ARTICLE

Determinants of growth in non-municipal areas of Delhi: rural–urban dichotomy revisited

Manisha Jain[1] · Artem Korzhenevych[1,2] · N. Sridharan[3]

Abstract
The current discourse on urbanization calls for new approaches to capture the peculiarities of growth in the global South. This paper takes the National Capital Territory of Delhi as a case study and adopts a mix of methods (field survey, ordinary least squares regression and geographically weighted regression) to highlight the emerging gradient of urbanization within official rural areas. The results show a certain catching-up effect in which the settlements with low population and employment rate grow faster than more urbanized settlements. Settlements with low basic infrastructure provision (such as schools and medical facilities), which are mainly census towns, tend to grow more slowly than villages with better infrastructure provision. Additionally, local characteristics of growth vary spatially depending on the distribution of socio-economic, demographic, and infrastructure variables. To avoid the unplanned transformation of villages into urban areas in Delhi and similar regions of the global South, this paper recommends moving from master planning towards strategic spatial planning, implementing integrated planning and governance of non-municipal peri-urban areas, and reforming spatial plans and development policies based on scientific methods.

Keywords India · Urban and rural · Ordinary least squares regression · Geographically weighted regression · Field survey

✉ Manisha Jain
m.jain@ioer.de

Artem Korzhenevych
a.korzhenevych@ioer.de

N. Sridharan
dr.nsridharan@gmail.com

[1] Leibniz Institute of Ecological Urban and Regional Development, Weberplatz 1, 01217 Dresden, Germany

[2] Faculty of Business and Economics, Technische Universität Dresden, Dresden, Germany

[3] Director, School of Planning and Architecture, Bhopal, India

1 Introduction

The interactions between rural and urban spaces have increased worldwide in recent decades and are predominantly driven by employment opportunities (such as manufacturing in rural areas or urban agriculture) and amenity values (such as recreational values of villages, medical and education facilities in cities). These new realities encourage a move beyond the simple rural–urban dichotomy, which is no longer adequate to analyze the roles of settlement and demographic processes (Uzell 1979; Hugo et al. 2003; Champion and Hugo 2003; Kroll et al. 2009; Partridge et al. 2010). Moreover, the persistent rural–urban dichotomy is inadequate for governance and coordination of public service delivery (Allen 2003; Shaw 2005; Ravetz et al. 2013).

Especially in the global South, the process of urbanization is characterized by a blurring of the boundaries between rural and urban areas. Managing this process has become increasingly complex due to the high speed of the transformation and a lack of local institutional capacity to provide adequate infrastructure. Recently, urban studies scholars have devoted their attention to analyzing the urbanization process occurring in the global South. These analyses have led to an acknowledgement of the need for new conceptual approaches and methods that can capture the special features of urbanization in these regions (Roy 2009; Brenner and Schmid 2015; Stroper and Scott 2016). In particular, Hugo et al. (2003) argued in favor of reexamining the parameters used to define "urban," especially with the availability of more sophisticated technologies capable of deriving more appropriate settlement classifications, such as geographical information systems. Such examinations are important not only for demographic research but also for devising new policies and programs.

The current paper aims to contribute to the literature by developing a methodological framework that can highlight the emerging gradient of urbanization within official rural areas in the state of Delhi (consisting of municipal areas, census towns and villages), India. This framework combines ordinary least squares (OLS) regression and geographically weighted regression (GWR) analyses with a field survey to elucidate the local characteristics of growth, which are crucial for determining appropriate space-specific policy responses. This approach might also benefit other regions of the global South facing similar issues.

As of 2018, India has 1.3 billion people, and the population is projected to increase to 1.66 billion by 2050 (UN 2017). In India, most population growth occurs just outside of municipal boundaries (WB 2013). Given the country's projected growth, these areas require research and policy attention for the following reasons: First, basic service delivery and land use regulation by municipalities are limited to the administrative boundary of each municipal area. Second, large industries and townships as well as special economic zones (SEZ) that are unable to find land within municipal boundaries due to land scarcity or high prices are allocated land by the state government in the urban periphery (Sridharan 2011). Third, employment opportunities attract unskilled rural migrants who settle in the peripheries of metropolises and large cities in an unplanned manner. The rising costs in cities and the lack of affordable housing forces these migrants into peri-urban areas that lack most basic amenities (Tacoli 2003; Bhagat 2014). Finally, over the last two decades an unprecedented transformation of rural to urban areas as 'census towns' has taken place. This transformation has been predominantly in close proximity to large metropolises, such as Delhi. The limited capacity of local rural governing

bodies to manage these settlements has raised social, environmental and health concerns (Jain 2018; Chattopadhyay 2015; Kuruvilla 2014).

Using Census of India data from 2001 to 2011 on spatial boundaries, socio-economic and demographic variables, and adopting a combination of statistical methods (OLS and GWR) and a field survey, this paper attempts to answer the following research questions: What are the determinants of non-municipal growth in Delhi? Do the factors driving growth differ in census towns and villages? What is the effect of geography on the distribution of socio-economic, demographic and infrastructure variables? What differences or similarities can be observed between the OLS and GWR findings? What policy insights can be drawn?

The paper is divided into six sections. This introduction is followed by an explanation of the institutional background of the study area. Section three describes the research methodology and the data, and then section four provides a summary of the key findings. Section five discusses the main findings for policy implications and section six presents the conclusions.

2 Institutional problem of rural and urban areas in India with a focus on the study area

2.1 Government backed complexities of urban and rural

In India, the discourse on policy, planning and governance is based on the rural–urban dichotomy. For instance, five-year plans for infrastructure funding (with separate sections for urban development and rural development), planning guidelines (such as the Urban and Regional Development Plans Formulation and Implementation Guidelines 2014 or the Rural Area Development Plan Formulation and Implementation Guidelines 2016) and local governance (Municipality, Municipal Corporation or Town Panchayat for urban areas and Gram Panchayat for rural areas, with different powers and functions) are essentially divided into urban and rural parts. As urban growth spills outside municipal boundaries, rural governing bodies (gram panchayats) that lack land use regulations and spatial planning expertise are not able to manage these areas, which results in unplanned and haphazard growth.

The state governments can declare an urban area a "statutory town" if it fulfils the statistical definition or possesses municipal status and is governed by an urban municipal body. Compared to statutory towns, a "census town" is an urban area that is not designated with a municipality by the state government despite meeting the statistical definition and thus remains under rural governance, which makes the governance of these areas difficult.

Despite having a high population and urban characteristics, state governments are reluctant to grant urban status to these villages (Chaurasia and Gulati 2008) and census towns (Bhagat 2005). Also, the gram panchayats are reluctant to obtain municipality status. Jain (2018) captured several reasons why a state government is reluctant to designate areas that have urban characteristics with a formal municipality classification. First, rural areas are entitled to rural development funds from the central government, whereas urban areas receive paltry funding. Second, the municipal notification of an area is entitled to increased service taxes. The state governments avoid municipal notification of an urban area due to fear of losing the election. Third, in rural areas, land use regulations are absent and land prices are cheap, taking advantage of this, the state governments allocate land for SEZ and

other large industries in such areas. Thus, the state governments for their vested interests retain the rural status of an area despite having urban characteristics.

A sub-objective of this paper is to examine the dichotomy between Census of India delineated urban (census towns) and rural (villages) but official rural areas, to determine differences in characteristics and factors of growth to provide support for planners with insights into possible policy reforms.

2.2 Statistical complexities in urban and rural delineations

Statistically, the Census of India uses the following criteria to define an area as urban: a population of more than 5000 people, a density of more than 400 people per square kilometer and more than 75% of males working in non-agricultural activities. Additionally, areas with Municipality, Municipal Corporation, Cantonment Board or Notified Town Area committee are considered urban, whereas all areas that are not categorized as urban are considered rural. However, this delineation of rural and urban by the Census of India is problematic and is derived ex-ante to the population census, in which area classifications are finalized before the census process (Pradhan 2017; Roy and Pradhan 2018). Moreover, the delineation process uses a threshold of 4000 people assuming that the village will reach the 5000 people mark in 10 years, and no adjustments are made for the population density and non-agriculture workforce.

Data from the Census of India town directories for 1991, 2001 and 2011 reveal that the number of towns with less than 5000 people (lower threshold for small towns) has been increasing since 1991 and doubled between 2001 and 2011. With regard to rural areas, the total number of villages with more than 10,000 people increased from 3962 in 2001–4681 in 2011. For villages the official upper threshold is 10,000 people, however, a large number of villages with more than 10,000 people are delineated by the Census of India as rural. Although the increase in the number of statutory towns (from 126 in 2001–135 in 2011) has been modest, the number of census towns tripled over the last decade (from 109 in 2001–367 in 2011) (GoI 2011a). This development reveals that rural areas are transforming, either from small villages to towns, or from small villages into large villages, and the rapid increase in census towns indicates that this transformation of villages to some extent takes the form of census towns rather than statutory towns. This conclusion is further confirmed by Samanta (2014).

In criticizing the trend and pattern of urbanization, some scholars (such as Sivaramakrishnan et al. 2005; Kundu 2011; Denis and Marius-Gnanou 2011; van Duijne 2017) have been critical of the official definition of "urban" used by the Census of India for not being realistic and failing to capture the characteristics of the areas because of the use of a stringent population-based definition. In this regard, Denis and Marius-Gnanou (2011) used the concept of settlement agglomeration instead of the Census of India's urban agglomeration. A settlement agglomeration is constructed on the basis of the contiguous built-up area less than 200 m apart and a cut-off level of 10,000 people to measure urbanization. The authors found India to be 37% urban in 2001, while the Census of India reported a value of 27%.

2.3 Study area

The study area, the National Capital Territory of Delhi (NCT), is the administrative capital of India. It has dual status as a city and a state. Between 2001 and 2011, the

population of the NCT increased from 13.8 to 16.7 million. During the same time period, the share of the population in the rural areas decreased from 37 to 24% (GNCT 2013). The 2021 Master Plan of Delhi declared that all of Delhi was urban (Jain, Personal Interview, 2017). However, the Census of India's enumeration for 2011 lists 112 villages and 110 census towns in Delhi (Fig. 1).
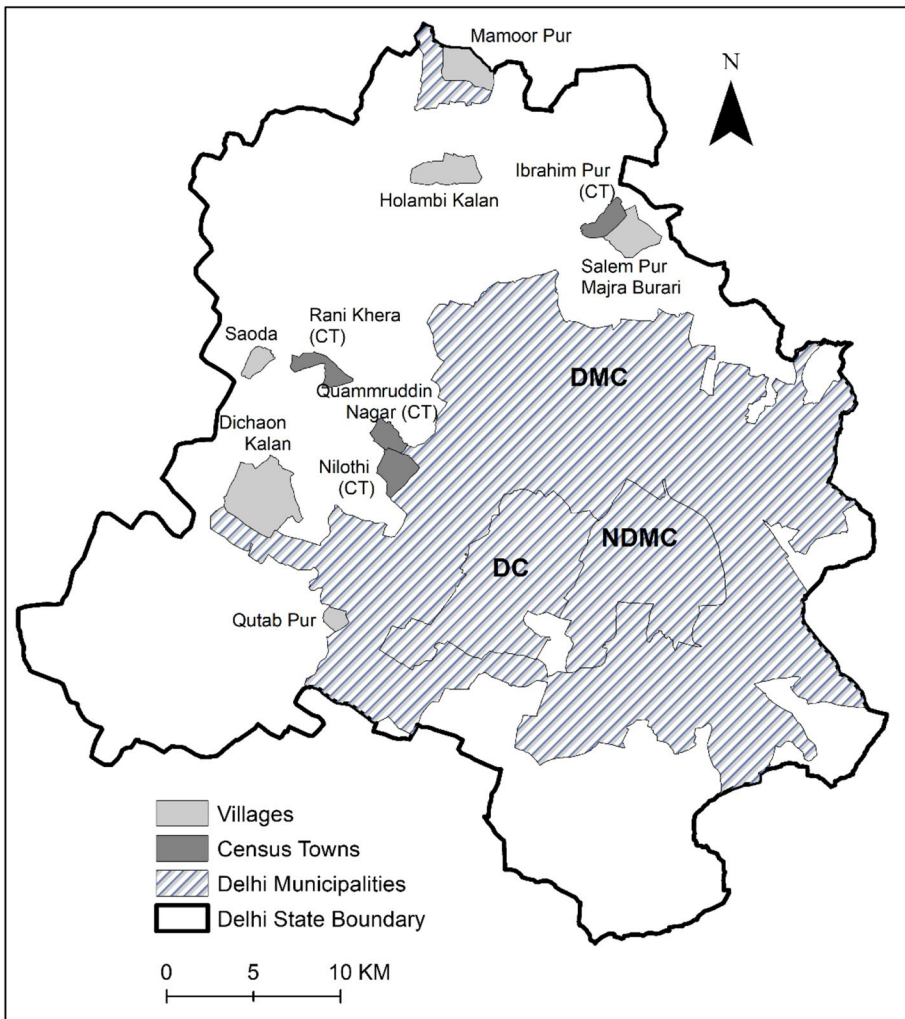

Fig. 1 Surveyed villages and census towns. *Note*: Delhi Municipal Corporation (DMC), New Delhi Municipal Corporation (NDMC), Delhi cantonment (DC), census town (CT) *Source:* Compiled by Authors

3 Research methodology and data

The analytical framework consists of four main steps: a descriptive analysis, field interviews, OLS regression and GWR analysis. These steps are explained in the section below:

3.1 Descriptive analysis and field interviews

First, to obtain a comprehensive view of the differences between municipal areas (Delhi Municipal Corporation, New Delhi Municipal Corporation and Delhi Cantonment area), census towns and villages, a descriptive analysis was conducted in which different types of employment, infrastructure and built-up area growth rates were compared.

A preliminary analysis revealed that of the 112 villages, 9 were uninhabited, and among the rest (i.e., 103 villages) 13 villages qualified under the Census of India's parameters as urban; however, these areas remain under village status. Similarly, of the 110 census towns in Delhi, all except six fulfilled the three criteria of being urban, but they all still have the status of a census town.

Second, a field survey in the villages and census towns in Delhi was undertaken in September 2017 in which households were surveyed and expert interviews were conducted to reveal the local characteristics of growth otherwise uncaptured by the secondary data. For instance, information on the types of land use, the provision of basic services such as electricity, sewer and water supply, and the implementation of building regulations was collected. Such a survey is important to capture the intensity of development and environmental degradation under urbanization pressure.

The following experts from different organizations were interviewed: (i) Retired Registrar General of the Census of India (Mr. Chakrobarty). The Census of India is a national-level organization with the role of population enumeration and, rural and urban classification. Census is conducted every 10 years. (ii) Chief Town Planner of the MCD (Mr. Mehra). The MCD is a state-level organization with responsibilities including the provision of basic services and the enforcement of land use regulations. (iii) Retired Director Planning from the DDA (Mr. Jain). The DDA is national-level organization with the main function of land use plan preparation and implementation for Delhi. (iv) Chief Town Planner, Town and Country Planning Office (TCPO) (Mr. Srinivas). The TCPO is a national-level organization whose main function is guiding the planning in India's urban areas.

Villages with a population greater than 10,000 were shortlisted for the field survey, and for the comparisons, census towns with the same population in close proximity to these villages were selected to capture the differences in urbanization process (Fig. 1).

3.2 Choice of variables and ordinary least squares regressions

The change in the employment rate and population growth rate in census towns and villages are selected as dependent variables in the regression analysis. Using relative indicators such as change in employment rate as dependent variables allows comparing the changes in large and small settlements.

Sufficient empirical evidence has demonstrated that the provision of urban amenities can affect urban growth. Glaser et al. (2001) and Glaser and Kohlhase (2004) argued that the importance of urban amenities (such as public services, the physical setting, transportation, etc.) in explaining population growth has been increasing over time. Cities where the provision of educational and medical facilities and transportation improve become

relatively more attractive, have increased population and attract economic activities, while cities where these amenities deteriorate lose population (Munnell 1992; Haughwout 1999; Mawby et al. 2009; Duranton and Puga 2013; Grimes et al. 2014; Jain and Korzhenevych 2017).

On the one hand, an improved transportation network, a new port or airport, or the introduction of a higher education or medical institution leads to increased amenities in a city, reduces travel costs, raises productivity, and increases skills at the local level. On the other hand, these amenities attract new migrants, which increases land costs and housing prices and reduces the quality of life due to congestion (Nijkamp 1986; Jimenez 1994; Haughwout 2001; Grimes et al. 2014). Thus, in the regression model, the provision of schools, medical centers and transport densities have been used to explain the population growth and employment rate change.

Some studies have also found that an increase in the built-up area is associated with increased population and employment (Schneider and Woodcock 2008; Schneider and Mertes 2014). Thus, the total built-up area has been used as an explanatory variable to test whether it helps to explain increases in the dependent variables. Table 1 lists the indicators used in the analysis along with their sources.

To determine the variables that explain growth in census towns and villages, a two-step OLS analysis was conducted. In the first step, all census towns and villages outside the

Table 1 Description of the variables used. *Source:* Compiled by Authors

Variables	Data source
Descriptive analysis	
Total employment, number of persons	GoI (2001a and 2011a)
Other employment, number of persons	
Agriculture-cultivation employment, number of persons	
Built-up area 2014 and 2000, sq. km.	Settlement repository (EC 2017)
Number of primary and secondary schools	GoI (2001b and 2011b)
Number of dispensaries, health centers, family welfare centers and primary healthcare centers	
Ordinary least squares regression	
Dependent variables	
Population change 2001–2011, %	GoI (2001a and 2011a)
Employment rate change 2001–2011, % points	
Explanatory variables	
2001 population, thousand people	GoI (2001a)
Employment rate 2001, %	
Number of schools (primary and secondary schools) per 100,000 population 2001	GoI (2001b)
Number of medical centers (dispensaries, health centers, family welfare centers and primary healthcare centers) per 100,000 population 2001	
Rail and road network density, km per sq. km	DIVA-GIS (2017)
Total built-up area 2000, sq. km.	Global human settlement repository (EC 2017)

Other employment category includes all workers who are not employed in the agriculture, cultivation or household industries

municipal area are considered in the analysis, whereas in the second step, the census towns and villages are differentiated by status.

3.3 Geographically weighted regressions

The socio-economic, infrastructure-related and geographic variables are unevenly distributed in space, and these factors play a crucial role in classifying or characterizing settlements. Traditional global OLS regression is limited in investigating geographic patterns. The OLS regression assumes that the coefficients of the independent variables are constant throughout the area, and thus omits fine-grained spatial information by estimating an average effect (Liu et al. 2011; Yoo 2012; Schoff and Yang 2012).

The GWR is a statistical method well-adapted to studying fine-grained spatial patterns. It is used for analyzing spatial patterns and proposing and testing spatial hypotheses in many fields, although not yet in economics (Fotheringham et al. 1998; Wang et al. 2008). Unlike conventional OLS regressions, the GWR does not assume that the relationships between independent and dependent variables are constant across space. Instead, the GWR explores whether the relationships between a set of predictors and an outcome vary by geographic location (Charlton et al. 2003). A spatially varying association suggests that a one-unit change in X provokes different levels of change in Y in different parts of the study area (i.e., non-stationarity). The GWR uses distance to define the spatial relationships among observations and can be used to measure spatially varying relationships between dependent and independent variables (Schoff and Yang 2012). While the OLS regression gives the same weight to all locations and provides a global estimate that is identical across all locations, the GWR gives relatively more weight to close observations and diminishing weight to distant observations. Thus, the GWR estimates a specific coefficient for each location, and every location has its own coefficient (Liu et al. 2011; Yoo 2012; Schoff and Yang 2012).

To conduct the in-depth analysis, spatial data for rural and urban areas were generated. The village and town boundaries were digitized in the geographic information systems software *ArcMap* based on the Census of India 2011 Administrative Atlas for Delhi. The availability of these data for the first time not only makes a comparison between OLS regression and GWR results possible but also helps elucidate the characteristics of rural and urban development in the area.

To display the results of the GWR analysis, standard residual of the GWR for population growth and employment rate change was mapped based on manual breaks with a common value to enable comparison. Finally, coefficients of the built-up area and the per capita provision of schools were mapped because these variables significantly explain the changes in population growth and the employment rate change.

4 Key findings

4.1 Descriptive analysis

The findings from Table 2 reveal that the growth rates are highest in villages followed by census towns and municipal areas. More specifically, the growth in rural (agriculture cultivation) employment is lowest in villages and highest in municipal areas, whereas other employment growth was highest in villages. Additionally, growth in the built-up area is six

Table 2 Growth rate (2001-2011) of socio-economic and built-up area indicators in different settlement types, %. *Source:* Compiled by Authors

	Total employment	Agriculture-cultivation employment	Other employment	Total population	Built-up area
Municipal area	20.3	149.5	19.5	18.5	2.9
Census towns	55.2	36.7	55.6	51.4	4.9
Villages	68.8	2.3	89.8	67.4	12.1

Built-up area was derived from the GHSL dataset available for years 2000 and 2014

and three times higher in villages compared to municipal areas and census towns, respectively. These results show the rapid transformation from rural to urban activities in villages compared to census towns. The lack of land use regulation enforcement in non-municipal areas (census towns and villages) compared to municipal areas seems to have increased the amount of built-up area in the former.

In alignment with the employment, population and built-up area growth, similar trend in the provision of social infrastructure was identified. In 2001, villages had the highest per capita provision of schools and medical centers, followed by the census towns and the municipal area. However, by 2011, the provision of social infrastructure has not kept pace with the population growth, especially the villages have experienced a substantial reduction (Table 3).

4.2 Field survey findings

The six villages and four census towns shortlisted for the field survey have more than 10,000 people, densities of more than 2000 people/sq. km. and greater than 80% main male employment in non-agricultural pursuits in 2011 (Table 4). Despite fulfilling the criteria of the Census of India for being urban, these areas were still considered either villages or census towns in the 2011 census. The developments in these towns and villages as captured during the field survey are narrated below (Table 5).

Dichaon Kalan is a village surrounded by lavish agricultural land where the residents are still active in cattle rearing. The village has a canal for irrigation purposes. The village is well maintained and is connected with a sewer line, and it has no problem with water clogging during the rainy season. The water supply is derived from the surrounding

Table 3 Population and provision of social infrastructure in the study area, 2001 and 2011. *Source:* Compiled by Authors

Type of area	Schools per 10,000 people	Medical centers per 10,000 people	Population
2011			
Municipal area	2.22	1.95	11,578,498
Census towns	3.47	0.48	4,949,465
Villages	8.73	4.96	421,539
2001			
Municipal area	2.35	1.69	9,770,944
Census towns	4.73	1.02	3,269,272
Villages	12.03	7.86	251,828

Table 4 Surveyed villages and census towns compared based on the Census of India criteria for urban areas (data for 2011). *Source:* Compiled by Authors

	Population	Population density (inh./sq.km.)	% male main workers in "other employment"
Villages			
Dichaon Kalan	27,255	2097	84.4
Holambi Kalan	42,392	8478	95.1
Mamoor Pur	18,937	3787	92.1
Salem Pur Majra Burari	10,438	2088	93.4
Saoda	16,309	8154	95.2
Qutab Pur	26,275	26,275	97.3
Census towns			
Ibrahim Pur	10,614	3538	94.7
Nilothi	43,371	10,843	96.9
Quammruddin Nagar	25,126	12,563	97.2
Rani Khera	16,402	5467	93.9

Inhabitants per square kilometer (inh./sq.km.), the area of Qutab Pur village is 1 sq.km

town of Nangloi for certain hours each day, so people store water in tanks. The land use is mostly residential.

Holambi Kalan is a village where the agricultural land has been rapidly converted into other uses, such as residential and commercial. The village has a canal for irrigation purposes. The area lacks a water supply line, and sewer lines have not been laid. The situation with garbage collection is also quite dismal, and clogging of the open storm water drains was identified. The changes in land use and the encroachments on the drains have increased flooding during the rainy season.

Mamoorpur (Mamurpur) is located on the border with Haryana, and the survey revealed a well-managed village surrounded by agricultural fields that is facing urbanization pressure. People complained about encroachment on the roads and flooding due to increased impervious surfaces. The water supply is derived from the Delhi Jal Board (DJB), and sewer lines were well laid.

Salem Pur Majra Burari (Suleman Mirja Burari) is located on the border with Uttar Pradesh. The visit revealed contrasting development on either side of the border. In Delhi, the development was haphazard, without a water supply or sanitation and a severe problem with garbage disposal. The water lines are provided by the DJB but are not connected. However, the provision of electricity was good. The other side of the border has flourishing agricultural land. Spillover effects of urbanization (in terms of garbage disposal) were observed in these agricultural fields.

Saoda (Sawda) is located on the border with Haryana and has a large parcel of agricultural land. The village is well maintained in terms of sanitation and garbage collection. However, the supply of drinking water remains a major source of concern. Nevertheless, the pressure of growth has not altered the characteristics of village life.

Qutab Pur (Qutab Vihar) is a village on the boundary with the DMC and is still surrounded by small parcels of agricultural land and a large cattle house (Goyla Dairy). A pond near the village was polluted with garbage. The agricultural land has been converted

Table 5 Characteristics of census towns and villages elucidated during the field survey (data for 2011). *Source:* Compiled by Authors

	Electricity provision	Drinking water supply	Sewer connection	Garbage collection	Water clogging	Land use
Villages						
Dichaon Kalan	3 h./day	3–2 h./day	Yes	Regular	No	Residential
Holambi Kalan	Good	No	No	Regular	Yes	Residential and commercial
Mamoor Pur	Good	DJB supply	No	Regular	Yes	Residential
Salem Pur Majra Burari	Good	No	No	No	Yes	Residential
Saoda	Good	Irregular	No	Regular	No	Residential
Qutab Pur	Good	No	No	No	Yes	Residential and commercial
Census towns						
Ibrahim Pur	Good	DJB supply	No	No	Yes	Residential and commercial
Nilothi	Good	No	No	No	Yes	Residential and commercial
Quammruddin Nagar	Good	MCD supply	No	No	Yes	Residential and commercial
Rani Khera	Good	Irregular	No	Regular	Yes	Residential and commercial

Delhi Jal Board (DJB), Municipal Corporation Delhi (MCD), hours per day (h./day)

for the development of housing and commercial activities. Since these areas are exempted from the building by-laws, they provide for cheap commercial and residential accommodations. Sewer lines have not been laid, the residents obtain drinking water through boring, and there is no garbage collection.

Ibrahim Pur (Ibrahimpur) is a census town located adjacent to Salem Pur Majra Burari. The urban environment is filthy, with a lack of sanitation and garbage disposal coupled with rampant construction. A small waterbody was identified some distance from the town that has turned into a sewer drain due to the disposal of garbage and sewer water. Ibrahim Pur was formerly a village that has transformed into a census town due to housing construction. Most of the residents are employed in low-paying jobs, and they have shops within their premises.

Nilothi is another example of a census town where development has caused concern due to a lack of urban services and the rampant development of housing and commercial activities. A canal that previously served agricultural purposes has been converted into a sewer drain. The residents lack jobs; thus, they are daily workers, and some have small shops. The provision of electricity is good, but the area lacks a water supply, sewer connections and garbage collection. During the rainy season, the streets are flooded with water.

Quammruddin Nagar (Kammruddin Nagar) is a census town just outside the DMC boundary. The development of this town is a matter of concern due to the lack of garbage collection and a sewer system. A canal has been converted into a sewer drain. Water is supplied by the MCD. The drains are clogged with garbage, and the drain water flows onto the roads. The streets flood when it rains. Mixed-use developments were identified, with the upper floors of buildings for residential use and the ground floor for commercial activities.

Rani Khera is a census town that is completely built-up with residential developments. Garbage collection is regular, water supply is irregular, and there are no sewer connections. There is no water clogging during the rainy season. Mixed-use developments were identified.

In summary, the census towns have high-density mixed-use developments with poor provision of basic amenities, and most of the agricultural land has been converted to other uses. In contrast, the villages have agricultural land available for development but face increasing pressure from urbanization, as revealed by the rapid changes in land use from agriculture to buildings, particularly for commercial activities.

5 Ordinary least squares regression results

The results in Table 6 reveal that increases in the employment rates are higher in census towns compared to villages. Employment rate growth is particularly high in the areas with a high provision of schools and high railroad density, and low in the areas with initially high employment rates. These results show that areas endowed with better infrastructure and having initial low employment rates attract new jobs. When differentiating the results by status of villages and census towns, it becomes clear that employment rate increases in villages with a higher provision of schools and medical facilities. The relationship seems to be significant in villages because these residential areas require education and health care facilities, whereas in census towns with high-density commercial areas, further development is determined by the availability of space for further construction.

Compared to the employment rate change, population growth is not significantly higher in census towns. Population growth is high in areas with a large amount of built-up area

Table 6 Determinants of growth in non-municipal areas of Delhi, 2001–2011 (Ordinary least squares regression results). *Source:* Authors

	Employment rate change model			Population change model		
	All areas	Villages	Census towns	All areas	Villages	Census towns
Census town dummy	.014**			−.670		
	(.007)			(.571)		
Population 2001	0	−.002	0	−.016	−.864***	−.008***
	(.000)	(.003)	(.000)	(.011)	(.314)	(.002)
Built-up area 2000	.000	.024	−.003	.408*	6.491***	.199***
	(.003)	(.023)	(.003)	(.271)	(2.046)	(.053)
Rail density	.036**	.051	.017	−.297	−3.904	−.672***
	(.016)	(.100)	(.012)	(1.258)	(9.129)	(.252)
Road density	.011	−.016	.011	−.387	−2.863	.066
	(.013)	(.031)	(.011)	(1.020)	(2.807)	(.227)
Schools per capita 2001	.007**	.007*	.006	−.528**	−.399	−.275**
	(.003)	(.004)	(.006)	(.242)	(.376)	(.117)
Other medical center per capita 2001	.001	.001**	−.014	.102***	.096**	.256
	(.000)	(.001)	(.012)	(.030)	(.046)	(.251)
Employment rate 2001	−.695***	−.861***	−.417***	−4.557	−5.667	−2.538*
	(.059)	(.088)	(.071)	(4.605)	(7.955)	(1.434)
Constant	.171***	.218***	.109***	2.847**	3.900*	1.426***
	(.018)	(.028)	(.023)	(1.442)	(2.586)	(.456)
Adj. R^2	.566	.654	.270	.069	.138	.179
F-Stat	35.19	28.32	6.69	2.95	3.307	4.369
N	211	102	109	211	102	109

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses

and high provision of medical facilities. When differentiating the non-municipal areas into villages and census towns, the results reveal that having a large amount of built-up area in 2000 and a low population in 2001 significantly explain the population growth in both categories, but the good provision of medical facilities leads to population growth in villages.

In summary, there are differences in the determinants of growth between census towns and villages with regard to urban amenities such as the provision of schools, medical facilities and rail networks.

6 Geographically weighted regression findings

To capture area-specific determinants, the GWR residuals for population growth and employment rate change are mapped (Fig. 2). The mapping shows that residuals are not distributed randomly over the space, as the OLS regression assumes. The residuals of the regression are clustered geographically, indicating that the effect of the explanatory variables is not constant throughout the non-municipal area; therefore, factors associated with geography are an important determinant of population growth and employment rate change. Additionally, the GWR does not differentiate between the official
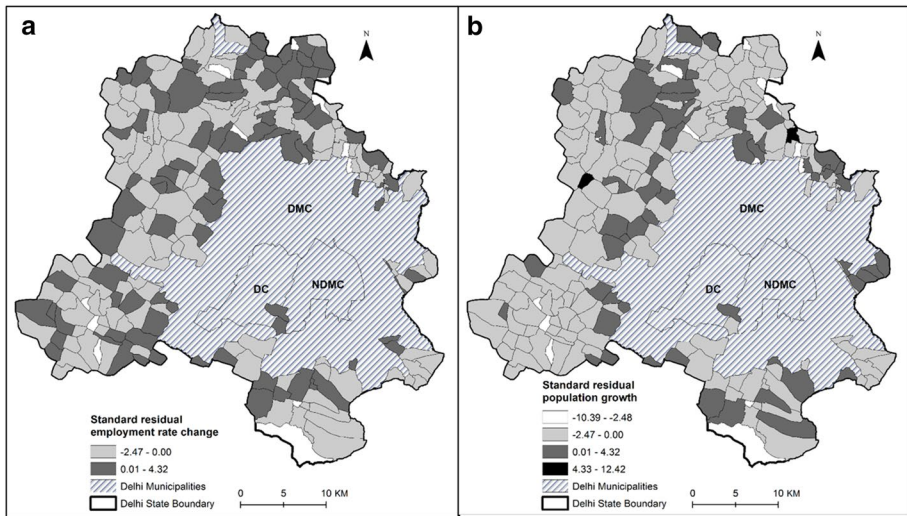
Fig. 2 Standard residual for other employment rate change, 2001–2011 (**a**) and population growth rate, 2001–2011 (**b**). *Note*: Delhi Municipal Corporation (DMC), New Delhi Municipal Corporation (NDMC), Delhi cantonment (DC). *Source:* Compiled by Authors

status (census town or village) of a polygon, it clusters the polygons based on their coefficients, whose values depend on the geographical distribution of socio-economic, infrastructure and built-up area variables. This raises concern for the Census of India population based delineation of rural and urban in close proximity to each other with similar urban services and built-up area growth.

To estimate the local effect of the provision of schools, the OLS regression model is expanded to the GWR. The GWR generates 211 different local regressions and is therefore different from a fixed-effect OLS regression. The GWR mapping of the coefficient of per capita school provision indicates a considerable spatial variation in the effect on the employment rate (Fig. 3a). Clustering is identified, and the effect is high in the south, east and north compared to the west. When differentiating the coefficients by status, the results show that the effect in villages is high in the north Delhi periphery (Fig. 3c), and in census towns that are in close proximity to the municipal boundary (Fig. 3b). This finding further ellborates the regression analysis with regard to the growth of census towns, illustrating the effect of space specific factor on their growth (Table 6).

To estimate the local effect of the built-up area on population growth, the OLS regression model is expanded to the GWR. The adjusted R-square for population growth from the GWR was 0.62 compared to 0.56 from the OLS regression. The GWR mapping (Fig. 3d) shows considerable spatial variation in the effect of the amount of built-up area. Clustering is identified, and the coefficients are high in the north, north-west and south, whereas they are relatively low in the southwest. When differentiated by status, it becomes clear that the effect of the built-up area is higher in villages compared to census towns (Fig. 3e, f). The field visit established that the agricultural land in census towns has been completely transformed into other uses, whereas villages still have agricultural land available. Thus, there has been greater transformation in villages compared to census towns. These results are also confirmed by the descriptive analysis (Table 2).
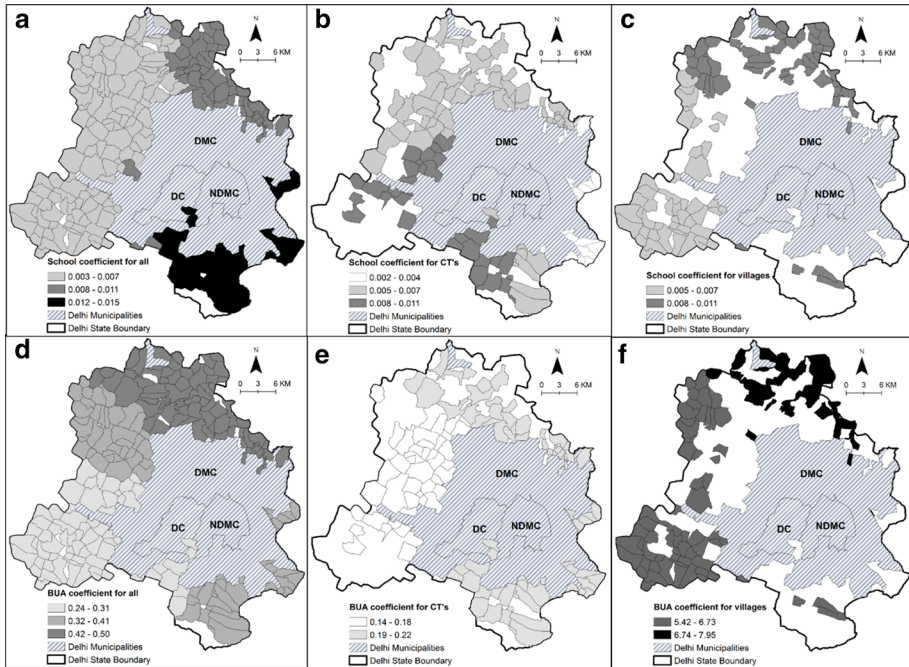
Fig. 3 Geographically weighted regression coefficients for the provision of schools per capita (**a**, **b** and **c**) and for the built-up area (**d**, **e** and **f**). *Note*: Delhi Municipal Corporation (DMC), New Delhi Municipal Corporation (NDMC), Delhi cantonment (DC), census town (CT), built-up area (BUA). *Source:* Compiled by Authors

7 Discussion and policy recommendations for non-municipal areas

7.1 Moving from master planning towards strategic spatial planning

The descriptive analysis revealed substantial differences in growth rates between villages and census towns with a rapid increase in the built-up area in villages (Table 2). The field survey established a rapid conversion of agricultural land into other uses in villages. In census towns, high-density mix-use developments and a lack of access to basic services has been established.

This situation is an outcome of land-use based master planning, which is imbedded with colonial principles, and a lack of reforms to address contemporary issues. The current Master Plan for Delhi is based on committee reports and not scientific projections where "the members of the committee are selected based on their past work experience" (Jain, personal interview, 2017). The preparation of the master plans takes a long time, and by the time they are implemented, they become redundant due to the rapid pace of growth. These master plans are delinked from local economic development opportunities, and therefore they fail to address the infrastructure needs due to booming economic activities.

The research by Jain (2018) and Mukhopadhyay et al. (2016) confirms the diverse economic opportunities associated with the growth of census towns. However, the provisioning of the basic services is poor in these towns. The OLS regression findings of this research further confirms that employment rate change is high in census towns compared

to villages (Table 6). In addition, the field survey shows that census towns are the transformation zones in terms of high-rise developments (especially incremental development) with inadequate infrastructure and other essential services. Addressing the issues of peri-urban areas in India, the WB (2013) study recommends governing for land use conversion, and land readjustment and managing urban densities to finance urban infrastructure. Here, there is a potential to introduce density incentives such as Floor Space Index or development tax to generate revenue for funding infrastructure

As argued by Watson (2009) and Ansari (2004), spatial planning in India is an extension of the colonial legacy, which is stringently based on land use regulation with little reforms to address the contemporary issues of urbanization. Accommodating the predicted urban growth will require a move away from land-use oriented master planning approaches towards strategic spatial planning, which integrates different sectors and different tiers of government to achieve sustainable development.

7.2 Rural–urban integrated planning and governance

Zerah (2017) in her work on census towns identifies limited responsibility of the municipal councilor for public works and urban management. The town planning and infrastructure decisions are taken over by the state government. The state development authorities surpass the local authorities, and the municipal commissioners are harassed by the threat of kidnapping for not passing the tenders.

Some of the similar issues were captured during the field survey and interviews: (i) land use plan has been formulated for all of Delhi, however, its implementation has been lacking, "mainly due to vested interests of the state government, where these violations are not fined in exchange for votes" (Srinivas, personal interview, 2017). (ii) "Municipal corporation employees fear entering these areas. It is not possible to ask the residents to follow the land use regulations because they have political backing" (Mehra, personal interview, 2017). (iii) Institutional conflicts are observed in terms of planning boundaries and their management. "The lack of conformity of DDA land use planning boundaries with rural and urban boundaries from the Census of India has created a serious problem of land use plan implementation for the MCD" (Srinivas, personal interview, 2017; Mehra, personal interview, 2017). Political willingness and stakeholder involvement appears to be required in planning and implementation to move the non-municipal areas towards sustainability path.

The rural–urban dichotomy for planning and governance has left areas outside the municipal boundaries (peri-urban areas) unattended. Consequently, growth has taken the form of unplanned and unserviced development. For this reason, there is a need to move towards integrated rural–urban governance for treating these areas as one unit for planning and implementation. Unfortunately, although District Planning Committees for integrated rural urban planning and governance was recommended in the 74th Constitutional Amendment Act, these have not been implemented in Delhi.

7.3 Moving beyond rural and urban

The OLS regression analysis (Table 6) reveals that in villages, employment rate change is explained by the provision of educational and medical facilities, and population growth is explained by medical facilities and built-up area. In contrast, in census towns, population growth is explained by the built-up area, and infrastructure provision does not have an

effect on employment rate change and population growth. These results indicate that there are different determinants of growth for census towns and villages. In addition, the GWR mapping (Figs. 2 and 3) indicates that the effects of growth are not uniform in Delhi, as indicated by the OLS regression. Instead, these effects vary depending on the distribution of socio-economic, demographic and infrastructure variables.

These findings raise questions regarding the demarcation criteria currently used by the Census of India, which does not incorporate information about urban amenities (such as educational and medical facilities), land use (commercial or residential) and built-up area. As stated by Chakrobarty (personal interview, 2017) "the Census of India is considering revising the definition of urban by using built-up area information, but so far no action has been taken". Punia et al. (2017) in their work on census towns show that definition of urban areas lacks clarity and that the growth of the census towns is driven by industrial, institutional, and real estate investments coupled with improved connectivity and infrastructure provision. Therefore, the incorporation of infrastructure information as well as land use and built-up area information can be helpful for accurately delineating rural and urban.

The GWR findings (Fig. 3a, d) indicate that the clustering effect is not due to 'census town' or 'village' status but rather is an outcome of spatial variation in socio-economic and infrastructure variables, which leads to the high or low values (coefficients) of infrastructure provision. Thus, irrespective of whether a polygon is defined by Census of India as rural or urban, the GWR clustering is based on the values of coefficients. This finding is important for moving towards integrated planning of non-municipal areas because the adjacent polygons present similar socio-economic, infrastructure and built-up area variables statuses irrespective of the census status (urban or rural) in the clustering.

A mixed approach is required, such as the one adopted in this paper, where field surveys are conduced to capture the specific features, and regression analyses are performed to identify the growth factors before any planning proposals are made. Implementing such an approach, which is based on the actual growth factors, can lead to better planning compared to current planning based on Census of India delineated census towns and villages.

8 Conclusions

This paper shows that using a combination of methods such as a field survey, OLS regressions and a GWR analysis is helpful for elucidating the characteristics of growth in the non-municipal areas, which otherwise are not captured by individual techniques in isolation. This research establishes the following: First, the results show a certain catching-up effect in which the settlements with low populations and low employment rates grow faster than more urbanized settlements. Second, settlements with low basic infrastructure provision (such as schools and medical facilities), which are mainly census towns, tend to grow more slowly than villages with better infrastructure provision (Table 3). In these villages, the provisioning of additional education and health care facilities leads to higher employment rates. Third, the socio-economic, demographic and infrastructure variables are not uniformly distributed in space but rather are clustered. Fourth, both the OLS regressions and the GWR methods identify a similar relationship between the dependent and independent variables, however, the GWR provides better measures of fit.

Finally, the development of villages undergoing transformation still have the potential to be regulated, and sustainable future growth in Delhi and in similar regions of the global South will require moving beyond the rural–urban dichotomy in planning and governance,

which calls for following reforms: (i) moving from land use based master planning towards strategic spatial planning, (ii) strengthening the institutional structure for integrated rural–urban planning and governance, and (iii) adopting a mix of methods for scientific analysis for formulating plans and policy reforms for different areas.

References

Allen, A. (2003). Environmental planning and management of the peri-urban interface: perspectives on an emerging field. *Environment & Urbanization, 15*(1), 135–147.

Ansari, J. (2004). Time for a new approach in India. *Habitat Debate*, *10*(4), 15.

Bhagat, R. (2005). Rural-Urban classification and municipal governance in India. *Singapore Journal of Tropical Geography, 26*(1), 61–73.

Bhagat, R. (2014). *Urban migration trends, challenges and opportunities in India*. World Migration Report 2015. International Organization for Migration.

Brenner, N., & Schmid, C. (2015). Towards a new epistemology of the urban? *City, 19*(2–3), 151–182.

Champion, T., & Hugo, G. (2003). *Beyond the urban-rural dichotomy: Towards a new conceptualisation of settlement for demographers*. Paper presented at the PAA2003 Annual Meeting, Minneapolis, 1–3 May.

Charlton, M., Fotheringham, A., & Brunsdon, C. (2003). *Software for geographically weighted regression. Spatial analysis research group*. Newcastle upon Tyne: Department of Geography, University of Newcastle upon Tyne.

Chattopadhyay, S. (2015). Financing India's urban infrastructure: Current practices and reform options. *Journal of Infrastructure Development, 7*(1), 55–75.

Chaurasia, R., & Gulati, C. (2008). *India: The state of population 2007*. New Delhi: Oxford University Press.

Denis, E., & Marius-Gnanou, K. (2011). Toward a better appraisal of urbanization in India: A fresh look at the landscape of morphological agglomerates. *Cybergeo European Journal of Geography*. (http://journals.openedition.org/cybergeo/24798).

DIVA-GIS (2017) 'Download data by country'. Available from http://www.diva-gis.org/gdata.

Duranton, G., & Puga, D. (2013). The growth of cities. In S. Durlauf & P. Aghion (Eds.), *Handbook of economic growth* (Vol. 2). Amsterdam: Elsevier.

European Commission (EC). (2017). *GHSL-global human settlement layer*. Available from http://ghslsys.jrc.ec.europa.eu/.

Fotheringham, A., Charlton, M., & Brundson, C. (1998). Geographically weighted regression: A natural evolution of the expansion method for spatial data analysis. *Environment and Planning A, 30*(11), 1905–1927.

Glaser, E., & Kohlhase, J. (2004). Cities, regions and the decline of transport costs. *Papers in Regional Science, 83,* 197–228.

Glaser, E., Kolka, J., & Saiz, A. (2001). Consumer city. *Journal of Economic Geography, 1*(2001), 27–50.

Government of India (GoI). (2001a). *Primary census abstract: Ministry of home affairs*. New Delhi: The Registrar General and Census Commissioner.

Government of India (GoI). (2001b). *Town directory India: Ministry of home affairs*. New Delhi: The Registrar General and Census Commissioner.

Government of India (GoI). (2001c). *Area and population*. New Delhi: The Registrar General and Census Commissioner.

Government of India (GoI). (2011a). *Primary census abstract: Ministry of home affairs*. New Delhi: The Registrar General and Census Commissioner.

Government of India (GoI). (2011b). *Town directory India: Ministry of home affairs*. New Delhi: The Registrar General and Census Commissioner.

Government of NCT of Delhi (GNCT). (2013). Economic Survey of Delhi 2012–2013: Demographic profile. Planning Department, Government of NCT of Delhi, India. Accessed from: http://www.delhi.gov.in/wps/wcm/connect/doit_planning/Planning/Economic+Survey+of+Dehli/Economic+Survey+of+Delhi+2012+-+2013.

Grimes, A., Apatov, E., Lutchman, L., & Robinson, A. (2014). *Infrastructure's long-lived impact on urban development: Theory and emprics*. Motu Working Paper pp. 14–11.

Harris, J. (1982). *Rural development, theories of peasant economy and agrarian change*. London: Hutchinson University Library.

Haughwout, A. (1999). State infrastructure and the geography of employment. *Growth and Change, 30,* 549–566.

Haughwout, A. (2001). Infrastructure and social welfare in metropolitan America. *Economic Policy Review*, *7*(3), 1–16.

Hugo, G., Champion, A., & Lattes, A. (2003). Toward a new conceptualization of settlements for demography. *Population and Development Review, 29*(2), 277–297.

Jain, M. (2018). Contemporary urbanization as unregulated growth in India: The story of census towns. *Cities, 73,* 117–127.

Jain, M., & Korzhenevych, A. (2017). Spatial disparities, transport infrastructure and decentralization policy in the Delhi region. *Journal of Urban Planning and Development, 143*(3), XX.

Jimenez, E. (1994). Human and physical infrastructure: Public investment and pricing policies in developing countries. In J. Behrman & T. T. Srinivasan (Eds.), *Handbook of development economics* (Vol. 3). Washington: The World Bank.

Kroll, F., Müller, F., Bell, S., Haase, D., et al. (2009). Indicator framework for evaluating impacts of land use changes. Peri-urban land use relationships- strategies and sustainability assessment tools for urban-rural linkages, integrated project. (PLUREL): Strategies and sustainability assessment tools for urban-rural linkages, integrated project. Contract No. 036921, D4.3.1.

Kundu, A. (2011). Method in madness: Urban data from 2011 census. *Economic & Political Weekly, xlvi, 40,* 13–16.

Kuruvilla, Y. (2014). Census towns in Kerala: Challenges of urban transformation. In: *International Conference for Deepening Democracy Through Participatory Local Governance*, At Kovalam, Thiruvananthapuram (January 2014).

Liu, Y., Jiang, S., Liu, Y., Wang, R., Li, X., et al. (2011). Spatial epidemiology and spatial ecology study of worldwide drug-resistant tuberculosis. *International Journal of Health Geographic, 10*(50), 1–10.

Mawby, R., Armstrong, M., & Hay, D. (2009). *An analysis of social infrastructure and city competitiveness—Synthesis and key findings*. Project: Social Infrastructure for Competitive Cities. Acessed from: https://suma.org/img/uploads/documents/City%20Competitiveness%20and%20Infrastructure%20Investments%20Synthesis_Report.pdf.

Mukhopadhyay, P., Zérah, M., Samanta, G., & Maria, A. (2016). *Understanding India's urban frontier: What is behind the emergence of Census Towns in India?*. Washington: The World Bank Group.

Munnell, A. (1992). Policy watch: Infrastructure investments and economic growth. *Journal of Economic Perspectives, 6,* 89–198.

Nijkamp, P. (1986). Infrastructure and regional development: A multidimensional policy analysis. *empec, 11,* 1–21.

Partridge, M., Ali, K., & Olfert, M. (2010). Rural-to-urban commuting: Three degrees of integration. *Growth and Change, 41*(2), 303–335.

Pradhan, K. (2017). Unacknowledged urbanisation: The New Census Towns in India. In E. Denis & M.-H. Zerah (Eds.), *Subaltern urbanisation in India* (pp. 39–66). Delhi: Springer.

Punia, M., Kumar, R., Singh, L., & Kaushik, S. (2017). Comparison of peripheral metropolitanisation in Haryana and Rajasthan, India. In *Subaltern urbanisation in India* (pp. 141–165). New Delhi: Springer.

Ravetz, J., Fertner, C., & Nielsen, T. (2013). The dynamics of peri-urbanization. In K. Nilsson, S. Pauleit, S. Bell, C. Aalbers, & T. Sick Nielsen (Eds.), *Peri-urban futures: Scenarios and models for land use change in Europe*. Berlin: Springer.

Roy, A. (2009). The 21st-Century metropolis: New geographies of theory. *Regional Studies, 43*(6), 819–830.

Roy, S., & Pradhan, K. (2018). *Census towns in India: current patterns and future discourses*. Working paper. Center for Policy Research.

Samanta, G. (2014). The politics of classification and the complexity of governance in Census Towns. *Economic and Political Weekly, XLIX, 22,* 55–62.

Schneider, A., & Mertes, C. (2014). Expansion and growth in Chinese cities, 1978–2010. *Environmental Research Letters, 9,* 11.

Schneider, A., & Woodcock, C. (2008). Compact, dispersed, fragmented, extensive? A comparison of urban growth in twenty-five global cities using remotely sensed data, pattern metrics and census information. *Urban Studies, 45*(3), 659–692.

Schoff, C., & Yang, T.-C. (2012). Spatially varying predictors of teenage birth rates among counties in the United States. *Demographic Research, 27*(14), 377–418.

Shaw, A. (2005). Peri-urban interface of Indian cities: Growth, governance and local initiatives. *Economic and Political Weekly, 40*(2), 129–136.

Sivaramakrishnan, C., Kundu, A., & Singh, B. (2005). *Handbook of urbanisation in India: An analysis of trends and processes*. New Delhi: Oxford University Press.

Sridharan, N. (2011). Spatial inequality and the politics of urban expansion. *Environment and Urbanization ASIA, 2*(2), 187–204.

Stroper, M., & Scott, A. (2016). Current debates in urban theory: A critical assessment. *Urban Studies, 53*(6), 1114–1136.

Tacoli, C. (2003). The links between rural and urban development. *Environment and Urbanization, 15*(1), 3–12.

United Nations (UN). (2017). *World population prospects: Key findings and advanced tables. 2017 revision*. New York: UN.

Uzell, D. (1979). Conceptual fallacies in the rural-urban dichotomy. *Urban Anthropology, 8*(3/4), 333–350.

Van Duijne, R. J. (2017). What is India's urbanization riddle*?*. *Economic and Political Weekly, LII, 28,* 76–77.

Wang, N., Mei, L., & Yan, C. (2008). Local linear estimation of spatially varying coefficient models: an improvement on the geographically weighted regression technique. *Environment and Planning A, 40*(4), 986–1005.

Watson, V. (2009). Seeing from the south: Refocusing urban planning on the globe's central urban issues. *Urban Studies*, *46* (11), 2259–2275.

World Bank (WB). (2013). *Urbanization beyond municipal boundaries: Nurturing metropolitan economies and connecting peri-urban areas in India*. Washington: World Bank.

Yoo, D. (2012). Height and death in the Antebellum United States: A view through the lens of geographically weighted regression. *Economics and Human Biology, 10,* 43–53.

Zerah, M.-H. (2017). Shedding light on social and economic changes in small towns through the prism of local governance: A case study of Haryana. In E. Denis & M.-H. Zerah (Eds.), *Subaltern urbanisation in India* (pp. 371–395). Delhi: Springer.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.