi Avge.: 31.9
High (More than 35)
DELHI
DILAPIDATED HOUSING
(District Level)
2011
(D)
Dilipidated Houses (%)
Low (Less than 2)
Moderate (2-3) Delhi Avge.: 2.88
High (More than 3)
DELHI
LIVABLE HOUSING
(Sub-District Level)
2011
(E)
Livable Houses (%)
High (More than 40)
Moderate (30 - 40)
Low (Less than 30)
DELHI
DILAPIDATED HOUSING
(Sub-District Level)
2011
(F)
Dilapidated Houses (%)
High (More than 3)
Moderate (2 - 3)
Low (Less than 2)

◀ **Fig. 3** Spatial patterns of livable and dilapidated houses in NCT Delhi, 2001–2011. *Source*: Based Census of India, (2001), (2011)

beggars, and the like. Likewise, the illustrations in Fig. 7: Left-E–G indicate the below average and above average shares of households that have bathroom facility inside their premises, bathrooms without a roof and those with no bathrooms at all. A retrospection into these basic amenities can be quite problematic that in the Capital City of the 2nd most populous country of the world, there is a significant share of population without bathing and latrine facilities. Likewise, the maps in Fig. 7: Right (A–E) illustrate the below average and above average shares of households with main source of energy for lighting their house.

While the maps tell interesting stories about the district-level source of lighting, Table 3 provides deeper insights into the district-level sources of lighting in 2001, 2011 and how it changed over the time period.[8] As noted in the table, there still existed significant shares of households in several districts of NCT-Delhi who used kerosene for lighting their homes, which thankfully improved by Census 2011. For example, in North East district, 13.47% households used kerosene for lighting their homes in 2001 as against only 0.50% by 2011, which is a significant improvement over the decade; likewise, the districts of South (9.23% to 0.6%), and Northwest (6.25% to 0.90%) showed significant progress during 2001–2011. However, while most households are lighted up right now through one source or another, not all homes have access to a source of drinking water within their premises. As illustrated in Table 3, even in 2011 Census, almost 20% to 30% of households in all the districts expect Central and East have no source of drinking water inside their premises, making these people fetch water from outside sources. The best statistics are for Central (91.7% coverage) and East (90.8% coverage) districts. Thus, while dependence on water sources outside of household premises is nothing new in Indian society, one must be aware that much of this responsibility falls on women and young girl's shoulders, who have to go out of their homes to fetch water. This is not a welcoming news, especially in context of Delhi which has been notoriously infamous for various types of crimes against women and young girls (e.g., gang rapes, harassments, eve-teasing, physical attacks, and murders).

Finally, there has also been significant progress made along major dimensions of providing basic amenities that determine quality of life for Delhi's residents. As noted above in the table above, and in Fig. 8 below, it is obvious that when looking at the entire NCT-Delhi for both Census 2001 and 2011, almost across all major dimensions of quality of live amenities associated with housing, there has been progress made. The bar charts for the variables of percent change in households with drinking water inside premises, percent change in households with latrine facilities inside premises, percent change in households with bathing facilities inside premises are all positive and above the horizontal line; likewise, the percent change in households with no latrine facilities and no bathing facilities inside their premises are all negative—suggesting progress over the decade.

Conclusions and policy implications

Delhi has experienced an overall increase of 15 million urban population since independence, and this growth has been rather rapid during the last two decades, with current urbanization at 97.5%. This analysis finds that the distribution of urban population is more concentrated in the central parts and towards the south and south-west—largely along the transportation corridors and in the satellite cites of Gurugram and Faridabad. This pattern is reaffirmed by the NDBI analysis. As discussed in the results section, the NDBI values for Delhi increased to a maximum of + 0.307 in 2020 as against + 0.342 in 2010, signifying growth in the built-up areas. Almost 0.8 million households have been urbanized during the 2001–2011 period. Overall, the housing quality has improved in the city, although a micro-scale analysis also suggests sub-regional variations at the district and sub-district levels. There are many districts with almost 30–40% of its houses in 'livable' conditions. Regarding dilapidated housing, two districts—New Delhi and Central District— are completely urbanized

[8] We were able to acquire data only for select variables pertaining to quality-of-life of residents for all these 9 districts for both Censuses of 2001 to 2011, and accordingly our analyses is limited in this regard.


DELHI
Type of Housing Structure, 2011
(A) Permanent
(B) Semi-Permanent
N
(C) Total Temporary
(D) Serviceable
(E) Non-Serviceable
(F) Unclassifiable
5 0 5 10 km
HOUSEHOLDS PERCENTILE
Below 35th (LOW)
35th-65th (AVERAGE)
Above 65th (HIGH)

◀**Fig. 4** Spatial pattern of census housing-structure types in NCT Delhi, 2011. *Source*: Census of India, Delhi, 2011

and yet these two also have a much higher percentage of 'dilapidated quality' of housing. Factors such as housing density, limited access to housing finance,

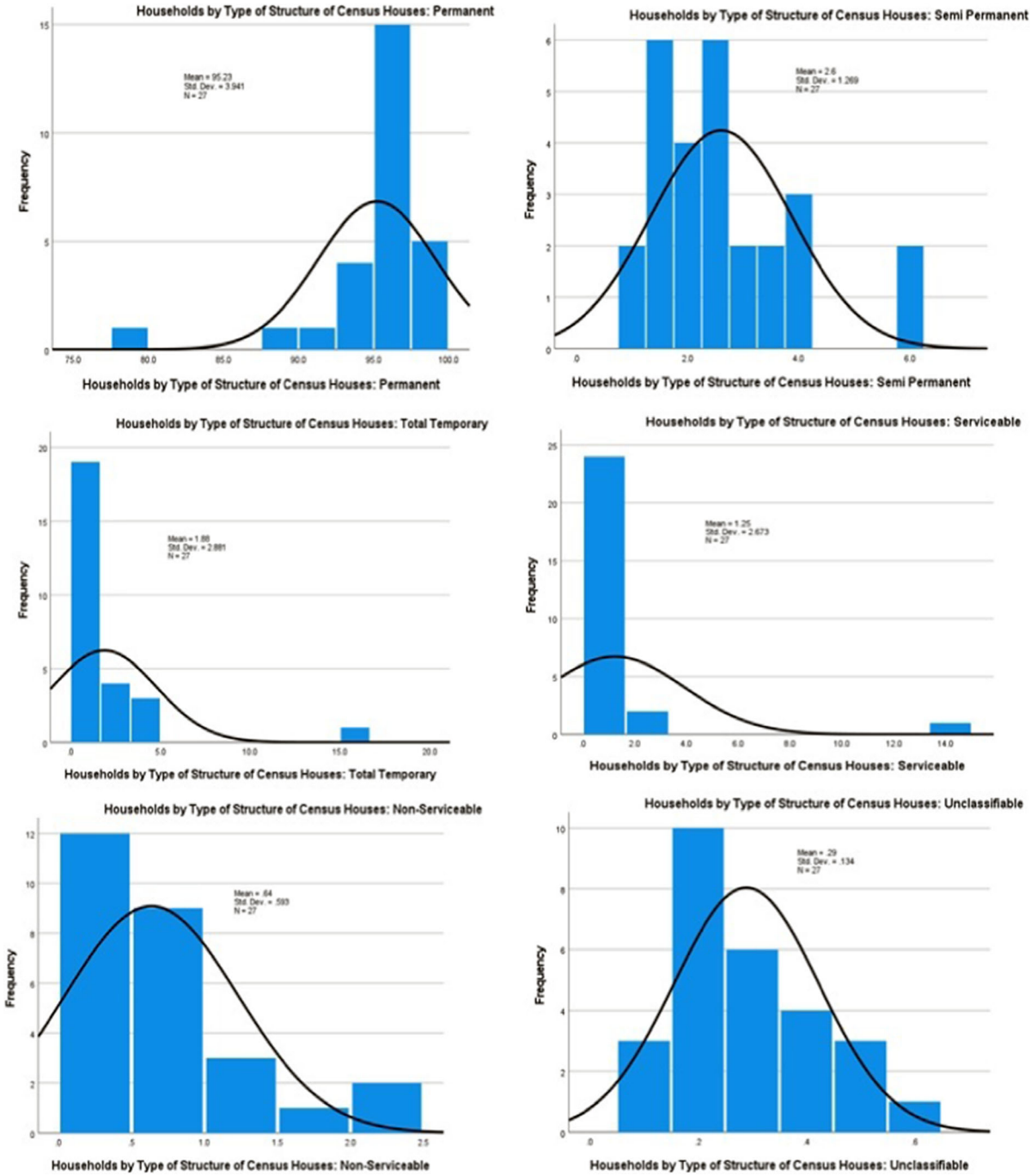


Fig. 5 Percentile distribution of census housing-structure types in NCT Delhi, 2011. *Source*: Census of India, Delhi, 2011

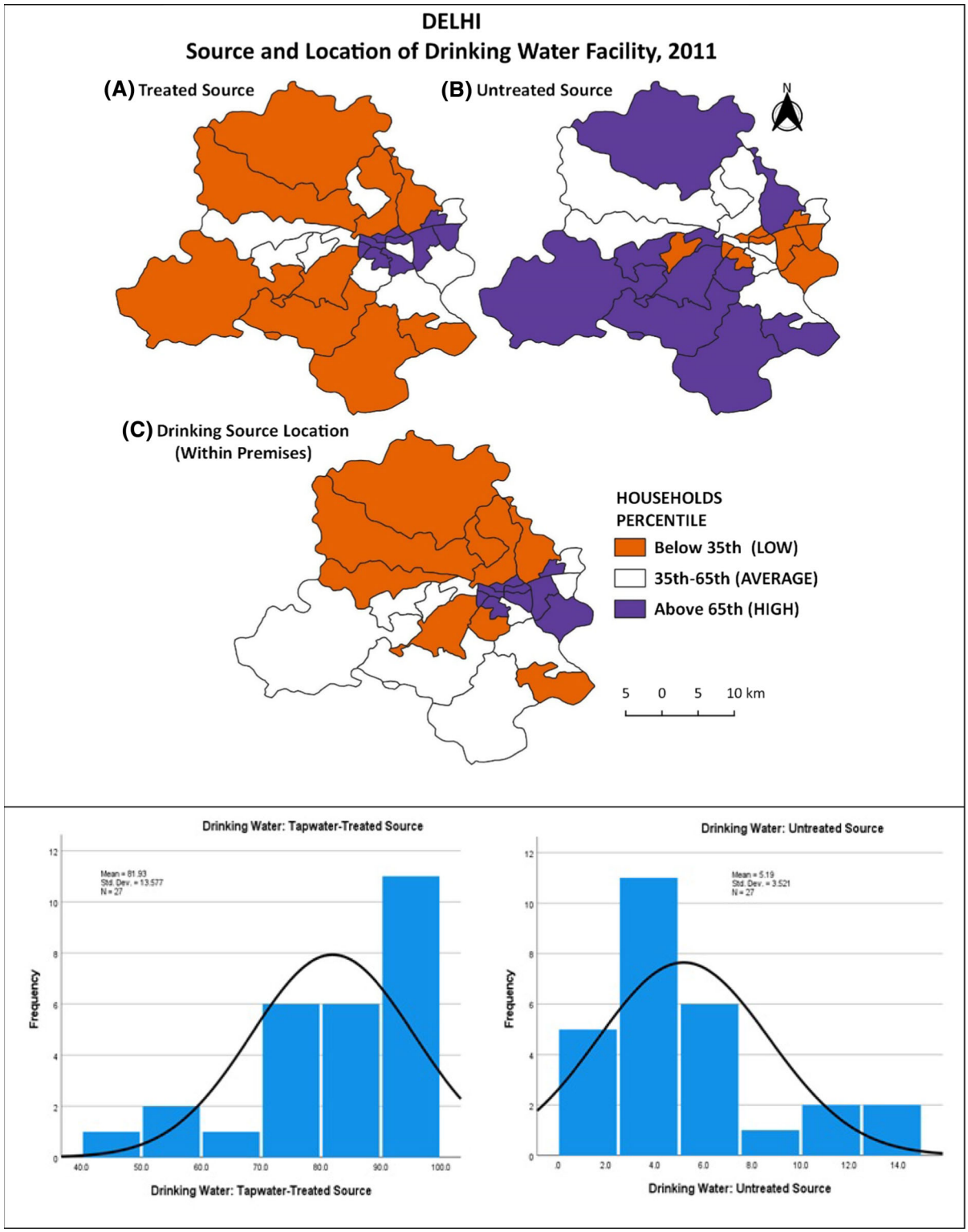


Fig. 6 Spatial patterns of drinking water source (top) and percentile distribution (bottom) in NCT Delhi, 2011. *Source*: Census of India, Delhi, 2011

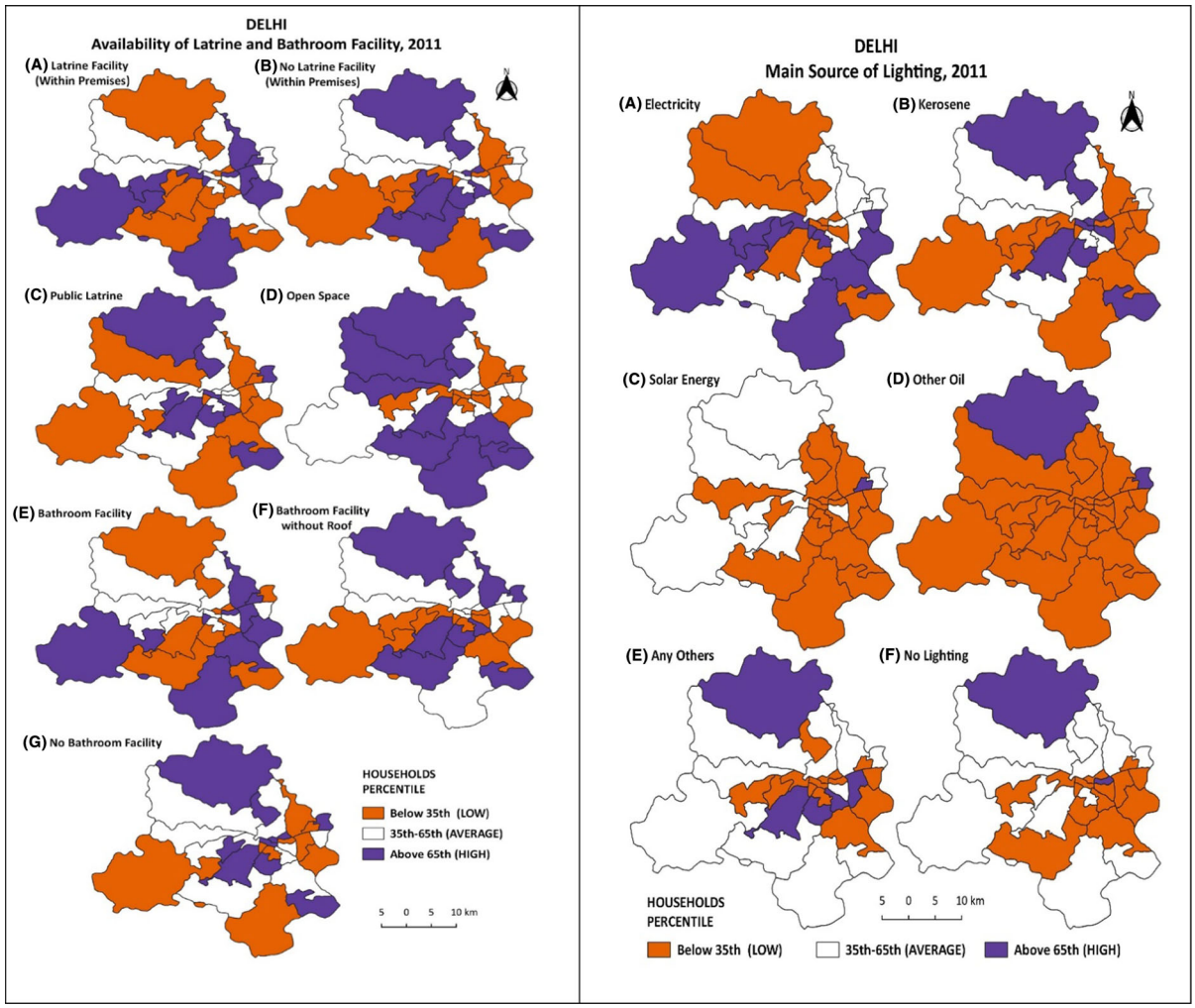


Fig. 7 Spatial patterns of availability of bathing and latrine facilities (left) and main source of lighting (right) in the census households of NCT-Delhi, 2011. *Source*: Census of India, Delhi, 2011

limited-to-low income/wages, higher cost of labor and renovation materials, practical difficulties in accessing theses homes to do repair and renovations, housing ownership, attraction towards satellite cities for better housing, etc. play major roles in determining the housing quality in the study area. These factors require attention to stop the further deterioration of houses in NCT-Delhi.

This research also finds interesting contradictions as far as quality of life of Delhi's residents is concerned. We find that overall percentage of dilapidated housing has decreased in NCT-Delhi, from 6% in 2001 to 2.9% in 2011, which is an encouraging progress in the right direction. Despite the limitations of data that qualify as quality of life indicators, we focused on four major aspects—source of drinking water, electricity/house lighting, latrine facilities, and bathing facilities—data for which were available from the Censuses of 2001 and 2011. Our research finds mixed results. While there has been significant progress in lighting most households in almost all the nine districts of NCT-Delhi, with dramatic improvement in coverage during the 2001–2011 decade, the availability of drinking water inside the premises is rather still quite discouraging. Almost 20% to 30% of all households in several districts of Delhi still do not have drinking water source inside their premises. This poses severe risk to women and young girls since they are the ones who generally fetch water from outside source, and this puts them at greater risks.

Table 3 Main source of household-lighting and drinking water within household premises in NCT-Delhi, 2001–2011. *Source*: Census of India (2001 and 2011)

Districts	Source of lighting														Drinking water within premises	
	2001 Electricity	2011 Electricity	2001 Kerosene	2011 Kerosene	2001 Solar energy	2011 Solar energy	2001 Other oil	2011 Other oil	2001 Any other	2011 Any other	2001 No lighting	2011 No lighting	2001 Yes	2011 No	2001 Yes	2011 No
North West	93.0	98.7	6.3	0.9	0.1	0.1	0.0	0.0	0.4	0.1	0.2	0.1	71.4	28.6	70.8	29.2
North	95.2	99.1	4.0	0.7	0.1	0.0	0.0	0.0	0.2	0.1	0.5	0.1	68.5	31.5	74.7	25.3
North East	85.0	99.2	13.5	0.5	0.1	0.1	0.1	0.0	0.9	0.1	0.3	0.1	77.8	22.2	76.8	23.2
East	97.4	99.5	2.2	0.3	0.1	0.0	0.0	0.0	0.2	0.1	0.1	0.0	82.5	17.5	90.8	9.2
New Delhi	97.0	98.8	2.5	1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.0	64.1	35.9	79.0	21.0
Central	97.3	99.0	2.3	0.9	0.1	0.0	0.0	0.0	0.0	0.1	0.3	0.0	79.5	20.5	91.7	8.3
West	94.8	99.3	4.5	0.5	0.1	0.1	0.0	0.0	0.3	0.0	0.2	0.0	77.7	22.3	80.7	19.3
South West	95.6	98.9	3.8	0.8	0.1	0.0	0.0	0.0	0.3	0.1	0.2	0.1	77.4	22.6	80.7	19.3
South	89.1	99.2	9.2	0.6	0.1	0.0	0.1	0.0	1.3	0.1	0.2	0.1	69.7	30.3	76.1	23.9

Also, it is a known fact that women in general and female child, particularly in India and generally in all developing countries of the world face enormously greater shares of unpaid household responsibilities that have high opportunity costs as they are unable to attend schools and build their lives and careers to same levels as that of the men in their respective societies (Sharma, 2020, 2021). This eventually puts the women and girls at higher risks of poverty and cyclic economic deprivation, thence posing risks toward attaining gender equity (Islam & Sharma, 2021; Sharma, 2020, 2021). Achieving overall well-being and socio-economic equality for gender is one of the 17 Sustainable Development Goals of the United Nations. Hence, if we do not address the issues of unequitable share of household-level unpaid activity burden across the gender, one of which included fetching water from outside sources, that are generally conducted by young girls and women in the households, we fail gender equity and their potential chances toward overall economic growth and prosperity in a nation of 1.31 billion population. Also, in twenty-first century India, if 20% to 30% of total households in its capital city still do not have drinking water source inside their premises, that is a matter of grave concern, and needs immediate action by politicians, policy makers and the citizens alike.

This research draws our attention toward various issues and challenges that require immediate action by the policymakers and housing development and planning professionals in NCT-Delhi. First, due to the continuous increase in its urban population, there is a severe deficit of housing, and this requires maintaining a balance between the housing demand and supply. Second, the cost of housing in the city has been on a continuous rise, and this is due to a shortage of supply as well as the nexus of corrupt developers and builders. This is also driven by the fact that the city is a major center of different services— trade, commerce, markets, infrastructure, transport, hospitals, education, political headquarters, etc., thence attracting population from near and far (Sharma, 2017). However, the city does not have adequate policies in place to provide housing to its ever-exploding population. This requires suitable policies to meet the housing deficit, in the absence of which, people seek shelter in low-quality, dilapidated housing. Overall lower levels of incomes, higher poverty, and reduced access to finances are additional constraints that demotivate owners' from investing and/or repairing their old and dilapidating housing. These issues get exacerbated due to lack of low-interest home financing mechanism, especially for the low-income population. Thus, we recommended planners to focus on developing systems for housing finance such that low-income groups can have access to decent housing and improved quality of life. Otherwise, the present status of housing, which is in livable condition, might further deteriorate if not addressed in time.

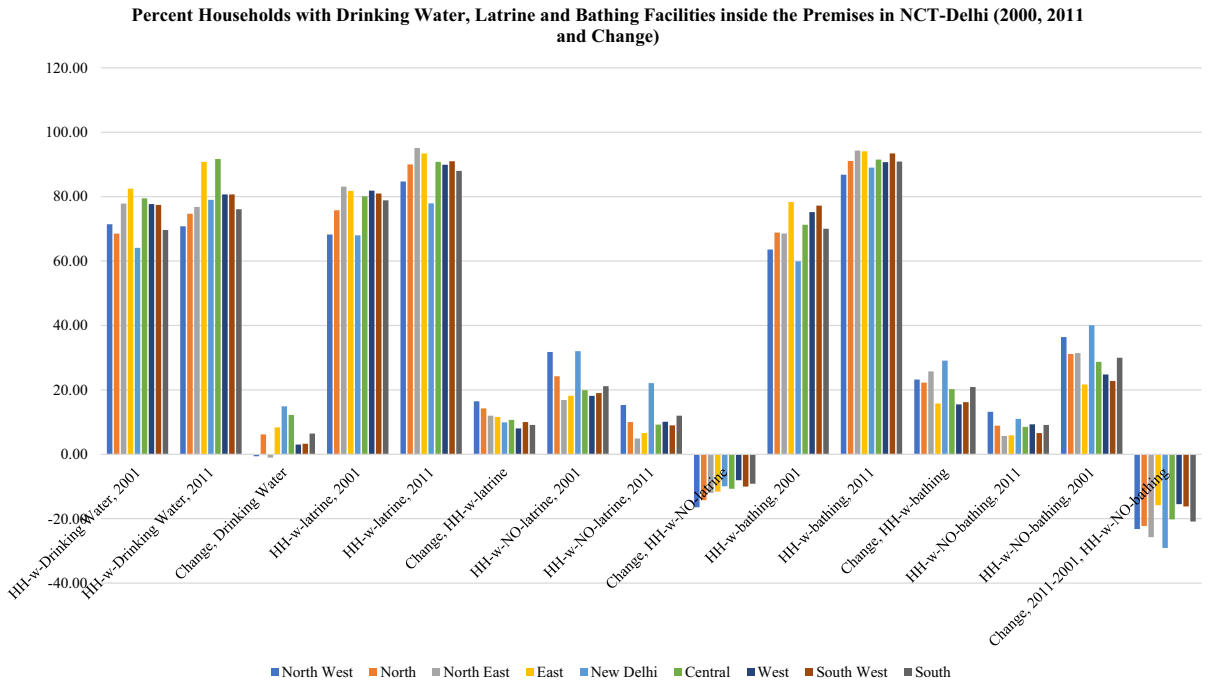


Fig. 8 Percent households with drinking water, latrine and bathing facilities inside the premises, Delhi (2000, 2011 and Change). *Source*: Census of India, Delhi, 2001 and 2011

In Delhi, India, the government has created various policies related to housing development and improvement, such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in December 2005. This aims toward a planned transformation of India's urban areas. Other programs like the BSUP (Basic Services for the Urban Poor) is designed for the upgradation and improvement of the conditions of slum settlements; the IHSDP (Integrated Housing and Slum Development Programme) seeks to tackle poor housing for urban slum dwellers in cities and towns as per the 2001 Census; the RAY (Rajiv Awas Yojana) has the motto of, "Slum Free India"; and Pradhan Mantri Awas Yojana (PMAY), launched by the Narendra Modi government in 2015, aspires to eliminate urban housing shortage in India by the year 2022 (D'Souza, 2019; Malhotra, 2016; Sharma & Sen, 2016). Realistically speaking, if all these programs are implemented in their earnestly planned ways, we should see significant change in the basic amenities for the households in Delhi and in other parts of the country. Housing is a basic human right and having access to basic amenities such as safe and clean drinking water, defecation, and bathing facilities, etc. are critical to maintaining basic human health, safety, and environment's purity. Our analysis clearly highlights the gaps that exist in providing these basics to Delhi's humans, and it is important that the humans of Delhi have access to these basic rights.

Finally, as a productive criticism to bureaucratic policies and government programs, we feel that most of these schemes have focused on slum upgradation and/or provision of basic amenities toward improvement, except the PMAY scheme which investigates the shortage of housing in a targeted manner. These schemes support construction of new housing and hence, almost no attention is given to the already dilapidated structures by (re)financing them for upgradation or repair. The Central district of Delhi has the oldest constructed housing and is still in the central business district of the city. Chandni Chowk and the surrounding areas of Old Delhi are full of dilapidated housing structures. As is evident of most old cities, such parts of Delhi not only have many older generations still residing in those homes, but they are also the population groups who do not necessarily have access to knowledge or finances to invest in upgradation of their residential structures. Also, despite these being the oldest structures, the cost of housing in these locations are quite high, and given the

congested streets, the reconstruction and/or repair of old housing is very expensive and cumbersome process. This requires strategic intervention by technically qualified developers who can preserve the old historical charm of these structures while still adding nuanced modernity to these homes. Finally, the government must illustrate stronger political will to improvise the old-built structures as well as promote affordability in the newer and upcoming projects in Delhi. A comprehensive multi-level investment toward repairing the old and strategic building of the new can provide a better quality of life to the residents of NCT-Delhi.

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