RESEARCH REVIEW JOURNALS
Volume-03
Issue-11
November -2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Application of Geospatial Techniques in the Study of Urban Growth/ Sprawl

*Sudhir Kumar Sinha

Associate Professor, Department of Geography, Shaheed Bhagat Singh (Eve.) College, University of Delhi, New Delhi (India)

ARTICLE DETAILS

Article History
Published Online: 10 November 2018

Keywords
Geospatial technique, Urban growth, Sprawl, and Sustainable urban development

***Corresponding Author**
Email: sk.sinha[at]sbse.du.ac.in

ABSTRACT

Urban growth is desirable for development. However, it is necessary to keep monitoring urban growth in any area to ensure that urban growth/sprawl does not become unsustainable. The study and monitoring of urban growth/sprawl is important to maintain good quality of life and inclusive development through proper policy intervention at the right time. Application of geospatial technique has been found to be appropriate to study and monitor urban growth/sprawl as it enables real time monitoring besides being cost and time saving technique. In this study, geospatial technique has been used to study and monitor urban growth in urban zone of Greater Noida Industrial Development Authority (GNIDA) in Uttar Pradesh. It has been found that rapid urbanization is taking place in the study area and the development needs to be closely watched and analyzed. The geospatial Technique was found to be quite useful in the study.

1. Introduction

Urbanization refers to an increase in the proportion of the total population living in the urban settlements, whereas an increase in the population of urban settlements is termed as urban growth. Commonly this increase in urban population is associated with increase in urban area as well, but it is not necessary. On the other hand, outward growth of city is basic to urban sprawl. Urban sprawl has been defined as "a particular type of sub-urban development characterized by very low–density settlements, both residential and non–residential; dominance of movement by use of private automobiles, unlimited outward expansion of new subdivisions and leap-frog development of these subdivisions; and segregation of land uses by activity" (HUD, 1999), and as "new urban development that occurs in a fragmented (discontinuous) and dispersed (non-compact) pattern across the landscape" (Carrion-Flores and Irwin, 2004). Ewing et al. (2002) defines Sprawl as "the process in which the spread of development across the landscape far outpaces population growth". While attempting universal definition on urban sprawl, Sinha (2018) has defined sprawl as "unsustainable form of out-growth of an urban settlement which betrays the principle of conservation of resources". Cities becomes congested due to overpopulation, and resources become limited in catering to the different needs of the people. Moreover, urban sprawl presents greater risk and damage to life and property in the occurrence of calamities and disasters. It endangers the living condition of inhabitants and puts ecosystems in jeopardy by compromising biodiversity (Yeh and Li, 2001). Thus, for sustainability of city and to prevent future disasters, it is important to monitor urban growth and sprawl.

Geospatial Technique gathers, stores, processes, and delivers geographic or spatially referenced information. It has been found that application of geospatial Technique is appropriate to study urban growth and sprawl as it has distinct advantages in terms of cost and time. Monitoring of sprawl could be done in real time essential for policy intervention. Geospatial Technique includes remote sensing, GIS and other related tools and softwares which helps in analysis and monitoring of urban growth and sprawl phenomena. The present study attempts to quantify the urban growth in GNIDA area by applying geospatial Technique- remote sensing, GIS and spatial metrics.

2. Review of Literature

A number of studies on urban growth/sprawl has been carried out by applying geospatial techniques especially in last ten years. Burns and Galaup have delimited the urban areas of Barcelona (Spain) from satellite images and highlighted the usefulness of remote sensing in quantifying and monitoring urban land uses. Feng (2009) has measured and monitored urban sprawl in Jianguing County (China) with the help of remote sensing and GIS. Carrion-Flores and Irwin (2004) have studied the urban sprawl pattern for Medina city in Ohio ((USA) with the help of spatial metrics. A number of studies on urban sprawl in Indian Cities have been carried out with the help of remote sensing and GIS (Tamilenthi and Baskaran, 2011; Ohri and Poonam, 2012; Gupta, 2012; and Sudhira, 2008). Some of the studies have tried to analyse sprawl with the help of Shannon's entropy (Shekhar, 2004; Bhailume, 2011; and Naik, 2013). Verzosa and Gonzalez (2010) have applied remote sensing, GIS and Shannon's entropy in measuring urban sprawl in the mountainous city of Baguio in Philippines. All these studies have shown the utility of measuring and monitoring urban growth and sprawl with the help of geospatial techniques, and need to study and constantly monitor urban growth and sprawl in individual cities.

3. The Study Area

The study area lies in the Gautam Buddha Nagar district of Uttar Pradesh. The urban development in the study area started with the creation of Greater Noida Industrial Development Authority (GNIDA) in 1991 under the UP Industrial Area Development Act, 1976. Urban GNIDA is part of National Capital region (NCR) and lies adjacent to Noida City with river Hindon making the boundary between the two zones. The notified area of GNIDA is about 38,000 ha comprising of 124 villages. However, in the present study, the urban areas of the GNIDA comprising of 20,820 ha has been demarcated to

RRIJM 2015, All Rights Reserved

study the urban growth in the area. Three Census Towns – Greater Noida, Chipiyana Buzurg, and Chapraula, lies within this urban zone. The population of largest city in GNIDA - Greater Noida was 1,02,054 persons in 2011 and it is a designated million city in NCR regional Plan-2021.

4. Database and Methodology

The study is based upon secondary sources of data. The major sources of information included Landsat Satellite imageries obtained from global land cover facilities (GLCF), an Earth Science Data Interface, toposheets form Survey of India, population data from Census of India, National Capital Region Planning Board, and Greater Noida Industrial Development Authority. Landuse/cover map of the study area for four time periods (1977, 1991, 2001 and 2011) was prepared from satellite imageries. ArcMap software and spatial analyst tools were used for demarcation of boundary and ERDAS Imagine (2013 version) was used for landuse/cover classification. For computation of spatial metrics, FRAGSTATS Software was used (Sinha, 2017).

5. Urban Growth in GNIDA Area

Urban growth in GNIDA area has been measured and monitored in terms of landuse/cover change, spatial pattern of built-up area, and spatial metrics.

Land use/cover Change: Between 1977 and 2011 the area under agriculture decreased by 10,643 hectares i.e. from 16221.60 hectares to 5579.13 hectares (Table 1). The maximum decrease in the area took place between 1991 and 2001 i.e. at the rate of 425.55 hectares per annum. Almost all the area under agriculture lost got changed into built-up (Table 2). The built-up area increased by 11,649 hectares i.e. from 3131.o6 hectares in 1977 to 14780.98 hectares in 2011 at the rate of 343 hectares per annum. Barren land decreased from 978 hectares in 1977 to 351 hectares into 2011. Almost all lost area under barren land got converted into built-up. Between 1977 and 2011, 380 hectares of area under water body was lost and almost all of it got converted into agriculture class.

Table 1: Land Use/Cover-Urban GNIDA

	In Hectares				In percentage			
Classes	**1977**	**1991**	**2001**	**2011**	**1977**	**1991**	**2001**	**2011**
Agriculture	16,221.60	12,745.13	8,489.65	5,579.13	77.91	61.21	40.77	26.80
Built Up	3,131.06	7,068.54	11,447.08	14,780.98	15.04	33.95	54.98	70.99
Barren Land	978.27	670.14	812.12	350.91	4.70	3.22	3.90	1.69
Water	489.94	337.06	72.03	109.85	2.35	1.62	0.35	0.53
Total	20,820.87	20,820.87	20,820.87	20,820.87	100	100	100	100

Table 2: Land Use/Cover Change-Urban GNIDA (per annum)

Year	**1977-1991**		**1991-2001**		**2001-2011**		**1977-2011**	
Classes	**Hectare**	**Percent**	**Hectare**	**Percent**	**Hectare**	**Percent**	**Hectare**	**Percent**
Agriculture	-248.32	-1.53	-425.55	-3.34	-291.05	-3.43	-313.01	-1.93
Built Up	281.25	8.98	437.85	6.19	333.39	2.91	342.64	10.94
Barren Land	-22.01	-2.25	14.20	2.12	-46.12	-5.68	-18.45	-1.89
Water	-10.92	-2.23	-26.50	-7.86	3.78	5.25	-11.18	-2.28

Thus, it can be seen that there have been major changes in the land use/cover in urban GNIDA area with built-up area increasing rapidly specially since 1991 when GNIDA was created. The annual increase in built-up area was 438 hectares between 1991 and 2001, and 334 hectares between 2001 and 2011.

The contribution of Chipyana Buzurg and Chhapraula in 2011 was meager 288 hectares and 313 hectares to the total built-up area of the urban GNIDA area (Table 3 and 5). These two settlements were rural till 2001 and categorized as a census town in 2011 as they met the criteria of census town. The population of these two settlements in 2011 was also low, i.e. 17400 persons in Chipyana Buzurg and 15,154 persons in Chhapraula. These two settlements are located near NH-81 at northern boundary between Gautam Buddha Nagar and Ghaziabad districts.

Table 3: Land Use/Cover-Chipyana Buzurg

	In Hectares				In percentage			
Classes	**1977**	**1991**	**2001**	**2011**	**1977**	**1991**	**2001**	**2011**
Agriculture	243.40	55.35	42.03	28.17	76.55	17.41	13.22	8.86
Built Up	33.32	211.59	273.15	288.45	10.48	66.54	85.90	90.72
Barren Land	18.41	0.90	0.81	0.00	5.79	0.28	0.25	0.00
Water	22.85	50.13	1.98	1.35	7.19	15.77	0.62	0.42
Total	317.97	317.97	317.97	317.97	100	100	100	100

RRIJM 2015, All Rights Reserved

Table 4: Land Use/Cover Change-ChipyanaBuzurg (per annum)

Year	1977-1991		1991-2001		2001-2011		1977-2011	
Classes	Hectare	Percent	Hectare	Percent	Hectare	Percent	Hectare	Percent
Agriculture	-13.43	-5.52	-1.33	-2.41	-1.39	-3.30	-6.33	-2.60
Built Up	12.73	38.22	6.16	2.91	1.53	0.56	7.50	22.52
Barren Land	-1.25	-6.79	-0.01	-1.00	-0.08	-10.00	-0.54	-2.94
Water	1.95	8.53	-4.82	-9.61	-0.06	-3.18	-0.63	-2.77

Table 5: Land Use/Cover-Chhapraula

	In Hectares				In percentage			
Classes	1977	1991	2001	2011	1977	1991	2001	2011
Agriculture	381.82	312.82	188.28	160.65	80.20	65.71	39.55	33.74
Built Up	42.91	143.49	280.89	313.83	9.01	30.14	59.00	65.92
Barren Land	3.44	0.89	0.63	0.36	0.72	0.19	0.13	0.08
Water	47.92	18.89	6.30	1.26	10.07	3.97	1.32	0.26
Total	476.10	476.10	476.10	476.10	100	100	100	100

Table 6: Land Use/Cover Change-Chhapraula (per annum)

Year	1977-1991		1991-2001		2001-2011		1977-2011	
Classes	Hectare	Percent	Hectare	Percent	Hectare	Percent	Hectare	Percent
Agriculture	-4.93	-1.29	-12.45	-3.98	-2.76	-1.47	-6.51	-1.70
Built Up	7.18	16.74	13.74	9.58	3.29	1.17	7.97	18.57
Barren Land	-0.18	-5.29	-0.03	-2.93	-0.03	-4.29	-0.09	-2.63
Water	-2.07	-4.33	-1.26	-6.67	-0.50	-8.00	-1.37	-2.86

Spatial Pattern of Built-up Area: In 1977 this urban zone of GNIDA was totally rural. Fig 1 shows that small patches of built-up area (rural settlements) are spread throughout the zone. In 1991 (Fig 2) densification of built-up patches appears in southern and northern part of the zone. This marks the beginning of setting in of urbanization process in the zone; leapfrog development is prominent. Fig 3 reveals further densification of the zone with a more contiguous development from north to south with patches of dense built-up area also appearing in the central part of the zone. By 2011 (Fig 4) the urban zone of GNIDA has evolved into a contiguous urban landscape. The built-up area of urban GNIDA has almost coalesced with Noida in the west and also in the east built-up area of Dadri has almost extended till Greater Noida (Sinha, 2017). The patches of built-up area have become quite dense indicating new urban growth as well as infill. With this the prominent leapfrog development pattern of 1991 and 2001 is giving way to more contiguous pattern of urban development. The built-up area of Chhaparaula and Chipyana Buzurg has developed along NH-91 indicating ribbon development.

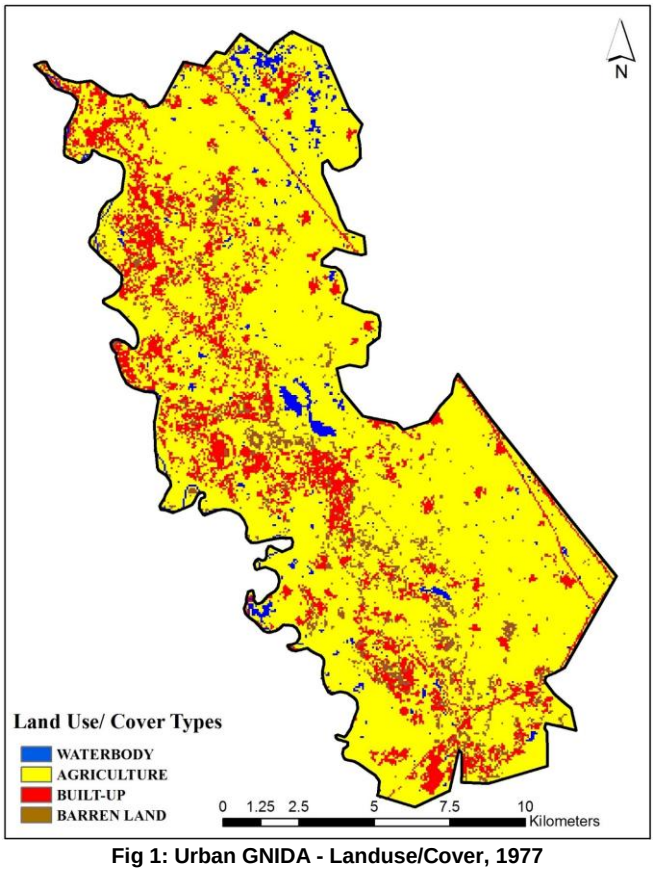

Fig 1: Urban GNIDA - Landuse/Cover, 1977

RRIJM 2015, All Rights Reserved

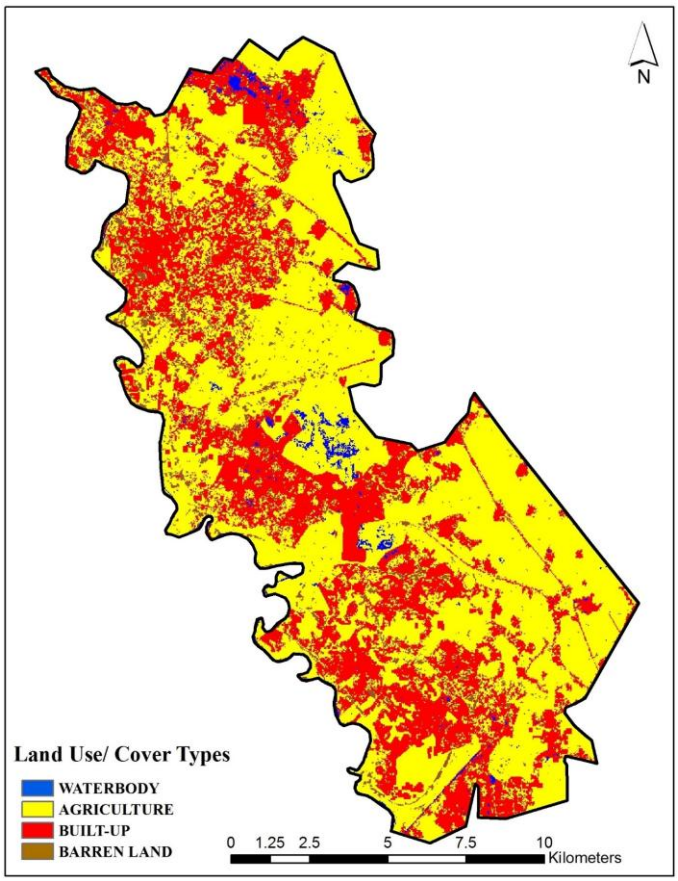

Fig 2: Urban GNIDA - Landuse/Cover, 1991

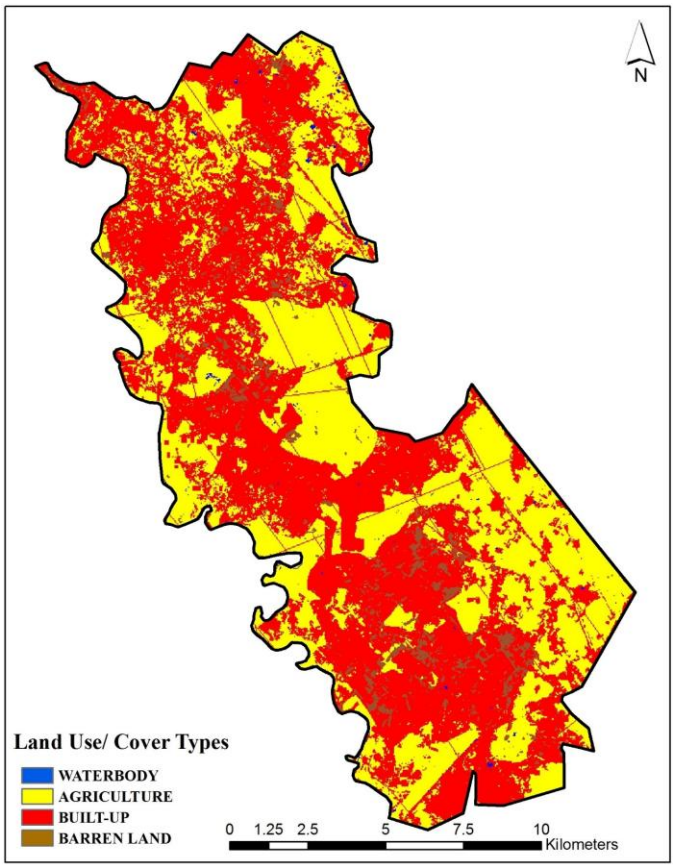

Fig 3: Urban GNIDA - Landuse/Cover, 2001

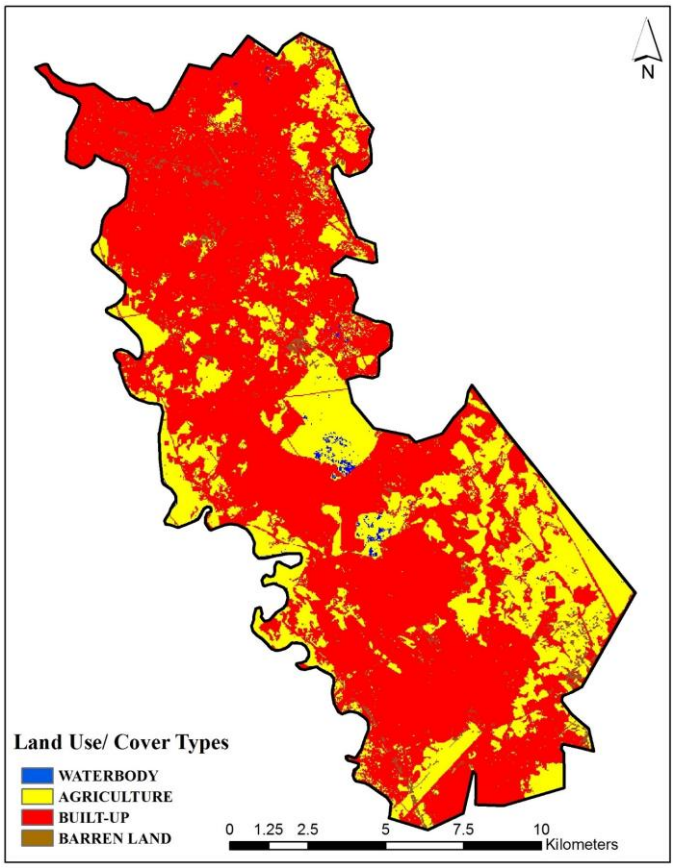

Fig 4: Urban GNIDA - Landuse/Cover, 2011

Spatial Metrics:

Spatial metrics (Table 7) has been calculated for the entire urban zone of GNIDA (which includes three census towns) to have a comprehensive and holistic view of the process of urbanization in the region. As stated earlier built-up area has increased rapidly since 1991. Consequently, from just 15.04 per cent of built-up area in 1977 it reached to 70.60 per cent in 2011. As a result of increase in built-up area together with decreasing number of patches, mean patch area has risen sharply i.e. from 5.05 hectares in 1977 to 101.38 hectares in 2011. Median of patch area decreased to 0.18 hectares in 1991 from 0.97 hectares in 1977 due to increase in number of patches of smaller size indicative of sprawl tendency. An increase in range of patch area over time suggests evolution of the largest patch. In 1977 LPI was only 9.32 per cent which increased to 97.48 per cent in 2011. Largest patch area in 2011 was 14,409 hectares with area of other 144 patches together being only 372 hectares. This indicates the evolution of urban zone of GNIDA into a contiguous settlement. The total core area in 1977 was just 7.28 per cent (228 hectares) of the total built-up area. Such a low percentage of core area clearly indicated the area has large number of small patches; a typical characteristic of a rural landscape. As the process of urbanization set-in in the region the core area started increasing rapidly. It increased to 7969 hectares in 2011 which was 54.20 per cent of total built-up area indicating the evolution of larger patches of urban settlement.

RRIJM 2015, All Rights Reserved

Table 7: Spatial Metrics- Urban GNIDA

Sl. No.	Metrics	1977	1991	2001	2011
1	Total Area (In Ha)	20820	20820	20820	20820
2	Built Up Area- in Ha (BUA)	3131	7068	11447	14781
3	BUA- % of landscape	15.04	33.76	54.68	70.60
4	No. of Patches	619	852	422	145
5	Patch Density	1.24	1.71	0.84	0.29
6	Patch Area Mean	5.05	8.25	26.98	101.38
7	Patch Area Median	0.97	0.18	0.18	0.27
8	Patch Area Range	292	1371	11046	14374
9	Largest Patch Area	289	1371	11073	14409
10	Largest Patch Index (LPI)	9.32	19.48	96.73	97.48
11	PAFRAC	1.58	1.49	1.46	1.51
12	Total Core Area (In Ha)	228	786	3084	7969
13	Core Area as % of BUA	7.28	11.81	27.09	54.20
14	Aggregation Index (AI)	57.30	81.25	87.93	94.34
15	Landscape Shape Index (LSI)	42.34	53.19	43.75	23.78
16	SHDI	0.71	0.84	0.84	0.69
17	SIDI	0.36	0.50	0.52	0.42

The value of perimeter area fractal dimension (PAFRAC) has not changed significantly between 1977 and 2011. It was 1.58 per cent in 1977 and 1.51 in 2011 indicating that there has not been much change in the shape of built-up area which is neither simple nor convoluted.

The number of patches of the built-up area decreased from 619 in 1977 to 145 in 2011. Similarly patch density decreased from 1.24 in 1977 to 0.29 in 2011. This indicates that the region had higher degree of fragmentation in 1977 compared to 2011. During the same period the value of aggregation index (AI) increased from 57.30 to 94.34 and value of landscape shape index (LSI) decreased from 42.34 to 23.78. A decrease in number of patches and LSI and increase in the value of AI indicates that the built-up area in the region is getting aggregated overtime.

The value of two diversity metrics (SHDI and SIDI) increased between 1977 and 2001 and decreased between 2001 and 2011. Thus, the diversity metrics suggest that the region was diversifying between 1977 and 2001 and diversity is getting reduced since 2001.

From the above description, it can be concluded that land use/cover in Urban GNIDA is changing rapidly. The percentage of built-up area is increasing mainly at the cost of agricultural land. Land use/cover data, spatial pattern of built-up area, and spatial metrics between 1977 and 2011 suggests that the urban zone of GNIDA was diversifying between 1977 and 2001 and after which it is evolving into a contiguous urban zone. The population of largest city of zone Greater Noida has not increased rapidly as it is slightly away from Delhi in comparison to Noida. Lack of good public transport is another major reason for slow rate of growth of urban population here. However, a very large number of flats in northern part of this city (popularly known as Noida Extension) have been built by private builders under group housing. There is a huge pile of unsold inventory (of flats) in this region. Construction of thousands of flat has resulted into increase in built-up area but commensurate increase in population has not taken place as the occupancy rate of these newly constructed flat is dismally low.

Low occupancy is the result of interplay of number of factors such as litigation between farmers and Greater Noida Authority over the issue of acquisition and compensation of land, lack of end users of flats constructed, safety concerns and lack of intra as well as inter-city public transport network. However, it is expected that within few years occupancy rate would substantially increase which would lead to rapid increase in the population of Greater Noida. It is expected that within a decade Greater Noida would emerge as a million city.

6. Conclusion

The study reveals that rapid urban development is taking place in the study area since 1991 indicated by increase in built-up area. Urbanization is desirable but loss of precious agricultural land is an area of concern. There was no urban settlement in the study area till 2011. Census of India for the first time in 2011 classified the three settlements of the study area as urban. The study indicates that although built-up area has increased rapidly, there has not been commensurate increase in urban population. Also, due to near absence of credible public transport system, the urban growth till now in the study area is dominated by private transport. A good inter and intra public transport system is a must for sustainable urban development presently lacking. Thus, for sustainable urban development, the planning must closely monitor the growth/sprawl regularly in the study area and follow principle of conservation of resources for the optimal utilization of resources. The study reveals that geospatial Technique is quite useful in the study and monitoring of urban growth/sprawl.

RRIJM 2015, All Rights Reserved

References

1. Bhailume, S.A. (2011). An assessment of urban sprawl using GIS and remote sensing techniques: A case study of Pune-Pimpri-Chinchwad area [unpublished Ph.D. thesis], Tilak Maharashtra Vidyapeeth, Pune.
2. Burns, M. C. and M. Galaup. The use of satellite images in the delimitation of urban areas. http://www-cpsv.upc.es/informacions/5aSetmanaGeomatica/5aSetmana GeomaticaImatge satellit.pdf.
3. Carrion-Flores, C. and Irwin, E. G. (2004). "Determinants of Residential Land Use Conversion and Sprawl at the Rural-Urban Fringe." American Journal of Agricultural Economics, 86(4): 889-904.
4. Ewing, R. et al. (2002). Measuring Sprawl and Its Impact. Smart Growth America, Washington, DC.
5. Feng, L. (2009). Applying remote sensing and GIS on monitoring and measuring urban sprawl. A case study of China, Numero 4, revista internacionals ostenibilidad, technology Humanismo.
6. Gupta, R. (2012). Monitoring urban land use land cover through Remote Sensing andGIS: A case study, Transactions Institute of Indian Geographers, vol.34, no. 1.
7. HUD (1999). The State of the Cities. US Department of Housing and Urban Development, Washington, DC.EPA (Environmental Protection Agency) (2000). Projecting Land Use Change: A Summary of Models for Assessing the Effects of Community Growth and Change on Land Use Pattern.URL: http://www.epa.gov/cbep/tools/reportfinal3.pdf.
8. Naik, M. (2013). Urban Sprawl of Bhubaneshwar city using GIS applications and entropy (Unpublished thesis).
9. Ohri, A. and Poonam (2012). Urban sprawl mapping and land use change detection using Remote Sensing and GIS. International Journal of Remote Sensing and GIS, Volume 1, Issue 1, 12-25.
10. Shekhar, S. (2004). Urban Sprawl Assessment Entropy Approach, GIS and Development, 8(5):43-48.
11. Sinha, S. K. (2017). Urban Sprawl in Gautam Budh Nagar, Ph.D. Thesis, Department of Geography, University of Delhi. [Unpublished].
12. Sinha, S. K. (2018) On Universal Definition of Urban Sprawl, *Research Analysis and Evaluation*, Vol. 10, No. 9, pp 70-71.
13. Sudhira, H. S. (2008). Studies on urban sprawl and spatial planning support system for Bangalore, India, unpublished PH.D. thesis submitted to Indian Institute of Science, Bangalore.
14. Tamilenthi, S. and R. Baskaran (2011). Recent research in science and Technique, 3(2).
15. Verzosa, L. C. O. and Gonzalez, R. M. (2010) Remote Sensing, Geographic Information Systems and Shannon's Entropy: Measuring Urban Sprawl in a Mountainous Environment, in Wagner, W. and Szekely, B. (eds.) ISPRS TC VII Symposium – 100 Years ISPRS Vienna, Austria, *IAPRS*, Vol. 38, Part 7A.
16. Yeh, A. G. O. and Li, X. (2001). Measuring and Monitoring of Urban Sprawl in a Rapidly Growing Region using Entropy, *Photogr. Eng. Remote Sens.,* Vol. 67, No. 1, pp 83-90.

RRIJM 2015, All Rights Reserved