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Measuring Urban Growth of Silchar Town Using Shannon Entropy Estimation

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ABSTRACT

Urban growth is a spatial and demographic process and refers to the increased importance of towns and cities as a concentration of population within a particular economy and society. Remote Sensing and GIS techniques at recent time is playing vital role in measuring the urban growth through various tools and techniques. The present study aims at measuring the urban growth of Silchar town using Shannon Entropy approach during the year 1991 to 2015. Shannon Entropy Estimation is an index that determines the distribution of built up as a function of the area of built up with in a defined spatial unit. The entropy values obtained in the study were 1.03 in 1991, 1.07 in 2001 and 1.09 in 2015, which are closer to the log(n) value 1.94, showing pattern of urban growth towards dispersion.

KEYWORDS: Urban growth, Shannon Entropy, Remote Sensing and GIS, Dispersion

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INTRODUCTION

Urban growth is a spatial and demographic process and refers to the increased importance of towns and cities as a concentration of population within a particular economy and society. It occurs when the population distribution changes from being largely hamlet and village based to being predominantly town and city dwelling (Clark, 1982). Urban growth or decline results from one of the three factors: natural increase/decrease from births and deaths, net migration, and reclassification of rural areas as urban. In developing countries natural increase dominates urban growth (UN State of the World Report, 2007). Urban growth in most of the developing world results primarily from the natural increase of urban populations. The most common measure of rate of urbanization is the annual change in the percentage of population living in urban areas. India is the second most populated country after China. The urban population of Indian has grown from 62.4 million in 1951 to 377.1 million in 2011. Assam is one of those states of India, which is traditionally rural in character with agriculture and allied activities being the primary occupation of its population. However, over the years there has been an upward trend towards urbanization and it got momentum particularly in the post Independence era. Silchar has grown from a small hamlet to a town. Therefore, to understand the pattern of urban growth in this town over a period of 25 years i.e. from 1991-2015, Remote Sensing and GIS techniques along with Shannon Entropy approach has been used for the present study.

The term 'entropy' has been used with different meanings in various contexts. The prevailing ambiguity and discussion surrounding entropy and its implications in these various domains is remarkable as the concept is one of the cornerstones of technologies that have defined our globalised civilization regarding transport, communication and energy transformation. The world's population is concentrated in urban areas that grow larger every day, and the uncontrolled expansions of these areas, commonly known as urban sprawl, has tremendous implications for the lives of most of us and for the future of our civilization. One of the measures commonly used to study the robustness of urban sprawl is Shannon Entropy (Yeh and Li, 2001). It is an index that determines the distribution of built up as a function of the area of built up with in a defined spatial unit (Jat *et al.*, 2007). For the purpose of studying pattern of urban growth in Silchar town, urban built up area has been taken into consideration. The entire study area has been divided into multiple buffer rings of 500 m interval from the city centre and the growth patterns have been studied based on urban built up density with respect to each circular buffer.

STUDY AREA

Silchar is the second largest and fast growing town of Assam. From an unknown village before the advent of the British in Cachar, which did not even find place in the revenue map of the district, it came into prominence after the annexation of Cachar by the British in 1832. It is located at the southern part of Assam, at 24.82^0N latitude and 92.8^0E longitude. It is situated 420 kilometers south-east of Guwahati. The town of Silchar has tremendous commercial importance and is consequently witnessing the settlement of a sizeable population of traders from distant parts of India. It is situated by the banks of Barak River. Silchar Municipal Board consists of 28 wards with a total area of 15.75 sq. km., and population of 172,830 in 2011.
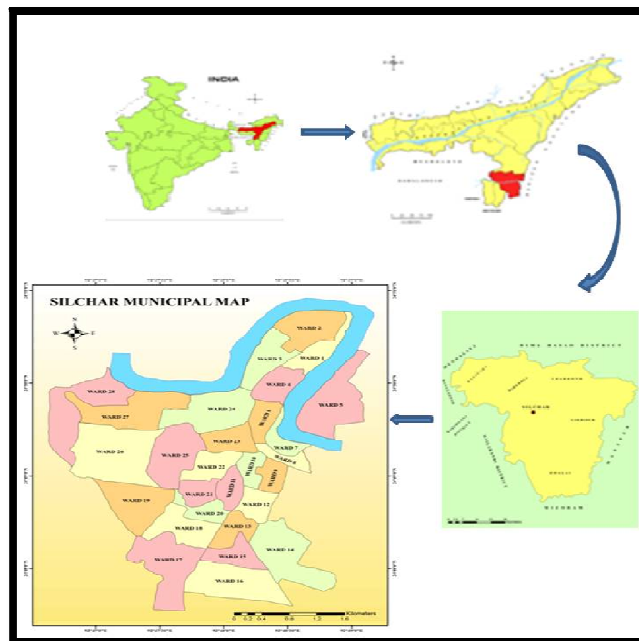

Figure No. 1 Study Area

OBJECTIVES

The main objective of the present study is to measure the urban growth of Silchar town using Shannon entropy approach.

MATERIALS AND METHODS

Materials

The collection of the materials involved ward map and satellite imageries. The detail sources of data used for the study have been shown in table 1.

Table No. 1 Sources of Data

S. No.	Data Used	Landsat-7 ETM+	Landsat-5TM	Landsat OLI/TIRS	Ward Map
1	Year/Month	1991, Feb 22	2001, Dec 8	2015, March 15	2011
2	Path/Row	136/43	136/43	136/43	-
3	Resolution	30m	30m	30m	-
4	Source	(http://earthexplorer.usgs.gov/)	(http://earthexplorer.usgs.gov/)	(http://earthexplorer.usgs.gov/)	

Methods

For the purpose of studying pattern of urban growth in Silchar town, urban built up area has been taken into consideration. The ward wise map of Silchar Municipal area was collected from Silchar Municipal Board. Satellite data were collected by downloading imageries from USGS for the three temporal periods 1991, 2001 and 2015. With the help of the GIS Software ArcGIS 9.3, the land use maps for the year 1991, 2001 and 2015 were prepared. In order to estimate the patterns of urban growth in Silchar town through Shannon Entropy, the entire study area was divided into multiple buffer rings of 500 m interval from the city centre and the growth patterns have been studied based on urban built up density with respect to each circular buffer. Further, by clipping out the built up of each buffer zone, the density of built up area in each zone was computed. Finally, the pattern of urban growth in Silchar town has been examined with the help of Shannon Entropy. In addition, to measure the compactness or dispersion of urban built up growth in urban areas, Shannon Entropy approach (Yeh and Li, 2001; 2004; Punia et al., 2011; Sudhira *et al.*, 2004; Bhatta *et al.*, 2010) was adopted.

The Shannon Entropy (H_n) value was calculated using the following formula;

$$H_n = - \sum P_i \log_e (P_i)$$

Where H_n is the relative entropy, P_i is probability or proportion of built up in the ith zone, it can be found out through,

$$P_i = X_i / \sum X_i$$

Where, X_i is the density of land development, which equals the amount of built up land and divided by the total amount of land in the ith zone. Entropy value ranges from 0 to log (n), where log (n) = Maximum limit of entropy. Here, if the value is closer to zero, the distribution is very compact and if the value is closer to log (n) the distribution is dispersed. The higher the value, the higher is the dispersion.

RESULTS

To analyse the pattern of built up growth in the study area concentric circles of 500m interval was made with the city centre at its focus. The built up density of each buffer was computed.
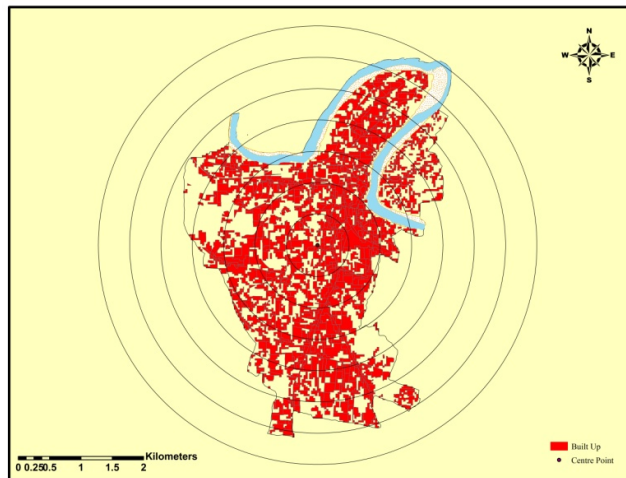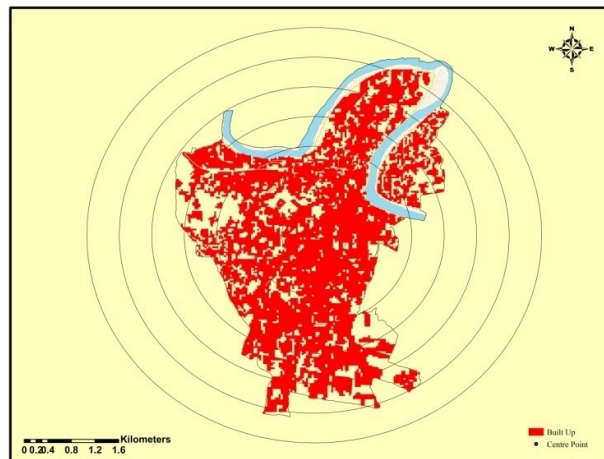
Figure No. 2 Buffer Zones, 1991
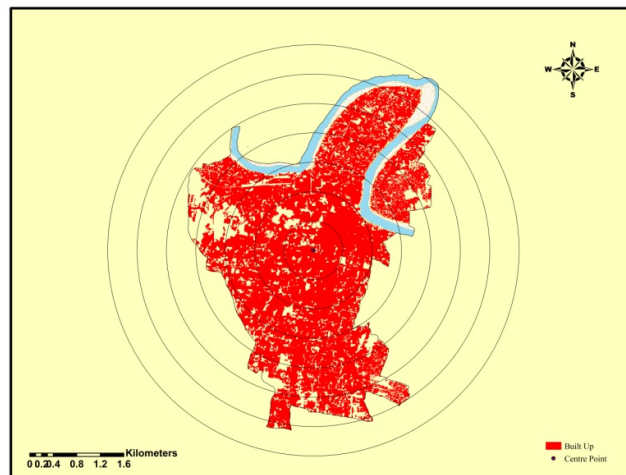

Figure No. 3 Buffer Zones, 2001

Figure No. 3 Buffer Zones, 2001

Source: Land Use/Land Cover Maps, 1991, 2001, 2015

Table No. 2 Shannon Entropy Value

S.No.	Year	Built Up (in Sq. Km.)	Shannon Entropy Value	Log (n)
1	1991	10.21	1.03	
2	2001	11.83	1.07	1.94
3	2015	13.38	1.09	

Source: Compiled by the author

Shannon Entropy value was calculated from the built up area of each individual zone (n=7). The entropy value of Silchar town is 1.03 in 1991, 1.07 in 2001 and 1.09 in 2015, while the log (n) value for the study area is 1.94. The value of entropy is closer to the log (n) value which shows that the pattern of urban growth in the town is towards dispersion. The degree of dispersion has slowly increased from 1991 to 2015. The increase in the dispersion from 1991-2015 is due to the increase in residential areas during this period. At the same time, there was also a significant increase in the commercial land use.

CONCLUSION

The Shannon Entropy analysis shows the ability of GIS and Remote Sensing tools in the study of urban planning and development. It gives a better understanding of the urban growth pattern in different parts of a city. The measurement of urban sprawl is very useful for urban planning both at local and global level. The concentric circles at a distance of 500m from the city centre have proved to be a useful method for the study of urban growth pattern.

The entropy values of Silchar town have increased from 1991 to 2015. It was 1.03 in 1991, 1.07 in 2001 and 1.09 in 2015, which is closer to the log (n) value 1.94. Hence, the values show that the urban growth pattern in Silchar town is towards dispersion. The proper understanding of the urban growth pattern of the town will help the local administration in the future developmental projects.

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