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ORIGINAL RESEARCH PAPER

Dynamics of urban growth in mid-sized cities using census data

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ABSTRACT

BACKGROUND AND OBJECTIVES: Currently, 56% of the global population, resides in cities, and this urbanization trend is predicted to result in more than doubling of the urban population by 2050. Similarly, mid-sized Indian cities have exhibited rapid urban growth in recent decades. However, a holistic study focusing on the temporal dynamics of urban growth in all the mid-sized Indian cities is lacking. Therefore, this study aims to investigate the urban growth pattern across eighty-eight mid-sized Indian cities with the help of Census data from 1971-2011.

METHODS: This research, utilizing a quantitative approach, investigates the relationship between economic growth and urban expansion in selected cities. The cities are categorized based on the Gross State Domestic Product of respective states, and the study evaluates changes in municipal areas and demographic growth patterns through the decadal urban expansion rate and decadal population growth rate. The urban growth character is further analyzed by dividing the population growth rate by the decadal urban expansion rate, with a value less than 1 indicating inefficient land utilization. This comprehensive methodology aims to provide insights into the dynamics of urban growth and its correlation with economic development.

FINDINGS: The results revealed that inefficient land utilization for urban growth during 1971-2011 had occurred in thirteen cities from the states with higher Gross State Domestic Product and three cities among the states with lower Gross State Domestic Product. Overall, the mid-sized Indian cities, such as Ajmer (0.65), Solapur (0.67), Asansol (0.79), Mangalore (0.83), Jhansi (0.84), Nellore (0.85), Belgaum (0.86), Thrissur (0.86), and Bareilly (0.89) exhibited the lowest PU values during 1971-2011. The major drivers for urban growth in mid-sized Indian cities are government policies and schemes, industrial growth, rise in Gross State Domestic Product, climatic conditions and terrains, social profile, transportation, and infrastructure.

CONCLUSION: Overall, there has been inefficient land utilization in several cities, particularly those from states with varying levels of Gross State Domestic Product. Noteworthy cities like Ajmer, Solapur, and Belgaum consistently demonstrated efficient land utilization, reflected in their lower Population-to-Urban Expansion values. The study emphasizes the intricate influences shaping urban growth, encompassing government policies, industrial development, economic factors, climate, social dynamics, and infrastructure. Future research endeavors could further delve into the specific impact of these factors on urban expansion, employing longitudinal analyses, and exploring the socio-economic ramifications of efficient or inefficient land utilization, contributing to more informed urban planning and policy formulation.

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INTRODUCTION

Today more than half of the global population resides in urban areas compared to 1950, when only 30% of the total population was urbanized (United Nations, 2018). Asia is home to 53% of the global urban population despite a low rate of urbanization (United Nations, 2019). Urbanization and urban growth are often used synonymously although there exists a significant difference between the two processes. Urbanization refers to a phenomenon wherein rural areas are transformed into urban areas primarily due to population immigration and changes in economic activities, while urban growth is a spatial process that promotes the expansion of cities (Bhatta, 2009; Bhatta, 2010). Urban areas are the engines of growth, i.e., they are the drivers that trigger economic, social, and cultural growth by creating wealth and generating employment, which ultimately leads to the development of humans (Akanbang *et al.,* 2021). Hence, it is assumed that urban living has better access to education, jobs, health facilities, and other social services, along with prospects for cultural and political participation (Chettry, 2023). However, rapid and haphazard urbanization in the last few decades has affected humans and, most importantly, the natural environment (Subadyo *et al.,* 2019; Chandrashekar and Aithal, 2021; Sethi *et al.,* 2021; Amare *et al.,* 2023). The cities and adjoining areas during this process of rapid urbanization were subjected to rapid growth leading to the development of peri-urban growth (World Bank, 2013; Hennig *et al.,* 2015; Hsu *et al.,* 2016). The major characteristics of urban growth include but are not limited to low-density development (Jiang *et al.,* 2007; Yue *et al.,* 2016); dispersed growth (Salvati and Carlucci, 2015; Ozturk, 2017; Chandrashekar and Aithal, 2021), vehicle dependent (Jain and Pallagst, 2015; Nielsen, 2017), growth along major roads (Tian *et al.,* 2017), poor environment (Bhattacharya, 2019; Dewa *et al.,* 2023), and poor quality of life (Bhat *et al.,* 2017; Oladehinde *et al.,* 2021). Currently, in India, there are 7933 cities and towns of different population sizes and cumulatively it accounts for 377.16 million (Jain *et al.,* 2019). The total urban population in India is approximately 11% of the global urban population and is expected to reach 13% by 2030. It is estimated that half of the population in India will live in cities by 2050, leading to a significant transition in urban areas (United Nations, 2015). In 2015, urban India contributed 63% of the Indian Gross Domestic Product (GDP), and a further increase is expected up to 75% by 2030 (Kantakumar *et al.,* 2016). Due to such tremendous urban growth in India over the years, there have been haphazard land cover changes (Kumar and Tripathi, 2014; Jain *et al*., 2017). Moreover, the urban growth in large Indian cities (population >5 million) occurred primarily through expansion towards the periphery (Sahana *et al.,* 2018). The large cities have already exceeded the threshold level of carrying capacities, and as a result, there has been a rise in pollution levels, traffic congestion, and a lack of infrastructure, facilities, and services (Ramachandra and Aithal, 2013). Furthermore, in recent decades mid-sized Indian cities (population 0.5-5 million) have also exhibited rapid urban expansion towards the periphery (Chettry, 2023a). However, a comprehensive study of all the eighty-eight mid-sized Indian cities to understand the urban growth pattern is missing from the literature. Moreover, the 11th Sustainable Development Goal (SDG) of the 2030 Agenda for Sustainable Development adopted by the United Nations Member States in 2015 emphasizes promoting sustainable cities and communities (United Nations, 2016). Therefore, it is essential to investigate the spatiotemporal urban growth pattern of cities to avoid unsustainable urbanization (Chettry, 2022). However, unlike China (Jiyuan *et al*., 2012), the USA Europe (Kasanko *et al.,* 2006), and other developed nations, there is a lack of an urban built-up database for Indian cities to analyze the urban growth pattern holistically. Numerous indices based on the urban land information are used to measure the growth of urban areas which includes but are not limited to Urban Expansion Rate (UER) calculated by Kantakumar *et al.* (2016) for Pune, India; Annual Expansion Rate (AER) by Zhao *et al.* (2015) for 32 major Chinese cities; Annual Growth Rate (AGR) by Espindola *et al.* (2017) for Teresina, Brazil. A comparative analysis of urban growth patterns in three metropolises of China and the USA using temporal Impervious Surface Area (ISA) datasets was done by calculating overall ISA change, annual expansion area, and annual expansion rate (Kuang *et al.,* 2014). Chen *et al.* (2014) utilized the Average Annual Population Growth Rate (AAPGR), Average Annual Urban Expansion Rate (UE), and Population Growth to Urban Expansion Ratio (PGUR) to study urban growth in Shenzhen and Dongguan during 1990-2008. PGUR is synonymous with the Land

Consumption Rate (LCR) and was used as an index to assess the dynamics of urban expansion in Bahir Dar, Ethiopia (Haregeweyn *et al.*, 2012). A similar index was used to analyze the urban growth of the Greater Accra Metropolitan Area, Ghana (Akubia and Bruns, 2019). Overall, it is a measure to understand urban growth patterns wherein the results may exhibit urban compactness or urban expansion. The Census of India collects data every ten years in India regarding the municipal expanse, demography, and socio-economic status of Indian cities and villages. Various researchers globally (Schneider and Woodcock, 2008; Garcia-López and Muñiz, 2013; Kukkonen *et al.*, 2017) as well as in India (Fazal, 2000; Das *et al.*, 2016; Sahana *et al.*, 2018) have used Census data in urban growth studies. However, most of these studies utilize the Census data only to explore the demographic characteristics of an area. Therefore, municipal area expansion data gathered from the Census of India can be used due to the lack of an urban built-up dataset for all the eighty-eight mid-sized Indian cities. A similar approach was attempted to measure the urban sprawl of Western Cape Province, South Africa due to a lack of physical urban expanse data (Horn and Eeden, 2018). Hence, in this context this research aims to investigate urban growth pattern among eighty-eight mid-sized Indian cities. It utilizes the census data for identifying mid-sized Indian cities that exhibited inefficient utilization of land resources to accommodate the rising population. The municipal expansion rate and population growth rate are quantified to investigate the urban growth pattern. The selected mid-sized Indian cities were classified into two categories based on Gross State Domestic Product (GSDP) for detailed analysis. The purpose of this study is to provide valuable insights for government agencies and city planners to address the pressing need for informed urban planning due to rapid urbanization and population growth. The findings aim to assist in formulating strategies for planned urban development. The current study has been carried out on eighty-eight mid-sized cities in India in 2023.

MATERIALS AND METHODS

Study area and datasets

India is a country in South Asia with a total area of 3.28 million km^2, the seventh-largest country by area, and the second-most populous country (1.2 billion population) as per the Census of India 2011 in the whole world (Census of India, 2011). The total urban population of the country is more than 377 million constituting 31.16% of the total population. The country has various geographic regions like Northern Mountain, Thar desert, Peninsular Plateau, Coastal Plains, and Indo-Gangetic plains. After the major economic reforms in 1991, India today is one of the fastest-growing economies of the world, fostering its cities towards growth (Chadchan and Shankar, 2012; Floater *et al.*, 2014). There are eight large cities with a population of more than 5 million (also known as Tier-I cities) and eighty-eight mid-sized cities with a population between 0.5 to 5 million (also known as Tier-II cities) in India as per the data obtained from the Ministry of Finance, Govt. of India (Fig. 1). The demographic and municipal expansion data were gathered from the Census of India detailed publication. The Census data is the official and most reliable data source to refer the demography and urban expansion data. The last Census was done is 2011 and hence the data in this study is based on Census 2011. The GSDP at Current Prices 2011-12 of all Indian states was obtained from the Central Statistical Organization, Govt. of India, New Delhi (Central Statistical Organisation, 2018). Microsoft Excel and ArcGIS 10.3 were used to analyse data and prepare maps in this study.

Methodology

The research methodology, illustrated in Fig. 2, commenced with the compilation of a list comprising eighty-eight mid-sized Indian cities obtained from the Ministry of Finance, Government of India. These cities were spatially mapped using ArcGIS 10.3. For a detailed analysis that aligns with the diverse urban growth processes within the selected cities, the GSDP of their respective states was chosen as a classification criterion. This choice was informed by the positive correlation between a city/state's economy and urban growth, as established in previous studies (UN-Habitat, 2012). The mid-sized cities were subsequently categorized into two groups based on the 75th percentile of the respective state GSDP in current prices for the base year 2011-2012 (adjusted to 2019-2020). This classification facilitated a more meaningful and contextually relevant examination of urban growth patterns within the selected cities. The list of cities is shown in Table 1 (Reserve Bank of India, 2023).

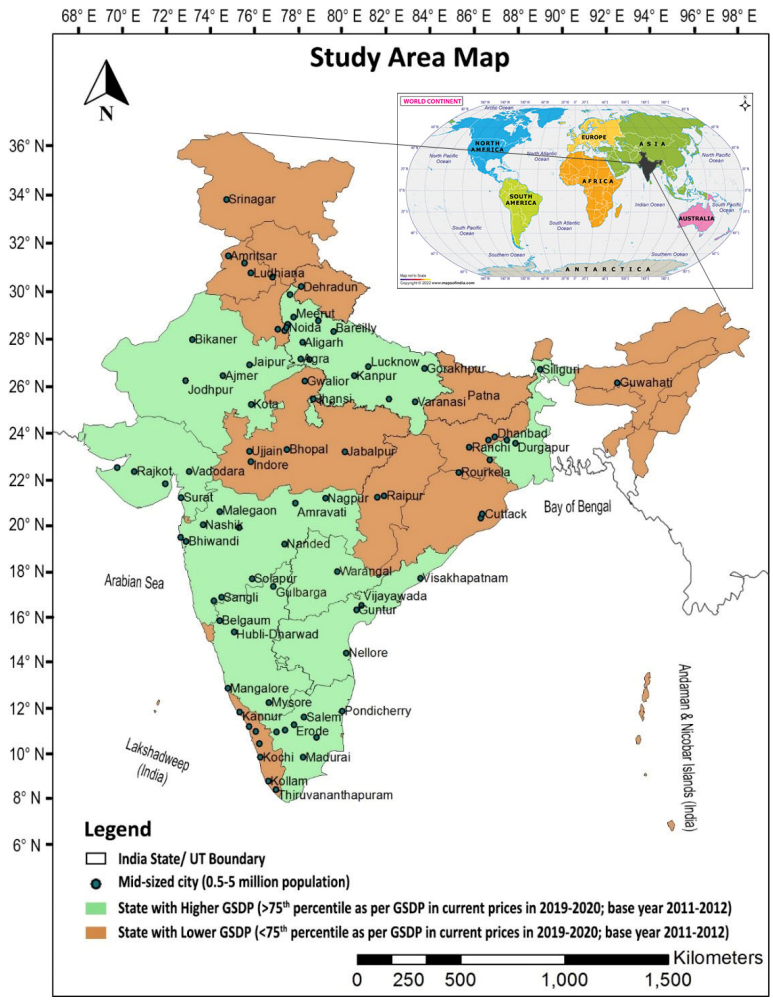

Fig. 1: Geographic location of the study area in India (Census of India, 2011)

The expansion of municipal area in India occurs after a detailed analysis of the population growth in the city and nearby areas, and land requirements for future development purposes. Therefore, details of the municipal area (decadal urban expansion rate) and the associated population (population growth rate) gathered from the Census of India were used as a variable to investigate the urban growth in the eighty-eight mid-sized Indian cities (Census of India, 2011). Overall, the Decadal Urban Expansion Rate (DUER) and Decadal Population Growth Rate (PR) indices were employed to monitor and analyze the urban growth pattern in mid-sized Indian cities (Peng *et al.,* 2015). UER measures the rate of urban expansion by quantifying the rise in the extent of municipal area within a decade was computed using Eq. 1 (Chettry, 2023a).

$$UER = \frac{UA_b - UA_a}{UA_a} \times 100\% \quad (1)$$

where UER is the decadal urban expansion rate, UA_a is the urban area in the a^{th} year (km^2), and UA_b is the urban area in the b^{th} year (km^2). PR measures the rate of population growth of an urban area within a decade was computed using Eq. 2 (Shahfahad *et al.,* 2020). These indices can effectively understand the temporal dynamics of urban growth occurring in each city.

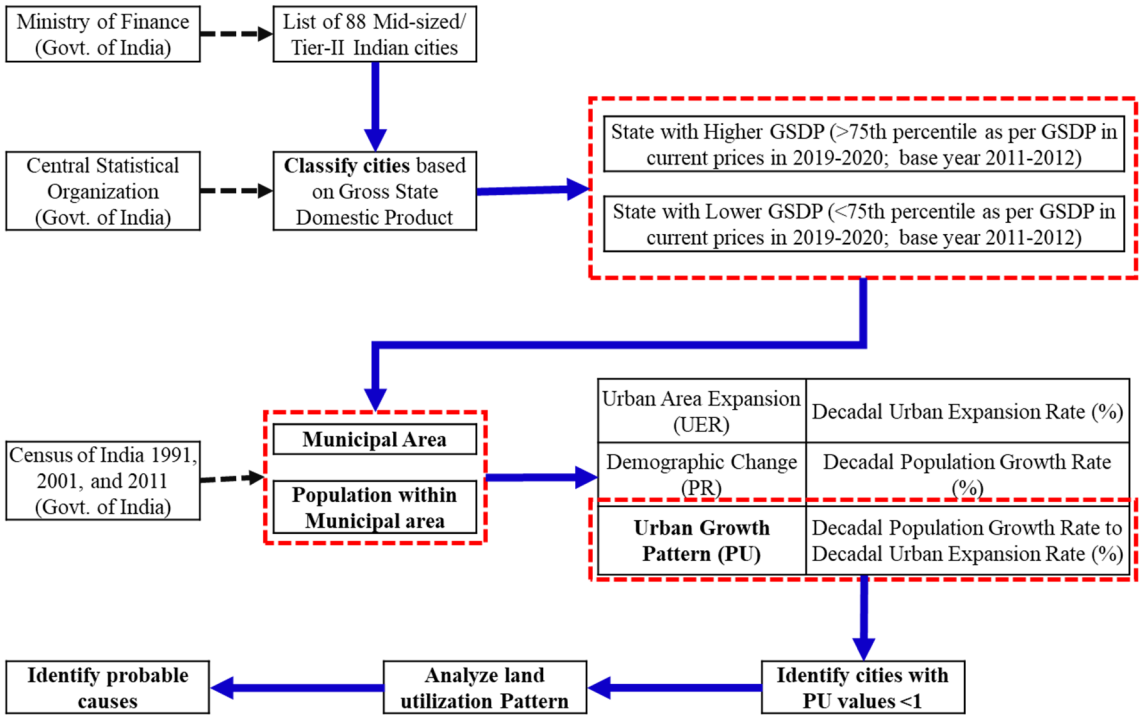

Fig. 2: Methodology adopted in this research

$$PR = \frac{P_b - P_a}{P_a} \times 100\% \quad (2)$$

$$PU = \frac{PR}{UER} \quad (3)$$

where PR is the decadal population growth rate, Pa is the total population in the a^{th} year, P_b is the total population in the b^{th} year, PU is the decadal population growth to urban expansion ratio, and UER is the decadal urban expansion rate.

Further population growth to urban expansion ratio (PU), i.e., a ratio of PR to UER was computed using Eq. 3 (Chen *et al.,* 2008; Dempsey, 2010; Chen *et al.,* 2014), provides an insight into the pattern of land utilization within municipal areas to manage rising population during the urban growth process. PU value less than 1 signifies the spatial expansion of municipal area is rapid compared to the rise in population within a decade. Such a pattern of urban growth is primarily due to inefficient land utilization and, in the future, it may lead to sprawl-like conditions (Akubia and Bruns 2019). Hence, if a PU value is less than 1, it signifies the prevalence of urban sprawl while a PU value of more than 1 signifies the occurrence of dense urban growth. Overall, PU assists in identifying whether the urban growth pattern in a city is towards sprawl or compact.

RESULTS AND DISCUSSION

The decadal UER and PR values from 1971 to 2011 in the mid-sized cities from the states with higher GSDP (>75th percentile as per GSDP in current prices in 2019-2020; the base year 2011-2012) are presented in Table 2. It was observed that during 1971-1981, Ajmer exhibited the highest decadal urban expansion growth rate, i.e., 82%, Siliguri (75%), Tirupur (73%), and Nellore (72%), followed by other remaining cities.

During 1981-1991, highest UER was observed in Nanded-Waghala (72%), Aurangabad (71%), Bareilly (70%), Visakhapatnam (69%), Meerut (67%) and followed by other remaining cities. Further during 1991-2001, highest UER was observed in Solapur (81%), Moradabad (59%), Firozabad (58%), Jaipur (55%) and followed by other remaining cities. Lastly

Table 1: List of states with higher and lower GSDP (Reserve Bank of India, 2023)

S.No.	States with higher GSDP (>75th percentile as per GSDP in current prices in 2019-2020; the base year 2011-2012)		States with lower GSDP (<75th percentile as per GSDP in current prices in 2019-2020; base year 2011-2012)	
	State/ UT (Mid-sized City)	GSDP in crores	State/ UT (Mid-sized City)	GSDP in crores
1	Maharashtra (Amravati, Aurangabad, Bhiwandi, Kolhapur, Malegaon, Nagpur, Nanded-Waghala, Nashik, Sangli, Solapur, and Vasai-Virar city)	2818555	Madhya Pradesh (Gwalior, Indore, Bhopal, Ujjain, and Jabalpur)	937405
2	Tamil Nadu (Coimbatore, Erode, Madurai, Salem, Tiruchirappalli, and Tirupur)	1797229	Kerala (Kozhikode, Kochi, Malappuram, Kannur, Kollam, Thiruvananthapuram, and Thrissur)	854689
3	Uttar Pradesh (Agra, Allahabad, Aligarh, Bareilly, Firozabad, Ghaziabad, Gorakhpur, Jhansi, Kanpur, Lucknow, Meerut, Moradabad, Noida, Saharanpur, and Varanasi)	1687818	Delhi	830872
4	Gujarat (Bhavnagar, Jamnagar, Rajkot, Surat, and Vadodara)	1630240	Haryana (Faridabad and Gurgaon)	780612
5	Karnataka (Belgaum, Gulbarga, Hubli-Dharwad, Mangalore, and Mysore)	1628928	Bihar (Patna)	594016
6	West Bengal (Durgapur, Siliguri, Asansol, Barddhaman)	1207823	Odisha (Cuttack, Bhubaneshwar, and Rourkela)	547959
7	Rajasthan (Ajmer, Bikaner, Jaipur, Jodhpur, and Kota)	998999	Punjab (Amritsar, Jalandhar, and Ludhiana)	539687
8	Andhra Pradesh (Vijayawada, Visakhapatnam, Nellore, and Guntur)	971224	Chhattisgarh (Durg-Bhilai and Raipur)	344955
9	Telangana (Warangal)	957207	Assam (Guwahati)	335238
10			Jharkhand (Dhanbad, Jamshedpur, Ranchi, and Bokaro)	321157
11			Uttarakhand (Dehradun)	253666
12			Jammu and Kashmir (Srinagar and Jammu)	170382
13			Himachal Pradesh	162816
14			Goa	74828
15			Tripura	55857
16			Chandigarh (Chandigarh)	43674
17			Puducherry (Puducherry)	37959
18			Meghalaya	34716
19			Manipur	31790
20			Sikkim	30809
21			Nagaland	29536
22			Arunachal Pradesh	28046
23			Mizoram	25149
24			Andaman & Nicobar Islands	9719

during 2001-2011, highest UER was observed in Vasai-Virar city (77%), Jhansi (66%), Kota (57%) and followed by other remaining cities. Overall, highest UER during 1971-2011 was observed in Vasai-Virar city (92%) followed by Solapur (87%), Nellore (86%), Meerut (85%), Surat (85%), Bhiwandi (84%), Ghaziabad (83%), and Visakhapatnam (82%). Highest decadal population growth rate, i.e., PR during 1971-1981 was exhibited by Siliguri (58%), Bhiwandi (53%), Ghaziabad (52%), Aurangabad (50%) and followed by other remaining cities. During 1981-1991, highest PR was observed in Vasai-Virar city (63%), Bhiwandi (55%), Aurangabad (48%) and followed by other remaining cities. Further during 1991-2001, highest PR was observed in Vasai-Virar city (58%), Noida (52%), Ghaziabad (47%), Surat (46%) and followed by other remaining cities. Lastly during 2001-2011, highest PR was observed in Vasai-Virar city (58%), Noida (52%), Ghaziabad (41%) and followed by other remaining cities. Overall, highest PR during 1971-2011 was observed in Vasai-Virar city (95%) followed by Ghaziabad (92%), Bhiwandi (89%), Surat (89%), Aurangabad (87%), Nashik (84%), and Siliguri (81%). The decadal UER and PR from 1971 to 2011 for the mid-sized cities from the states with lower GSDP (<75th percentile as per GSDP in current prices

Table 2: UER and PR values of mid-sized Indian cities from the state with higher GSDP

S. No.	Mid-sized cities from the states with higher GSDP (>75th percentile as per GSDP in current prices in 2019-2020; the base year 2011-2012)	Decadal Urban Expansion Rate (UER)					Decadal Population Growth Rate (PR)				
		1971 -81	1981 91	1991 -2001	2001 -11	1971-2011	1971 -81	1981 91	1991 -2001	2001 -11	1971-2011
1	Amravati	0%	56%	0%	0%	56%	25%	30%	23%	15%	66%
2	Aurangabad	0%	71%	0%	0%	71%	50%	48%	34%	26%	87%
3	Bhiwandi	57%	64%	0%	0%	84%	53%	55%	37%	16%	89%
4	Kolhapur	0%	0%	0%	0%	0%	24%	16%	18%	10%	53%
5	Malegaon	0%	0%	0%	0%	0%	22%	28%	16%	13%	59%
6	Nagpur	0%	0%	0%	0%	0%	29%	25%	21%	15%	64%
7	Nanded-Waghala	0%	72%	5%	21%	79%	34%	38%	28%	22%	77%
8	Nashik	23%	61%	0%	0%	69%	36%	45%	39%	28%	84%
9	Sangli	24%	2%	28%	0%	46%	25%	27%	19%	13%	62%
10	Solapur	8%	23%	81%	0%	87%	23%	17%	29%	8%	58%
11	Vasai-Virar city	3%	46%	32%	77%	92%	28%	63%	58%	58%	95%
12	Coimbatore	2%	0%	0%	0%	2%	20%	14%	12%	11%	46%
13	Erode	-1%	1%	0%	0%	0%	26%	11%	-6%	4%	33%
14	Madurai	2%	0%	9%	0%	12%	23%	13%	-1%	9%	38%
15	Salem	12%	-6%	12%	0%	19%	20%	10%	21%	16%	52%
16	Tiruchirappalli	5%	14%	24%	0%	38%	17%	15%	14%	11%	47%
17	Tirupur	73%	0%	-60%	0%	56%	31%	30%	32%	22%	75%
18	Agra	0%	49%	0%	0%	49%	15%	22%	30%	20%	63%
19	Allahabad	0%	0%	1%	10%	10%	20%	22%	19%	12%	56%
20	Aligarh	-1%	0%	16%	0%	15%	21%	33%	28%	23%	71%
21	Bareilly	11%	70%	0%	0%	74%	28%	28%	18%	21%	66%
22	Firozabad	46%	7%	58%	-39%	71%	35%	23%	38%	28%	78%
23	Ghaziabad	42%	6%	51%	34%	83%	52%	44%	47%	41%	92%
24	Gorakhpur	20%	64%	3%	0%	72%	26%	38%	19%	8%	66%
25	Jhansi	24%	5%	16%	66%	79%	30%	23%	25%	16%	66%
26	Kanpur	0%	0%	0%	0%	0%	22%	21%	27%	8%	58%
27	Lucknow	15%	62%	0%	11%	71%	18%	41%	26%	22%	73%
28	Meerut	54%	67%	0%	0%	85%	34%	40%	29%	18%	77%
29	Moradabad	0%	0%	59%	-18%	52%	21%	22%	31%	28%	69%
30	Noida			0%	2%	2%			52%	52%	77%
31	Saharanpur	0%	0%	2%	45%	46%	24%	21%	18%	35%	68%
32	Varanasi	9%	1%	6%	-14%	3%	18%	23%	14%	8%	50%
33	Bhavnagar	0%	0%	0%	-69%	-69%	27%	24%	21%	14%	62%
34	Jamnagar	12%	1%	0%	-4%	10%	29%	19%	26%	-5%	56%
35	Rajkot	13%	31%	4%	5%	46%	32%	31%	34%	25%	77%
36	Surat	47%	19%	49%	33%	85%	47%	39%	46%	38%	89%

Continued Table 2: UER and PR values of mid-sized Indian cities from the state with higher GSDP

S. No.	Mid-sized cities from the states with higher GSDP (>75th percentile as per GSDP in current prices in 2019-2020; the base year 2011-2012)	Decadal Urban Expansion Rate (UER)					Decadal Population Growth Rate (PR)				
		1971 -81	1981 91	1991 -2001	2001 -11	1971-2011	1971 -81	1981 91	1991 -2001	2001 -11	1971-2011
37	Vadodara	28%	0%	12%	26%	53%	36%	29%	23%	20%	72%
38	Belgaum	66%	6%	10%	0%	71%	30%	16%	18%	18%	61%
39	Gulbarga	51%	31%	25%	0%	74%	34%	28%	27%	21%	73%
40	Hubli-Dharwad	5%	0%	11%	0%	15%	28%	19%	18%	17%	60%
41	Mangalore	55%	34%	3%	3%	72%	30%	22%	14%	14%	60%
42	Mysore	39%	-4%	35%	0%	58%	24%	20%	22%	15%	60%
43	Asansol	28%	52%	20%	-2%	71%	22%	30%	4%	16%	56%
44	Durgapur	0%	0%	0%	0%	0%	34%	27%	14%	13%	64%
45	Siliguri	75%	0%	-47%	0%	63%	58%	37%	23%	8%	81%
46	Ajmer	82%	-9%	-8%	-2%	78%	30%	7%	18%	10%	51%
47	Bikaner	19%	55%	0%	-7%	61%	27%	31%	21%	18%	68%
48	Jaipur	-23%	4%	55%	0%	47%	37%	33%	35%	24%	79%
49	Jodhpur	0%	4%	-9%	68%	66%	37%	24%	22%	17%	69%
50	Kota	36%	0%	2%	57%	73%	41%	33%	24%	30%	79%
51	Guntur	0%	0%	34%	0%	34%	27%	22%	8%	21%	58%
52	Nellore	72%	0%	45%	10%	86%	44%	25%	22%	19%	73%
53	Vijayawada	5%	-18%	27%	-37%	-11%	35%	25%	25%	9%	67%
54	Visakhapatnam	2%	69%	5%	37%	82%	40%	42%	22%	22%	79%
55	Warangal	0%	1%	41%	-38%	19%	38%	25%	20%	9%	66%

in 2019-2020; base year 2011-2012) is presented in Table 3. It was observed that during 1971-1981, Faridabad exhibited highest decadal urban expansion growth rate, i.e., 86%, Thrissur (77%), Ludhiana (62%) and followed by other remaining cities. During 1981-1991, highest UER was observed in Patna (47%), Malappuram (42%), Thiruvananthapuram (42%) and followed by other remaining cities. Further during 1991-2001, highest UER was observed in Raipur (44%), Gurgaon (37%), Kozhikode (35%) and followed by other remaining cities. Lastly during 2001-2011, highest UER was observed in Gurgaon (72%), Jamshedpur (41%) and followed by other remaining cities. Overall, highest UER during 1971-2011 was observed in Gurgaon (91%) followed by Faridabad (87%), Guwahati (80%), Thrissur (79%), and Ludhiana (74%). Highest decadal population growth rate, i.e., PR during 1971-1981 was exhibited by Faridabad (63%), Thrissur (59%), Bokaro Steel City (58%), Bhubaneswar (52%) and followed by other remaining cities. During 1981-1991, highest PR was observed in Bhubaneswar (47%), Faridabad (46%), Malappuram (45%), Ludhiana (42%) and followed by other remaining cities. Further during 1991-2001, highest UER was observed in Faridabad (42%), Gurgaon (40%), Bhubaneswar (36%) Raipur (36%) and followed by other remaining cities. Lastly during 2001-2011, highest UER was observed in Gurgaon (73%), Raipur (30%) and followed by other remaining cities. Overall, the highest PR during 1971-2011 was observed in Gurgaon (93%) followed by Faridabad (91%), Bhubaneswar (87%), and Raipur (80%).

The mid-sized Indian cities from the higher GSDP states with PU values less than 1 are presented in Table 4. During 1971-1981, the city with the lowest PU value was Ajmer (0.36) followed by Tirupur

Table 3: UER and PR values of mid-sized Indian cities from the states with lower GSDP

S. No.	Mid-sized cities from the states with lower GSDP (<75th percentile as per GSDP in current prices in 2019-2020; the base year 2011-2012)	Decadal Urban Expansion Rate (UER)					Decadal Population Growth Rate (PR)				
		1971-81	1981-91	1991-2001	2001-11	1971-2011	1971-81	1981-91	1991-2001	2001-11	1971-2011
1	Gwalior		0%	-74%	4%	-67%	25%	22%	16%	22%	61%
2	Indore	48%	31%	-3%	-22%	55%	32%	25%	26%	23%	71%
3	Bhopal	57%	0%	5%	-4%	57%	43%	37%	27%	19%	79%
4	Ujjain	0%	20%	0%	0%	19%	26%	22%	16%	16%	60%
5	Jabalpur	0%	-13%	-15%	-1%	-32%	31%	13%	20%	10%	57%
6	Kozhikode	0%	0%	35%	-51%	2%	15%	6%	18%	-19%	23%
7	Kannur	0%	0%	0%	0%	0%	9%	7%	-2%	-12%	3%
8	Kochi	0%	13%	18%	-41%	0%	14%	12%	12%	-9%	27%
9	Kollam	10%	35%	11%	0%	48%	21%	32%	14%	-4%	52%
10	Malappuram	0%	42%	0%	0%	42%	20%	45%	16%	14%	68%
11	Thiruvananthapuram	7%	42%	5%	-20%	39%	16%	31%	11%	-14%	41%
12	Thrissur	77%	9%	2%	0%	79%	59%	13%	10%	0%	68%
13	Faridabad	86%	0%	10%	3%	87%	63%	46%	42%	25%	91%
14	Gurgaon	36%	19%	37%	72%	91%	43%	29%	40%	73%	93%
15	Patna	-26%	47%	1%	-1%	33%	42%	15%	33%	15%	72%
16	Cuttack	7%	37%	16%	0%	51%	30%	28%	24%	12%	66%
17	Bhubaneswar	30%	26%	7%	0%	52%	52%	47%	36%	23%	87%
18	Rourkela	8%	0%	-5%	-34%	-28%	42%	8%	-9%	1%	42%
19	Amritsar	59%	0%	15%	0%	66%	24%	16%	28%	13%	60%
20	Jalandhar	22%	1%	21%	-1%	39%	27%	20%	28%	18%	66%
21	Ludhiana	62%	18%	15%	0%	74%	34%	42%	25%	14%	75%
22	Durg-Bhilai Nagar	-12%	26%	21%	-6%	31%	44%	30%	20%	12%	73%
23	Raipur		10%	44%	26%	63%	39%	25%	36%	30%	80%
24	Guwahati			0%	1%	80%			28%	15%	79%
25	Dhanbad	2%	-4%	5%	0%	2%	33%	15%	22%	11%	61%
26	Jamshedpur	-6%	-1%	0%	41%	37%	22%	5%	20%	9%	46%
27	Ranchi	49%	0%	0%	-1%	49%	48%	18%	29%	21%	76%
28	Bokaro Steel City	0%	-3%	0%	0%	-3%	58%	33%	15%	5%	77%
29	Dehradun	0%	20%	26%	24%	54%	21%	25%	34%	25%	71%
30	Jammu	-17%			34%	52%	26%			9%	69%
31	Srinagar	52%			19%	65%	30%			21%	65%
32	Chandigarh	16%	12%	2%	23%	44%	45%	27%	29%	16%	76%
33	Puducherry	3%	0%	16%	-19%	3%	18%	20%	17%	0%	45%

(0.42), Belgaum (0.45), Mangalore (0.54), and other remaining cities. During 1981-1991, the lowest PU value was observed in Bareilly (0.40) followed by Agra (0.44), Nanded-Waghala (0.52), Amravati (0.53), Bikaner (0.56), Asansol (0.57) and other remaining cities. Further during 1991-2001, the city with the lowest PU value was Madurai (-0.11) followed by Asansol (0.20), Guntur (0.23), Solapur (0.35), Nellore

Table 4: PU values of mid-sized Indian cities from the state with higher GSDP

S. No.	Mid-sized cities from the states with higher GSDP (>75th percentile as per GSDP in current prices in 2019-2020; the base year 2011-2012)	PU (Decadal Population Growth Rate to Decadal Urban Expansion Rate)				
		1971 -81	1981 -91	1991 -2001	2001 -11	1971 -2011
1	Amravati		0.53			
2	Aurangabad		0.67			
3	Bhiwandi	0.92	0.85			
4	Nanded-Waghala		0.52			0.97
5	Nashik		0.73			
6	Sangli			0.67		
7	Solapur		0.74	0.35		0.67
8	Vasai-Virar				0.75	
9	Madurai			-0.11		
10	Tiruchirappalli			0.58		
11	Tirupur	0.42				
12	Agra		0.44			
13	Bareilly		0.40			0.89
14	Firozabad	0.76		0.65		
15	Ghaziabad			0.92		
16	Gorakhpur		0.59			0.92
17	Jhansi				0.24	0.84
18	Lucknow		0.66			
19	Meerut	0.63	0.59			0.91
20	Moradabad			0.52		
21	Saharanpur				0.77	
22	Surat			0.93		
23	Vadodara				0.77	
24	Belgaum	0.45				0.86
25	Gulbarga	0.66	0.90			0.99
26	Mangalore	0.54	0.64			0.83
27	Mysore	0.61		0.62		
28	Asansol	0.78	0.57	0.20		0.79
29	Siliguri	0.77				
30	Ajmer	0.36				0.65
31	Bikaner		0.56			
32	Jaipur			0.63		
33	Kota				0.52	
34	Guntur			0.23		
35	Nellore	0.61		0.48		0.85
36	Vijayawada			0.92		
37	Visakhapatnam		0.60		0.60	0.96
38	Warangal			0.48		

Table 5: PU values of mid-sized Indian cities from the states with lower GSDP

S.No.	Mid-sized cities from the states with lower GSDP (>75th percentile as per GSDP in current prices in 2019-2020; base year 2011-2012)	PU (Decadal Population Growth Rate to Decadal Urban Expansion Rate)				
		1971 -81	1981 -91	1991 -2001	2001 -11	1971 -2011
1	Indore	0.67	0.81			
2	Bhopal	0.75				
3	Kozhikode			0.51	0.37	
3	Kochi		0.92	0.67	0.22	
4	Kollam		0.91			
5	Thiruvananthapuram		0.74		0.70	
6	Thrissur	0.77				0.86
7	Faridabad	0.73				
8	Patna		0.32			
9	Amritsar	0.41				0.91
10	Ludhiana	0.55				
11	Durg-Bhilai Nagar			0.95		
12	Raipur			0.82		
13	Guwahati					0.99
14	Jamshedpur				0.22	
15	Ranchi	0.98				
16	Jammu				0.26	
17	Srinagar	0.58				
18	Chandigarh				0.70	
19	Puducherry				0	

(0.48), Warangal (0.48) and other remaining cities. Lastly, during 2001-2011, the city with the lowest PU value was Jhansi (0.24) followed by Kota (0.52), Visakhapatnam (0.60), and other remaining cities. Overall, the lowest PU value during 1971-2011 was observed in Ajmer (0.65) followed by Solapur (0.67), Asansol (0.79), Mangalore (0.83), Jhansi (0.84), Nellore (0.85), Belgaum (0.86), Bareilly (0.89) and other remaining cities.

The mid-sized Indian cities from the lower GSDP states with PU values of less than 1 are presented in Table 5. During 1971-1981, the city with the lowest PU value was Amritsar (0.41) followed by Ludhiana (0.55), Srinagar (0.58), and other remaining cities. During 1981-1991, the lowest PU value was observed in Patna (0.32) followed by Thiruvananthapuram (0.74), Indore (0.81), and other remaining cities. During 1991-2001, the lowest PU value was observed in Kozhikode (0.51) followed by Kochi (0.67) and other remaining cities. Lastly, during 2001-2011, the city with the lowest PU value was Kochi (0.22), Jamshedpur (0.22) followed by Jammu (0.26), Kozhikode (0.37), and other remaining cities. Overall, the lowest PU value during 1971-2011 was observed in Thrissur (0.86) followed by Amritsar (0.91), and Guwahati (0.99).

The findings highlight a nuanced pattern within mid-sized Indian cities from higher GSDP states, where cities such as Ajmer, Tirupur, Belgaum, and Mangalore consistently exhibit PU values below 1 across different decades. This suggests an ongoing trend towards urban sprawl in these economically more prosperous regions. Ajmer, with the lowest PU value of 0.36 during 1971-1981, exemplifies an early instance of urban sprawl. Similar pattern of urban growth in these cities has been found in previous

studies based on land cover change analysis (Lakra and Sharma, 2019; Elangovan and Krishnaraaju, 2023). Despite economic advancements, these cities face challenges in optimizing land use, potentially leading to future sprawl-like conditions. Similarly, mid-sized cities from lower GSDP states, including Amritsar, Patna, and Kozhikode, exhibit PU values less than 1, pointing to a similar trend of urban sprawl. Thrissur consistently maintains the lowest PU value (0.86) overall, emphasizing a prolonged pattern of inefficient land utilization in this region. The significance of these findings lies in the implications for urban planning and policy interventions. The identification of cities experiencing urban sprawl highlights the urgency of adopting measures to promote sustainable and efficient land use. Urban planners and policymakers can draw upon these findings to formulate strategies as per the specific challenges faced by cities in different economic contexts. Implementing land-use regulations, encouraging mixed-use development, and investing in infrastructure that supports compact urban growth can be crucial steps toward mitigating the adverse effects of urban sprawl. The significant driving factors that triggered urban growth in the selected Indian cities are government policies and schemes, industrial growth, GSDP, climatic conditions and terrains, social profile, transportation, infrastructure, and coordination between the central and state governments. After the liberalization of the Indian economy during the early 1990s, growth in economic opportunities started pouring into India and triggered urban growth in mid-sized Indian cities. This led to the creation of new cities such as Gurgaon, and Noida, and the expansion of existing cities towards the peripheral areas (Sanyal *et al.*, 2010). The reforms in industrial sectors were introduced to reduce trade barriers. Overall, the urban growth was prominently due to the huge growth momentum experienced by mid-sized Indian cities combined with unplanned urbanization. It led to urban expansion towards the periphery in the form of urban sprawl. Such an urban growth pattern is evident through the built-up growth in low-density rural areas. Growth in the GSDP of states due to several reforms and policies positively correlated with land conversion, i.e., an increase in an urban area (Pandey and Seto, 2015). It also shows that the combined service and manufacturing sector had a higher share in the GSDP of states which experienced higher urban growth due to agricultural land loss. The population in these cities increased due to natural growth and migration from nearby towns and cities to seek a better quality of life and improved living standards. Further, improved life expectancy rates, lower infant and maternal mortality rates during birth, and child mortality rates led to high population growth. Better transportation facilities and infrastructure up-gradation led to the growth in employment opportunities, thereby attracting migrants (Chandrasekhar and Sharma, 2015). Moreover, the political and administrative interventions directed through the master plan significantly affect the urban growth within the city (Rath *et al.*, 2022). All these factors cumulatively led to the expansion of mid-sized Indian cities. The introduction of policies and schemes by the Government of India post the liberalization of the Indian economy in 1991 has played a pivotal role in catalyzing rapid urban growth, as depicted in Fig. 3. The post-liberalization era witnessed a significant policy framework designed to stimulate industrial growth through various measures. These initiatives included promoting investment in research and development, embracing new technologies, fostering the development of the capital market, enhancing competitiveness, and encouraging entrepreneurship for the overall benefit of the public. The cornerstone

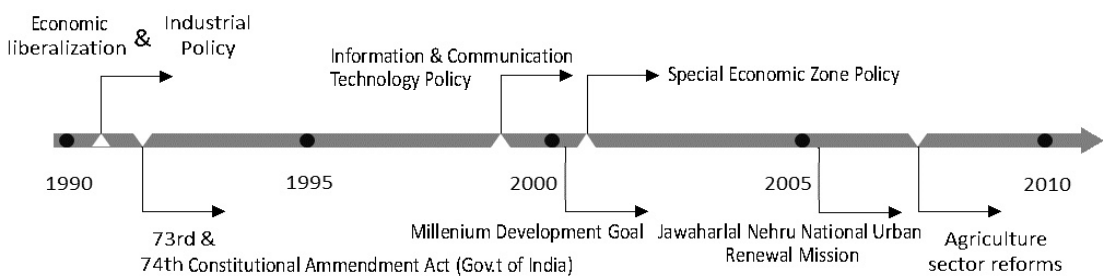

Fig. 3: Key policies undertaken post-liberalization of the Indian economy in 1991

of this transformative phase was the New Industrial Policy of 1991, which, along with other complementary policies, aimed at the liberalization of activities previously reserved for the public sector. These policy interventions have contributed to the dynamic urbanization observed in Indian cities, fostering economic development and shaping the urban landscape in the post-1991 period. The multifaceted approach of these policies has played a crucial role in promoting a vibrant and competitive urban environment, aligning with the broader goals of economic growth and development (Neisiani *et al.,* 2016).

Further, the 73rd and 74th Constitutional Amendment Act (CAA) by the Govt. of India was aimed to promote effective governance and improve the delivery of urban infrastructure and other basic services. However, a complete devolution of powers to the local government as per the CAA is yet to be completed in all the states. Significant steps were taken to promote Information and Communications Technology (ICT) with a strong focus on software development for export and the telecommunication sector. It was further enhanced by policy towards deregulation of Foreign Direct Investment (FDI). Under the automatic route, FDI up to 100 percent was allowed for most manufacturing activities in Special Economic Zones (SEZs). In India, most of the SEZs are located in peripheral areas under non-urban jurisdiction; hence no stringent rules are framed to check the ribbon and scatter growth occurring in these areas. Various social schemes and policies focusing on urban areas further raised the quality of living and fostered rapid population growth. Key social schemes initiated from 1991 to 2011 were the Twenty-point Programme, Affordable Housing for All, and the Jawaharlal Nehru National Urban Renewal Mission. Urban transport policy promoted safe, affordable, and efficient public transportation for increased mobility of urban populations and lower the impact of increasing vehicles on air quality. National Highway Development Project, Delhi-Mumbai Industrial Corridor, and Amritsar-Kolkata Industrial Corridor further led to the creation of small towns and villages and triggered urban expansion in the periphery of existing cities. Such cities expanded in the form of ribbon development along these routes and major junctions (Ministry of Environment and Forests and Government of India, 2011).

CONCLUSION

Mid-sized cities in India have been experiencing rapid urban growth due to the saturation of large cities. Such rapid development has triggered haphazard urban growth in these cities. However, there are lack of studies that attempts to comprehensively analyze the urban growth pattern in these cities for the preparation of strategies to mitigate such adverse conditions. Moreover, the 11th SDG of the 2030 Agenda for Sustainable Development emphasizes the promotion of sustainable cities and communities through urban planning strategies. Therefore, this study investigated the urban growth patterns across eighty-eight mid-sized Indian cities from 1971 to 2011, using census datasets. Overall, the results from states with higher GSDP revealed inefficient land utilization for urban growth, indicated by a PU (Population-to-Urban Expansion) ratio of less than 1 during 1971-2011 in thirteen (24%) out of fifty-five mid-sized Indian cities. Prominent mid-sized cities from states with higher GSDP that exhibited a PU less than 1 during 1971-2011 included Ajmer (0.65), Solapur (0.67), Asansol (0.79), Mangalore (0.83), Jhansi (0.84), Nellore (0.85), Belgaum (0.86), Bareilly (0.89), and the remaining five cities. In contrast, results extend to other countries facing similar economic disparities, emphasizing the importance of strategic planning to manage urbanization effectively. A global approach in future studies could involve comparative analyses with mid-sized cities in other countries to identify commonalities and unique regional drivers affecting land utilization efficiency. The major drivers for urban growth in mid-sized Indian cities include government policies and schemes, industrial growth, a rise in GSDP, climatic conditions and terrains, social profile, transportation, and infrastructure. This study has some limitations, such as the unavailability of data regarding the built-up area of all mid-sized Indian cities; hence, the decadal expansion of the municipal area obtained from the Census of India was used as a variable. Urban growth occurring outside the municipal boundary is not considered in this study, and there is no recent data available as the last census survey was conducted in 2011. The government has introduced various popular schemes and policies in India to channel urban growth in the right direction, including Smart City, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and Heritage City Development and Augmentation

Yojana (HRIDAY). These schemes might impact the pattern of urban growth; therefore, further monitoring of urban expansion in cities with a PU of less than 1 from 1971-2011 is necessary to investigate its effectiveness. Future research could also explore the applicability of the methodology in diverse international contexts, contributing to a broader understanding of urbanization challenges and sustainable development.

AUTHOR CONTRIBUTIONS

V. Chettry performed the literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition.

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CONFLICTS OF INTEREST

The authors declare that there is not any conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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PUBLISHER'S NOTE

ABBREVIATIONS

AER	Annual Expansion Rate
AGR	Annual Growth Rate
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
CAA	Constitutional Amendment Act
FDI	Foreign Direct Investment
GSDP	Gross State Domestic Product
HRIDAY	Heritage City Development and Augmentation Yojana
ICT	Information and Communications Technology
ISA	Impervious Surface Area
LCR	Land Consumption Rate
PR	Population Growth Rate
PU	Urban Growth Character
SDG	Sustainable Development Goal
SEZ	Special Economic Zones
AAUER	Average Annual Urban Expansion Rate
UER	Urban Expansion Rate
USA	United States of America
UT	Union Territory

REFERENCES

Akanbang, B.A.A.; Ibrahim A-S.; Yakubu Z., (2021). The evolving dynamics of land administration and its implications for physical planning in Sub-Saharan Africa: experiences from Wa, Ghana. SN Soc. Sci., 1: 259 **(10 pages).**

Akubia, J.E.K.; Bruns, A., (2019). Unravelling the frontiers of urban growth: spatio-temporal dynamics of land-use change and urban expansion in greater accra metropolitan area, Ghana. Land. 8: 1-23 **(23 pages).**

Amare, M.T.; Demissie, S.T.; Beza, S.A.; Erena, S.H., (2023). Land cover change detection and prediction in the Fafan catchment of Ethiopia. J. Geovisualization Spat. Anal., 7: 1–11 **(11 pages)**.

Bhat, P.A.; Shafiq, M.; Mir, A.A.; Ahmed, P., (2017). Urban sprawl and its impact on landuse/land cover dynamics of Dehradun city, India. Int. J. Sustain. Built Environ., 6: 513–521 **(9 pages)**.

Bhatta, B., (2009). Analysis of urban growth pattern using remote sensing and GIS: a case study of Kolkata, India. Int. J. Remote

Sens., 30: 4733–4746 **(14 pages)**.
Bhatta, B., (2010) Analysis of urban growth and sprawl from remote sensing data. Springer, Heidelberg **(172 pages)**.
Bhattacharya, G., (2019). Location decisions of industries in the presence of transportation costs and environmental regulations: empirical evidence from India. J. Soc. Econ. Dev., 21: 24–53 **(30 pages)**.
Census of India., (2011). Census of India 2011 META DATA
Chadchan, J.; Shankar, R., (2012). An analysis of urban growth trends in the post-economic reforms period in India. Int. J. Sustain. Built Environ., 1: 36-49 **(14 pages)**.
Chandrasekhar, S.; Sharma, A., (2015). Urbanization and spatial patterns of internal migration in India. Spat. Demogr., 3: 63–89 **(27 pages)**.
Chandrashekar, C.M.; Aithal, B.H., (2021). Impact assessment of corridor-oriented development: a case of urban agglomerations of India. Int. Rev. Spat. Plan. Sustain. Dev., 9: 172–194 **(23 pages).**
Chen, H.; Jia, B.; Lau, S.S.Y., (2008). Sustainable urban form for Chinese compact cities: challenges of a rapid urbanized economy. Habitat Int., 32: 28–40 **(13 pages)**.
Chen, J.; Chang, K. T.; Karacsonyi, D.; Zhang, X., (2014). Comparing urban land expansion and its driving factors in Shenzhen and Dongguan, China. Habitat Int., 43: 61–71 **(11 pages)**.
Chettry, V., (2023). Geospatial analysis of urban sprawl in Agartala municipal council, India, from 1991 to 2021. In: Filho WL, Ng TF, Iyer-Raniga U, *et al*. (eds) SDGs in the Asia and Pacific region, implementing the UN sustainable development goals – regional perspectives. Springer Nature Switzerland., **(25 pages).**
Chettry, V., (2023a). A critical review of urban sprawl studies. J. Geovisualization Spat. Anal., 7: 1-13 **(13 pages).**
Chettry, V., (2022). Peri-urban area delineation and urban sprawl quantification in Thiruvananthapuram urban agglomeration, India, from 2001 to 2021 using geoinformatics. Appl. Geomatics., 14, 639–652 **(14 pages).**
Das, N.; Soumendu, C.; Ansar, C., (2016). Spatial modeling of urban sprawl around Greater Bhubaneswar city, India. Model Earth Syst. Environ., 2: 1–21 **(21 pages)**.
Dempsey, N., (2010) Revisiting the compact city? Built Environ., 36: 5–8 **(4 pages).**
Dewa, D.D.; Buchori, I.; Rudiarto, I.; Sejati, A.W., (2023). Modifying the contact perimeter approach for measuring urban compactness gradients in the Joglosemar urban region, Indonesia. J. Geovisualization Spat. Anal., 7: 1–20 **(20 pages).**
Elangovan, K.; Krishnaraaju, G., (2023). Mapping and Prediction of Urban Growth using Remote Sensing, Geographic Information System, and Statistical Techniques for Tiruppur Region, Tamil Nadu, India. J. Indian Soc. Remote Sens., 51, 1657–1671 **(15 pages).**
Espindola, G.M.; Carneiro, E.L.N.C.; Façanha, A.C., (2017). Four decades of urban sprawl and population growth in Teresina, Brazil. Appl. Geogr., 79: 73–83 **(11 pages).**
Fazal, S., (2000). Urban expansion and loss of agricultural land - a GIS based study of Saharanpur city, India. Environ. Urban., 12: 133–149 **(17 pages).**
Floater, G.; Rode, P.; Friedel, B.; Robert, A., (2014). Steering urban growth: governance, policy and finance. LSE Cities., 1-49 **(49 pages).**
Garcia-López, M.À.; Muñiz, I., (2013). Urban spatial structure, agglomeration economies, and economic growth in Barcelona: an intra-metropolitan perspective. Pap. Reg. Sci., 92: 515–534 **(20 pages).**
Haregeweyn, N.; Fikadu, G.; Tsunekawa, A., (2012). The dynamics of urban expansion and its impacts on land use/land cover change and small-scale farmers living near the urban fringe: A case study of Bahir Dar, Ethiopia. Landsc. Urban Plan., 106: 149-157 **(9 pages).**
Hennig, E.I.; Schwick, C.; Soukup, T., (2015). Multi-scale analysis of urban sprawl in Europe: towards a European de-sprawling strategy. Land use policy., 49: 483-498 **(16 pages).**
Horn, A.; Eeden, A.V., (2018). Measuring sprawl in the Western Cape Province, South Africa: an urban sprawl index for comparative purposes. Reg. Sci. Policy Pract., 10: 15-23 **(9 pages).**
Hsu, K-C.; Lai, T-Y.; Li, C-N., (2016). Why is there an urban pattern toward sprawling development? Proc. Inst. Civ. Eng. Urban Des. Plan., 169: 200–208 **(9 pages).**
Jain, M.; Korzhenevych, A.; Pallagst, K., (2019). Assessing growth management strategy: a case study of the largest rural-urban region in India. Land use policy., 81: 1–12 **(12 pages).**
Jain, M.; Pallagst, K., (2015). Land Use beyond control: How fragmented governance created sprawl in the Delhi metropolitan area. disP – Plan. Rev., 51: 29–43 **(15 pages).**
Jain, R.K.; Jain K.; Ali, S.R.; (2017). Remote sensing enabled urban growth analysis for Gurgaon from 1995 To 2015. Adv. Comput. Sci. Technol., 10: 1745–1757 **(13 pages).**
Jiang, F.; Liu, S.; Yuan, H.; Zhang, Q., (2007). Measuring urban sprawl in Beijing with geo-spatial indices. J. Geogr. Sci., 17: 469–478 **(10 pages).**
Jiyuan, L.; Qian, Z.; Yunfeng, H.U., (2012). Regional differences of China's urban expansion from late 20th to early 21st century based on remote sensing information. Chinese Geogr. Sci., 22: 1–14 **(14 pages).**
Kantakumar, L.N.; Kumar, S.; Schneider, K., (2016). Spatiotemporal urban expansion in Pune metropolis, India using remote sensing. Habitat Int., 51: 11–22 **(12 pages).**
Kasanko, M.; Barredo, J.I.; Lavalle, C., (2006). Are European cities becoming dispersed? A comparative analysis of 15 European urban areas. Landsc. Urban Plan., 77:111–130 **(20 pages).**
Kuang, W.; Chi, W.; Lu, D.; Dou, Y., (2014). A comparative analysis of megacity expansions in China and the U.S.: patterns, rates and driving forces. Landsc. Urban Plan., 132:121–135 **(15 pages).**
Kukkonen, M.O.; Muhammad, M.J.; Käyhkö, N.; Luoto, M., (2017). Urban expansion in Zanzibar City, Tanzania: analyzing quantity, spatial patterns and effects of alternative planning approaches. Land use policy., 1–12 **(12 pages).**
Kumar, M.; Tripathi, D.K., (2014). Spatial monitoring of urban growth of Nagpur city (India) using geospatial techniques. J. Settlements Spat. Plan., 5: 91–98 **(8 pages).**
Lakra, K.; Sharma, D., (2019). Geospatial Assessment of Urban Growth Dynamics and Land Surface Temperature in Ajmer Region, India. J. Indian Soc. Remote Sens., 47:6, 1073–1089 (**17 pages**).
Ministry of Environment and Forests, Government of India., (2011). Sustainable development in India: stocktaking in the run up to Rio+20. New Delhi **(117 pages)**.
Neisiani, B.A.; Seyedan, S.M.; Radfar, E., (2016). Urban green spaces assessment approach to health, safety and environment. Int. J.

Hum. Capital Urban Manage., 1(2): 123-132 **(10 pages).**
Nielsen, E.S., (2017). Smart growth entrepreneurs: partners in urban sustainability. Springer International Publishing AG, Pennsylvania **(189 pages).**
Oladehinde, G.J.; Popoola, K.O.; Makinde, A.A., (2021). Urban expansion and rural landscape transformations in selected communities of Obafemi Owode local government area of Ogun State Nigeria. SN Soc. Sci., 1: 191 **(191 pages).**
Ozturk, D., (2017). Assessment of urban sprawl using Shannon's entropy and fractal analysis: a case study of Atakum, Ilkadim and Canik (Samsun, Turkey). J. Environ. Eng. Landsc. Manag., 25: 264–276 **(13 pages).**
Pandey, B.; Seto, K.C., (2015). Urbanization and agricultural land loss in India: comparing satellite estimates with census data. J. Environ. Manage., 148: 53–66 **(14 pages).**
Ramachandra, T.V.; Aithal, B.H., (2013). Urbanisation and sprawl in the Tier II city: Metrics, dynamics and modelling using spatio-temporal data. Int. J. Remote Sens. Appl., 3: 66–75 **(10 pages).**
Rath, S.S.; Mohanty, S.; Panda, J., (2022). Analyzing the fragmentation of urban footprints in eastern and southern Indian cities and driving factors. J. Indian Soc. Remote Sens., 50: 1499–1517 **(19 pages).**
Reserve Bank of India., (2023). State wise data GSDP
Sahana, M.; Hong, H.; Sajjad, H., (2018). Analyzing urban spatial patterns and trend of urban growth using urban sprawl matrix: a study on Kolkata urban agglomeration, India. Sci. Total Environ., 628–629: 1557–1566 **(10 pages).**
Salvati, L.; Carlucci, M., (2015). Patterns of sprawl: the socioeconomic and territorial profile of dispersed urban areas in Italy. Reg. Stud., 1–15 **(15 pages).**
Sanyal, S.; Nagrath, S.; Singla, G., (2010). Urbanisation & sustainability in India: an interdependent agenda. New Delhi
Schneider, A.; Woodcock, C.E., (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 Stud., 45: 659–692 **(34 pages).**
Sethi, P.K.; Sankalp, S.; Sahoo, S.N., (2021). Quantifying the dynamics of urban growth modes in Bengaluru, India. Proc. Inst. Civ Eng. Urban Des. Plan., 174: 1–14 **(14 pages).**
Shahfahad, M.M.; Kumari, B., (2020). Indices based assessment of built-up density and urban expansion of fast-growing Surat city using multi-temporal Landsat data sets. GeoJournal., 154: 173-185 **(13 pages).**
Subadyo, A.T.; Tutuko, P.; Jati, R.M.B., (2019). Implementation analysis of green city concept in Malang - Indonesia. Int. Rev. Spa.t Plan. Sustain. Dev., 7: 36–52 **(17 pages).**
Tian, L.; Li, Y.; Yan, Y.; Wang, B., (2017). Measuring urban sprawl and exploring the role planning plays: a Shanghai case study. Land use policy., 67: 426–435 **(10 pages).**
United Nations, (2018). World urbanization prospects: the 2018 revision (key facts).
United Nations, (2019). World urbanization prospects: the 2018 revision. New York
United Nations, (2015). World urbanization prospects: the 2014 revision. New York
United Nations, (2016). Transforming our world: the 2030 agenda for sustainable development.
Yue, W.; Zhang, L.; Liu, Y., (2016). Measuring sprawl in large Chinese cities along the Yangtze river via combined single and multidimensional metrics. Habitat Int., 57: 43–52 **(10 pages).**
Zhao, S.; Zhou, D.; Zhu, C., (2015). Rates and patterns of urban expansion in China's 32 major cities over the past three decades. Landsc. Ecol., 30: 1541–1559 **(19 pages).**

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