Chapter 12
Spatio-Temporal Changes in Metropolitan Cities of India: A Comparative Study of Delhi and Mumbai

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Abstract India witnessed a significant transformation in urban area from last few decades. Most of the million cities emerged rapidly in a very short period. Migration is one of the most important factors due to which most of the cities are transforming into one lakh cities and million cities. This study is based on the comparative analysis of urban transformation of Delhi (Administrative Capital) and Mumbai (Economic Capital) metropolitan cities of India. The study analyzes the changes among the major attributes of urban place (i.e., water, greenery and built-up). Traditional outfit of these cities has changed drastically over the years. Understanding the trends of urbanization in these cities is very important for planners and decision makers. Geospatial techniques are used to carry out spatial and temporal variation. In this study, spatial pattern of urban place with focus on built-up area has been studied with the help of land use/land cover maps extracted from the temporal satellite imageries. The Shannon's entropy is calculated in this process to find the actual change and pattern of change taken place in these cities where built-up is taken as spatial phenomena. An attempt is made to draw relationship between built-up and its other causing elements by using statistical techniques (Stepwise-Regression). Landscape metrics as quantitative measures are carried out in this paper to examine the spatial structures and patterns of landscape in these cities.

Keywords Urban transformation · Spatial and temporal analysis · Shannon's entropy · Stepwise regression

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12.1 Introduction

In present scenario, most of the metropolitan cities of developed and developing countries are changing rapidly. These cities are growing in every aspect of spatial phenomena such as area, population and density. These cities are experiencing changes in physical conditions also due to change in population over time. Urban areas are transforming every day due to the facilities it provides to its population. Population of small towns and cities are magnetized to the metropolitan cities like Delhi and Mumbai for better and efficient facilities. Unsatisfactory nature of human beings somehow changes the shape and texture of urban places. Urban places have always shown significant role in the transformation of society from ancient time to present. Landscape spatial patterns are connected with dynamic process (Wu et al. 2001; Nagendra and Pareeth 2006). Cities are growing in both aspect; population as well as area. Unmeasured flow of population toward these cities is also expanding its boundaries. Boundaries of these metropolitan cities are expanding in the fringe areas. This rapid growth of urban places in a developing country like India results positive growth in share of urban population from 109 million in 1971 (19.90%) to 388 million in 2011 (31.30%). Urban area contributes for less portion of the total land surface on earth, rapid changes in the urban areas significantly transformed natural set-up and created huge environmental and social impacts (Berling and Wu 2004; Grimm et al. 2000). It is very important to monitor and plan the expansion of urban place especially in this case where people from all parts are marking their presence in these fragile cities. A great amount of work has been done in the field that enables researcher to review a vast amount of literature. Sinha (2017) has carried out LU/LC change and change detection through post classification comparison in his study on urban sprawl in Gautama Budh Nagar District, Uttar Pradesh. Geospatial techniques such as GIS and Remote Sensing has been used to carry out these types of research. Bhagwat (2011) analyzed the change in land use and land cover by evaluating statistics of four different time classified data of Kathmandu Metropolitan with the help of Geospatial Techniques. He suggested that analysis based on land use statistics and transition metrics are very meaningful to analyze change taken place in any city. Yuan et al. (2005) has used multi-time (1986, 1991, 1998, 2002) Landsat TM satellite image to map and monitor land cover change for twin cities of Metropolitan Area of Minnesota. Urban area has increased between 1986 and 2002 by 9.1% (23.7–32.8%) which is common trend for the metropolitan cities like this. Rawat et al. (2014) have done a study on five towns of Uttarakhand i.e., Ramnagar, Nainital, Bhimtal, Almora and Haldwani and extracted land use land cover changes which took place in these towns over 20 years. Satellite data of 1990–2010 has been used to carry out the result of this study which shows conversion of agricultural and vegetation land into built-up area. Mehta et al. (2012) used geospatial techniques i.e., Remote Sensing and GIS to understand and analyze changes that occur in arid environment of Kutch region in Gujarat between 1999 and 2009. Amin et al. (2012) monitored a significant change in land use land cover of Srinagar city in Kashmir

Valley by studying land use land cover maps by processing satellite images of 1990–2007. Besides methodologies of change detection, statistical techniques are also used by integrating geospatial techniques to quantify, estimate, map and monitor the urban change and urban expansion. Two major types of methods are used in quantifying, assess, mapping and monitoring urban change is Shannon's Entropy. Shannon's entropy is basically a mathematical model to estimate the unorganized changes that occur at any geographical area. Shannon's Entropy (Hn) is used to calculate degree of spatial concentration of geographic phenomena (Xi) for any "n" spatial units. Entropy can also be apply to identify the degree of urban change or growth with respect to development in a city either compact or dispersed in nature. In most of the work related to geospatial technologies built-up area is generally taken as base variable to quantify urban change. The main objective of this study is to extract, understand, analyze and compare the changes that took place in both the cities (Mumbai and Delhi) from 2001 to 2011. These methods are also applied to find out the actual result of urban change taken in both the metropolitan cities.

12.2 Study Area

Delhi is the administrative capital of India and one of the most grown metropolitan city in India. Delhi is the second most populous city of world and the largest city in terms of total area. Delhi is also known by NCT (National Capital Territory). Delhi along with other satellite towns have got the status of National Capital Region. The geographical extent of Delhi is 28.61°N 77.23°E, and lies in Northern India. Delhi borders Haryana on the north, west and south whereas Uttar Pradesh in the east. Yamuna is the only one river which is flowing the through Delhi. Delhi and Uttar Pradesh are separated by Hindon River flowing through. Delhi is surrounded by The Delhi Range from three sides which originates from the Aravali range in the south. This Delhi ranges reaches a height of 318 m (1043 ft.) and is the prominent feature of this region.

Mumbai is India's most populous city and also the administrative capital of Maharashtra State. Mumbai is often known as Economical Capital of India. The city is located at western side of Maharashtra as well as India and lies between 18° 53′ and 19° 16′ N latitudes and between 72° 46′ and 72° 57′ E longitudes. The city has forest area in the northern part and also at the coast of Arabian sea. Thus, the changes in built-up area has been mainly in the south, south-east and eastern part of Mumbai. Mumbai is the largest city in the state whereas this is the only city in the state which has million plus population. The city is experiencing highest population growth rates. The city will also experience spatial expansion in the coming future due to the economic growth which will eventually attract population. The location of both the cities in India has been depicted in Fig. 12.1.
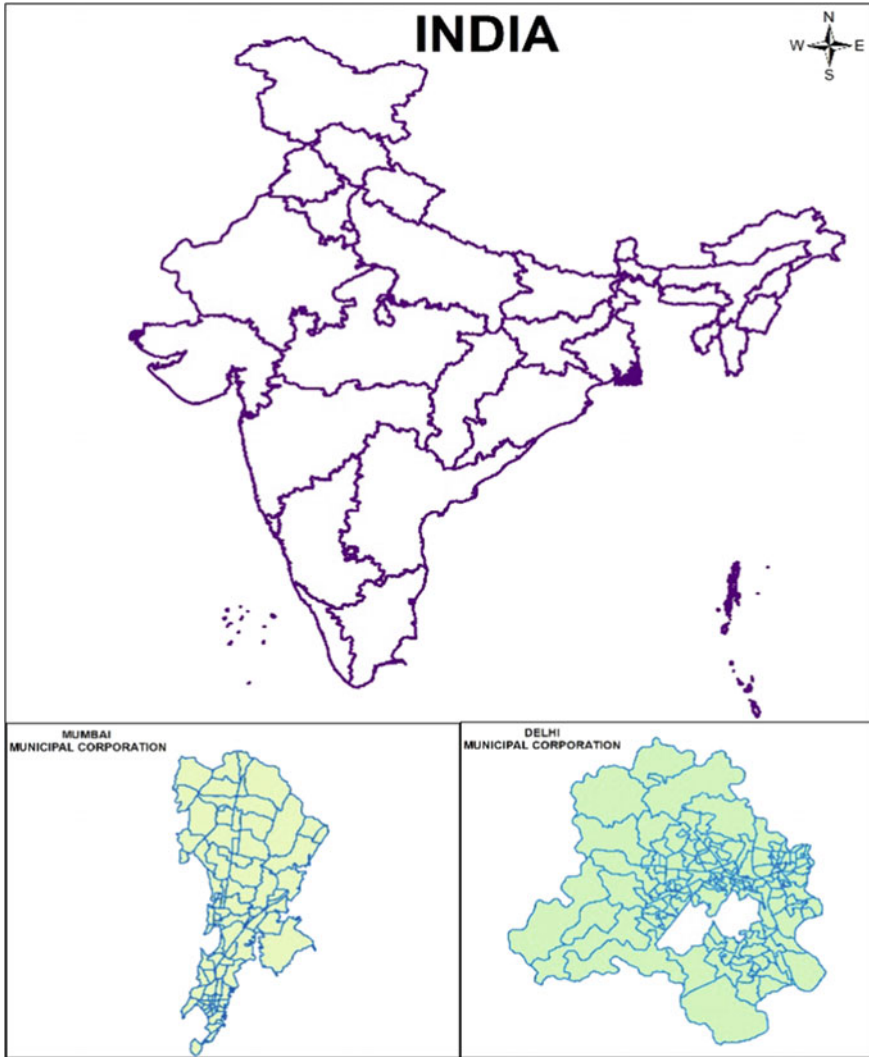
Fig. 12.1 Study area map

12.3   Materials and Methods

12.3.1   *Database*

This study is based on primary and secondary source of database. Demographic data have taken from Census of India (2011). Ward map of Delhi and Mumbai is also taken from Census of India. Urban transformation or changes in urban area is carried

Table 12.1 Radiometric characteristic (Landsat 4–5 TM)

Satellite	Spectral resolution (nm)	Band	Spatial resolution (m)
Landsat 4–5 TM	Band 1:0.45–0.52	Blue	30
	Band 2:0.52–0.60	Green	30
	Band 3: 0.63–0.69	Red	30
	Band 4: 0.76–0.90	Near IR	30
	Band 5: 1.55–1.75	Mid IR	30
	Band 6: 10.4–12.5	Thermal	
	Band 7: 2.08–2.35	Mid IR	30

out with the help of temporal satellite imagery (February 2001 and January 2011). Satellite images are downloaded from Earth Explorer (USGS) through Internet.

The Thematic Mapper (TM) is very advanced, multispectral scanning sensor designed to provide higher resolution, narrow and sharper spectral variation, enhanced geometric conformity and a high radiometric accuracy and resolution than earlier MSS Data (Table 12.1, Fig. 12.2).

Fig. 12.2 Schematic diagram of methodology
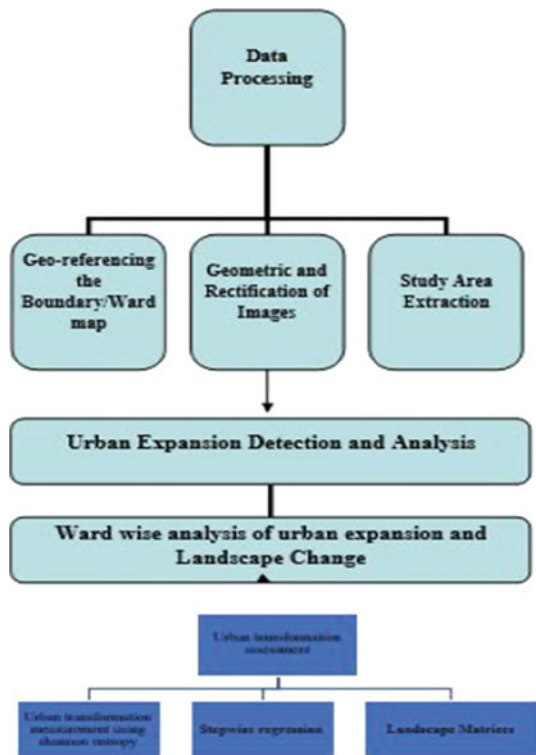
12.3.2 Image Classification

Geometric correction and Rectification is done for better interpretation and classification result, False Colour Composite (FCC) images were created for 2001 and 2011 of the study area. The geo-rectified image was enhanced to better identification of features on earth surface. Image interpretation technique is used for FCC image to extract different features in the study area by using unsupervised classification. Some of the misclassified area with respect to pixel is also corrected through recode in ERDAS Imagine 15. Four major land use/cover types are identified and used in this study, namely; built-up area, vegetation, water bodies, non-built-up area.

12.3.3 Change Detection

To performing overall change taken place with respect to LU/LC, To find out actual change and significant result post classification method used in this case. Exact pixel wise change has been observed through change matrix. Temporal satellite data has been used for overall loss and gain of each land use and land cover class between 2001 and 2011. This information from all the classes has been compiled to generate land use land cover maps. To analyze the actual changes in land cover over period few change detection techniques are used. Post classification method is often used to detect urban change detection of any area (Jensen 1996). Rectified imagery of each date is independently classified to match their respective classes based on the reflectance value. The resulting classes based on the grouping of all pixels are overlaid in its initial stage to compare land cover maps of the cities.

12.3.4 Ward Wise Analysis of Urban Transformation

For analysis and comparison of total land use changes took place in these metropolitan cities. Built-up area from each image has been extracted for further analysis. To carry out ward wise information about the urban land use changes, images of urban and built-up land of all the 88 wards in Mumbai Municipal Corporation and 134 wards in Delhi Municipal Corporation were extracted from the classified images. Digitization of outline boundaries of each ward was employed for extraction of built-up area and total area. These areas were later incorporated in ward wise entropy assessment in order to find out exact compactness and dispersion in both the cities.

12.3.5   Urban Transformation Analysis

12.3.5.1   Urban Transformation Measurement Using Shannon's Entropy

Urban area change is a complex phenomenon and causes environmental as well as social impacts. It can be caused by population growth, topography, proximity to major resources, services, and infrastructure. Many attempts have been made to measure urban sprawl by measuring Shannon's entropy within a GIS. Shannon's Entropy is used to measure the degree of spatial concentration and dispersion, as defined by geographical variables. In other words, Shannon's entropy is a measure to determine the compactness or dispersion of built-up land growth in the urban areas. To find out the compactness or dispersion of the urban development, an integrated analysis has been carried out. To measure the compactness or dispersion of urban built-up, Shannon's entropy method was adopted (Yeh 2001; Li and Yeh 2004; Lata et al. 2001; Sudhira et al. 2004). H_n can be used to measure the degree of spatial concentration or dispersion of geographical variable among n zones. The Shannon's entropy (H_n) is given by,

$$\mathbf{H_n} = -\Sigma \mathbf{Pi \, log \, (P_i)}$$

where $P_i = Xi/\Sigma Xi$, and *xi* is the density of land development, which equals the amount of built-up area divided by the total amount of land in the *i*th of n total zones $n = $ Total number of zones.

The value of entropy ranges from 0 to log n. If the distribution is very compact then the entropy value would be closer to 0 and when the distribution is much dispersed the value will be closer to log n. Large value of entropy indicates the occurrence of urban sprawl. This methodology was adopted to study the distribution of built-up in different wards, around the core, and along the National Highway. To analyze the sprawl of Mumbai city, the study area was divided into 88 and 134 zones based on the administrative wards of Delhi and Mumbai City. The ward boundaries were digitized from the scanned map of Mumbai Municipal Corporation. Two types of thematic layers are needed for calculation of densities of land development in each zone. The ward boundaries formed one layer and the built-up area formed the other layer. The overlay of boundaries layer on the built-up layer can clip the built-up area of individual wards and villages. The density of built-up area was calculated by dividing the built-up area of each ward from its total area. In general, the sprawl is affected by some location factors, such as distance to urban centres and roads.

12.3.6   Stepwise Regression

Step-by-step regression was used to trace the impact on the positive growth of dependent aspect like the built-up of the independent variable. The density of the population, the literacy of women, non-agricultural workers, the absolute population and the variable dependent are independent variables, and they account for the proportion between the areas of the buildings and the walls.

12.3.7   Landscape Matrices

Utilizing "landscape metrics as quantitative measures of spatial structures and patterns gives the ability to describe urban land use features, structures and patterns of a landscape" (Herold et al. 2002). Most of the landscape metrics correlate with each other. For this study the most widely applied methods such as landscape metrics extracted from the classified images was used. These are the following metrics which we focused to find these metrics.

12.4   Result and Discussion

To study the spatial–temporal changes in urban place over the past 10 years, Satellite Imageries are maps of 2001–2011 as mentioned in the above section (database) were procured and processed according to the detailed methodologies mentioned in the earlier section. In order to analyze the urban change pattern and to identify the causing factors behind these urban changes various approaches were adopted for built-up statistics for the city as a whole, ward wise, zone wise and distance wise.

12.4.1   Land Use/cover Status of Delhi and Mumbai

Figures 12.3 and 12.4 depicts spatial distributional pattern of land use/cover of Delhi ($541.12 \, \text{ml}^2$) and Mumbai ($152.63 \, \text{ml}^2$) for the year 2001 while 2011. Table 12.2 and 12.3 reveal that in 2001, about 45.76% ($247.67 \, \text{ml}^2$) area was under built-up area in Delhi, whereas about 60.51% ($92.37 \, \text{ml}^2$) area was under built-up in Mumbai. Likewise, 50.43% ($272.67 \, \text{ml}^2$) and 34.42% ($34.42 \, \text{ml}^2$) area was under vegetation, 2.76% ($14.98 \, \text{ml}^2$) and 0.65% ($1 \, \text{ml}^2$) under open space and 5.56% ($1.02 \, \text{ml}^2$) and 4.39% ($6.71 \, \text{ml}^2$) area was covered by water body in Delhi and Mumbai, respectively. In 2011, the contribution of urban area under Delhi increased by 22.37% ($23.62 \, \text{ml}^2$) but Mumbai experienced a slow change in urban area in comparison to 2001 i.e.,
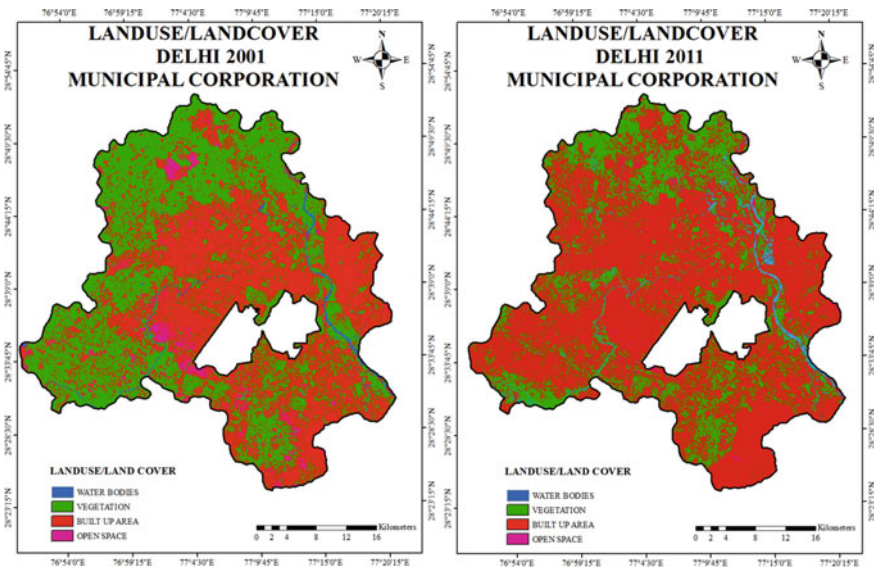
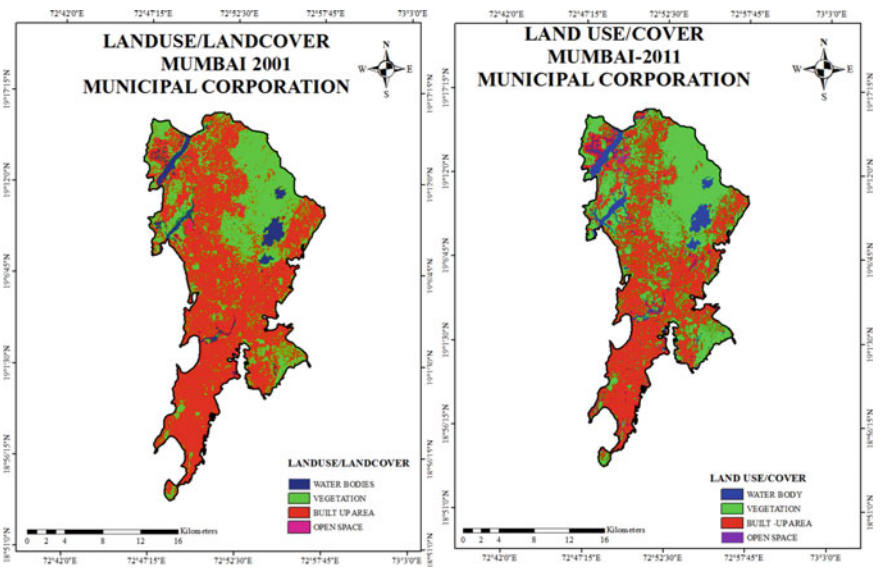**Fig. 12.3** Land use/cover of Delhi, 2001and 2011

Fig. 12.4 Land use/cover of Mumbai, 2001 and 2011

Table 12.2 Area and amount of change in different land use/cover categories in Delhi, 2001–2011

Land use/cover categories	2001		2011		Change 2001–2011	
	ml^2	%	ml^2	%	ml^2	%
Water body	5.56	1.02	10.16	1.870	−2.50	0.85
Vegetation	272.91	50.43	157.92	29.180	−22.39	−21.25
Built up	247.67	45.76	368.680	68.130	23.62	22.37
Open space	14.98	2.76	4.37	0.800	−0.52	−1.96

Table 12.3 Area and amount of change in different land use/cover categories in and Mumbai, 2001–2011

Land use/cover categories	2001		2011		Change 2001–2011	
	ml^2	%	ml^2	%	ml^2	%
Water body	6.71	4.40	6.97	4.56	−2.50	0.85
Vegetation	52.55	34.43	44.83	29.40	−22.39	−21.25
Built up	92.37	60.52	100.36	65.80	23.62	22.37
Open space	1.00	0.66	0.47	0.30	−0.52	−1.96

5.23% (7.99 ml^2). On the other hand, vegetation cover of Delhi depleted at very high rate in these 10 years and was left with only 29.18% (157.92 ml^2).

Mumbai underwent through the same scenario but the rate of change is bit slow at 29.4% (44.83 ml^2). The proportion of water body increased in both the metropolitan cities reached at 1.87% (10.16 ml^2) and 4.56% (6.97 ml^2) in Delhi and Mumbai respectively. Open space of both the metropolitan cities decreased in 2011 down with −1.96% and −0.35% in Delhi and Mumbai, respectively.

12.4.2   Land Use/cover Change

The data presented in Tables 12.2 and 12.3 depict that both positive and negative changes occurred in the land use/cover pattern in Delhi and Mumbai. During the last decades, the built-up area has increased from 247.67 ml^2 in 2001 to 368.68 ml^2 and 92.37 ml^2 in 2001 to 100.36 ml^2 in 2011 which accounts for 22.37% and 5.23% of the total sprawl area of Delhi and Mumbai. The vegetation cover has been decreased from 272.90 ml^2 in 2001 to 157.92 ml^2 in 2011 in Delhi and 52.55 ml^2 in 2001 to 44.83 ml^2 in 2011. This decrease in vegetation accounts for 21.25% and 5.05% in Delhi and Mumbai, respectively. Similarly, decrease in water bodies and open space land may also be seen from the table. The change in land use/cover under various categories have been clearly depicted (Figs. 12.5, 12.6, 12.7 and 12.8).
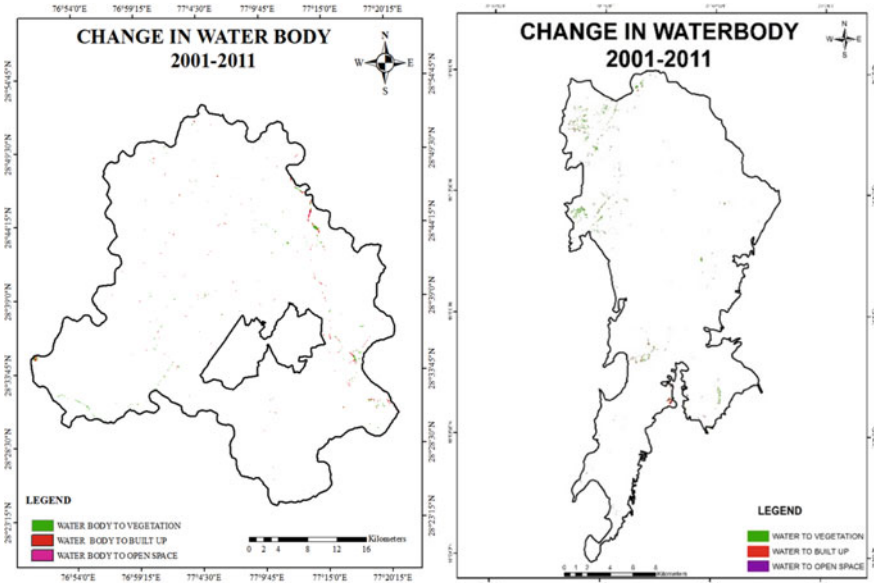
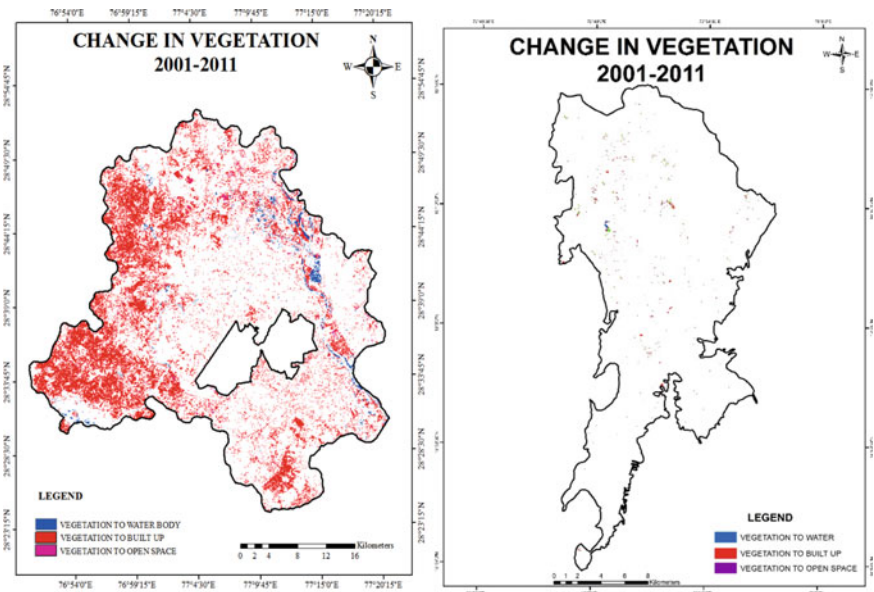**Fig. 12.5** Change in water body in Delhi and Mumbai (2001–2011)

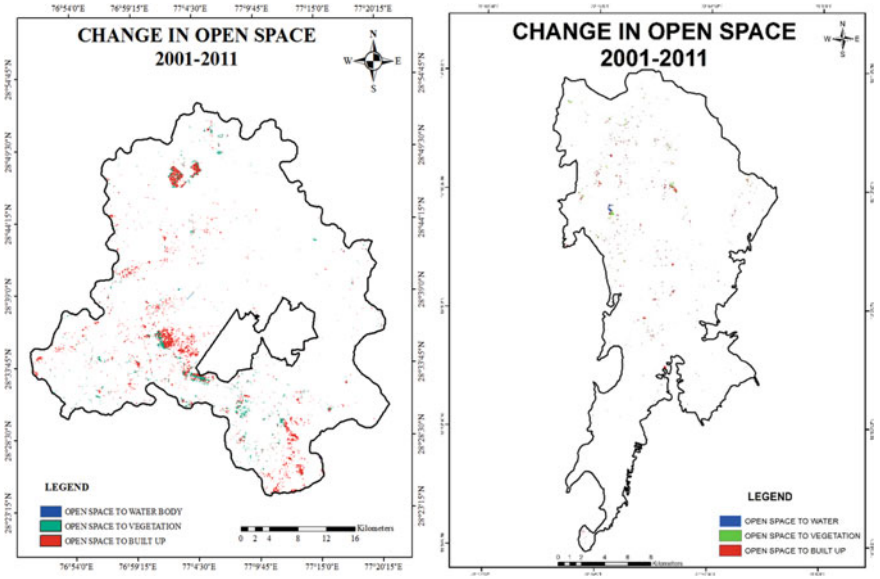**Fig. 12.6** Change in vegetation in Delhi and Mumbai (2001–2011)

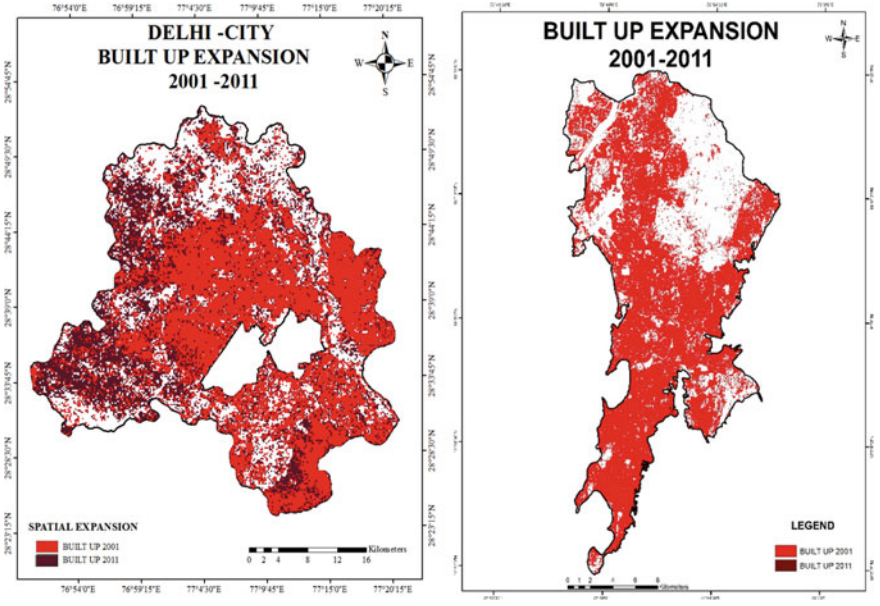**Fig. 12.7** Change in open space in Delhi and Mumbai (2001–2011)

Fig. 12.8 Expansion of built-up area in Delhi and Mumbai (2001–2011)

Table 12.4 Land use/cover change matrix showing land encroachment in Delhi, 2001–2011

Land use/cover categories Year 2011	Year 2001				
	Water body	Vegetation	Built up	Open space	Sum_2011
Water body	3.91	6.18	0.00	0.07	10.16
Vegetation	0.89	152.67	0.00	4.37	157.93
Built up	0.72	110.76	247.67	9.51	368.66
Open space	0.05	3.29	0.00	1.02	4.36
Sum_2001	5.56	272.91	247.67	14.97	

Table 12.5 Land use/cover change matrix showing land encroachment in Mumbai, 2001–2011

Land use/cover categories Year 2011	Year 2001				
	Water body	Vegetation	Built up	Open space	Sum_2011
Water body	5.69	1.23	0.00	0.04	6.96
Vegetation	0.70	43.89	0.00	0.23	44.82
Built up	0.30	7.09	92.37	0.58	100.35
Open space	0.01	0.32	0.00	0.15	0.47
Sum_2001	6.70	52.53	92.37	0.92	

To understand land encroachment for different land categories during the last one decade, a change detection matrix (Tables 12.4 and 12.5) was prepared which reveals that:

- About 110.76 and 7.09 ml^2 area of vegetation covered has been converted into built-up land, 3.293 and 0.32 ml^2 area under barren land and 6.181 and 1.23 ml^2 area under water body in Delhi and Mumbai respectively;
- About 4.37 and 0.22 ml^2 area of barren land has been converted into vegetative area, 9.51 and 0.58 ml^2 into built-up area and 0.070 and 0.044 ml^2 into water body in Delhi and Mumbai;
- About 0.887 and 0.7 ml^2 area of water body has been converted into vegetation cover and 0.048 and 0.007 ml^2 area under barren land whereas 0.717 and 0.304 ml^2 area has been encroached by built-up in Delhi and respectively.

12.4.3   Urban Sprawl Measurement: Shannon Entropy

For each ward, the entropy of the urban areas was calculated in 2001 and 2011. The entropy shows that the patterns of urban change/growth between the study area have changed substantially internally. Usually, urban growth/change in the entire region is quite evident. The municipal area Delhi and Mumbai grew nearby in all the wards, the growth threshold ($Log(n) = log(134) = 2.12$) and ($Log(n) = log(88) = 1.94$) were almost reached. Increased or closer to log (n) means that the development spread or
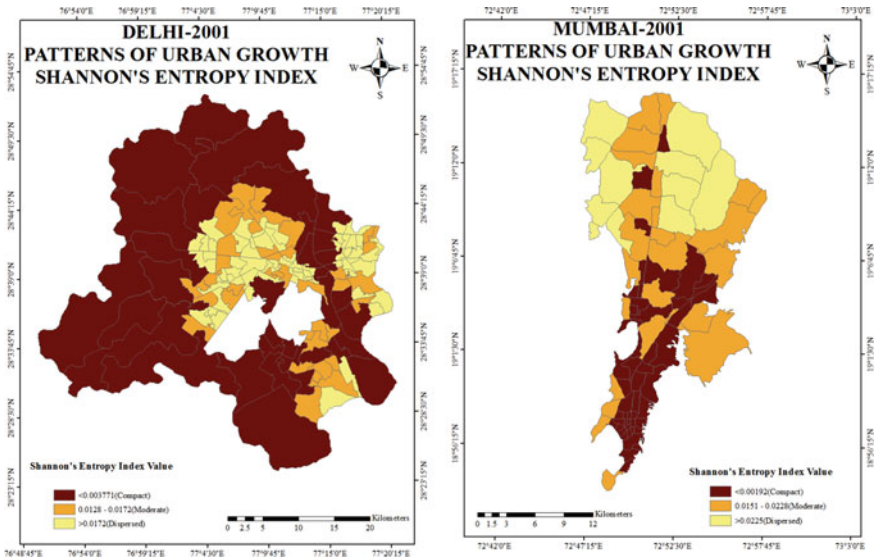
Fig. 12.9 Patterns of urban growth in Delhi and Mumbai, 2001 (Shannon's entropy index)

dispersed or sparse. The lower the entropy values, both aggregated and compact is the development. In 2011, the lower ward entropy values show aggregated or compact growth in the region as a whole. During the study period (2001–2011), the wards in Delhi, Mumbai grew phenomenally and the entropy value in 2011 has been higher (Figs. 12.9 and 12.10).

12.4.4 Correlates and Determinants of Urban Growth

There are a variety of factors that influence urban development. Due to a lack of data, it is difficult to include all of those factors in a quantitative analysis. As a result, this analysis includes the factors for which data was provided by the Census of India and satellite. Stepwise regression was used to estimate the contribution of these factors in urban growth because it tells us the contribution of an added or deleted variable in explaining the dependent variable by looking at changes in the R^2 value (Mahmood 1977). The determinants of urban growth were studied using ward level data from 2001.Other years did not have ward-level population data for the same municipalities as 2001. As previously stated, the built-up density or percentage of built-up area has been regarded as the most important indicator of urban growth, and thus it has been used as a dependent variable in the analysis, as shown in Tables 12.6 and 12.7. The determinants of urban growth are broken down into four categories, each of which explains 78.8% of the variation in urban growth. This proportion has been deemed very significant in regression analysis. The population density, which represents the
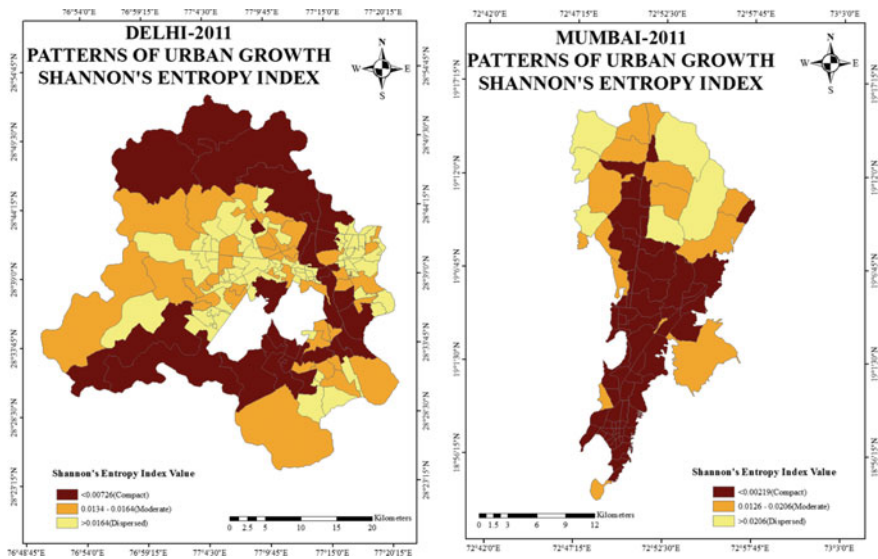
Fig. 12.10 Patterns of urban growth in Delhi and Mumbai, 2011(Shannon's entropy index)

Table 12.6 Model summary of stepwise regression-Delhi

Model	R	R Square	Increase in R Square	Adjusted R Square	Increase in adjusted R Square	Std. error of the estimate
1	0.813	0.748		0.755		1.083092082
2	0.902	0.823	0.075	0.819	0.74	0.902471038
3	0.913	0.831	0.007	0.825	0.006	0.887713476
4	0.911	0.834	0.004	0.827	0.002	0.882215120
5	0.916	0.838	0.004	0.829	0.002	0.877487146
6	0.913	0.841	0.003	0.830	0.001	0.873613483
7	0.913	0.851	0.000	0.828	−0.002	0.879048537

Table 12.7 Model summary of stepwise regression-Mumbai

Model	R	R Square	Increase in R Square	Adjusted R Square	Increase in adjusted R Square	Std. error of the estimate
1	0.871	0.758		0.755		1.093092082
2	0.913	0.833	0.075	0.829	0.74	0.912471038
3	0.917	0.841	0.007	0.835	0.006	0.897713476
4	0.919	0.844	0.004	0.837	0.002	0.892215120
5	0.921	0.848	0.004	0.839	0.002	0.887487146
6	0.923	0.851	0.003	0.840	0.001	0.883613483
7	0.923	0.851	0.000	0.838	−0.002	0.889048537

basic characteristic of city growth, i.e., a large population in a small area, explains the highest proportion. Female literacy rate is the second most important explanatory variable, indicating the educational importance of Delhi and Mumbai in city growth. The third variable is the percentage of female workers in the secondary and tertiary sectors, which is an indicator of the city's employment opportunities. For the rural and other migrants, these opportunities act as a "pull factor." Absolute population is the model's final indicator, and it represents the role of wards in city growth.

a.   Predictors: (Constant), No_HH
b.   Predictors: (Constant), No_HH, alpha
c.   Predictors: (Constant), No_HH, alpha, TOT_WORK_P
d.   Predictors: (Constant), No_HH, alpha, TOT_WORK_P, total pop
e.   Predictors: (Constant), No_HH, alpha, TOT_WORK_P, total pop, LIT_gap
f.   Predictors: (Constant), No_HH, alpha, TOT_WORK_P, total pop, LIT_gap, sex_ratio
g.   Predictors: (Constant), No_HH, alpha, TOT_WORK_P, total pop, LIT_gap, sex_ratio, bita

12.4.5   Spatial/Landscape Metrics

The process of urban growth in Delhi and Mumbai has also been measured with the help of spatial or landscape metrics. It could be seen that percentage of built-up area increased from 45.76 and 60.51% in 2001 to 68.13 and 65.8% in 2011 for Delhi and Mumbai respectively (Table 12.2). In absolute terms, built-up area increased from 247.67 and 92.37 ml^2 in 2001 to 368.68 and 100.36 ml^2 in 2011 i.e., it increased near to half of 2001 in Delhi whereas in Mumbai it increased in very less amount about 10 ^{years}. This indicates that there has been rapid growth in Delhi as far as horizontal urban growth of built-up, on the other hand in Mumbai urban growth in terms of built-up area is very less in comparison to Delhi. Core area of Delhi sharply increased from 247.67 to 368.68 ml^2 between 2001 and 2011.On the other hand, Mumbai experiences fraction of changes in core area (Tables 12.8 and 12.9).

The quick growth in the core region is attributable to both an increase in built-up area and a decrease in the number of patches. From 2000 to 2011, not only did

Table 12.8 Spatial /landscape change (ml^2) in Delhi

Metrics	2001	2011	Δ%2001–2011
CA	247.67	368.68	48.86
NP	82.79	50.44	− 39.074
LPI	0.32	0.12	108.034
ED	0.20	0.18	− 5.731
FRAC_AM	0.0051	0.005	3.71
ENN_MN	0.24	0.21	− 8.537
Contagion	0.20	0.22	9.247

Table 12.9 Spatial/landscape change (ml^2) in Mumbai

Metrics	2001	2011	Δ%2001–2011
CA	92.37	100.36	8.6472
NP	14.11	11.64	− 17.5006
LPI	0.10	0.11	11.3172
ED	0.15	33.3911	− 17.6390
FRAC_AM	0.0052	0.0051	− 1.4090
ENN_MN	0.57	0.23	− 59.5946
Contagion	0.20	0.22	7.0985

the largest patch area grow, but so did the percentage (LPI) of the largest patch area to total built-up area, which increased from 45.76% in 2000 to 68.130% in 2011, indicating that almost all of Delhi's built-up area in 2011 has become a single interconnected patch. While the overall built-up area in Mumbai expanded from 60.52% in 2000 to 65.80% in 2011, the majority of built-up patches remained in single patches. Similarly, in both cities, all other landscape features have changed dramatically over the decades. The rest of 165 built-up patches had an area of just 478 hectares contributing to less than 4% of built-up area in 2011. Thus, the area and edge metrics indicates that there has been rapid increase in built-up area as well as largest patch area between 2001 and 2011.

12.5 Conclusion

This study shows that the metropolitan cities such as Delhi and Mumbai somehow indicate the same trend of changes which occurred in last one decade. Remote sensing data means satellite imageries, temporal data is used to extract the amount of changes in both the metropolitan cities. Facilities offered by these cities automatically attract people from nearby small towns. These two metropolitan cities are approximately proving the concept of "Primate City" given by Mark Jafferson. The core area of the city has become more compact than earlier and surrounding region getting clusters. Somewhere sprawl has been expanded beyond city boundary limits. The most expansion happened along major roads as well as outer part of the city, the flow of migrations not only all India. In order to restrict consequences of urban change, there is need of proper management of new built-up. No doubt in upcoming years Delhi and Mumbai becomes one of very large city of World.

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