ASSESSMENT OF URBAN SPRAWL AND LAND USE CHANGE DYNAMICS, USING REMOTE SENSING TECHNIQUE. A STUDY OF KOLKATA AND SURROUNDING PERIPHERY, WB, INDIA.

Sukanya Ghosh[1], Dr. Prafull Singh[1], [2]Ms. Maya Kumari

[1]*Amity Institute of Geoinformatics and Remote Sensing, Amity University Noida, Sector-125*

Email: sukanyaghosh772@gmail.com

[1] *Assistant Professor (Amity Institute of Geoinformatics and Remote Sensing)*

[2] *Assistant Professor (Amity Institute of Natural Resource and Sustainable Development),*

KEY WORDS: Satellite image, Land use, Change analysis, Entropy, ArcGIS.

ABSTRACT: Rapidly growing urbanization is one of the major issues of developing countries. Sometimes it might lead to an unhealthy and unplanned urban growth. The metropolitan cities of India are growing rapidly in all aspects. The capital of West Bengal, Kolkata is listed among the fastest growing metropolitan city. The identification of urban sprawl using satellite data and GIS technique is a very scientific method. In the current study an attempt has been made to analyse major urban change that has taken place in Kolkata and its surrounding periphery from 1977 to 2017 using geo-spatial technique. Landsat TM and Landsat 8 along with Census data has been analysed in ArcGIS 10.0 and Erdas Imagine software. The result illustrates that a high rate of changes in terms of its vegetation cover, built-up area and accessible roads. These changes are creating serious environmental issues in the urban environment. The result achieved through the classification suggests a need of implication of effective land use planning and monitoring of the environmental issues for their sustainable use.

INTRODUCTION

Urbanization or Urban growth is defined as the physical growth of the urban areas on being subjected to the fields like economic, social as well as political forces of the metropolitan area. With the rapid growth of population and simultaneous upsurge as well as spread of urban sprawl triggered to be a major issue in India. This unplanned growth might lead to conversion of rural-urban fringes into urban spaces irrespective of any comforts along with exploiting the existing resources.

Thus, Urban Sprawl is well-defined as the low density residential and commercial development on undeveloped land. Most of the time, people move from these areas to find better place to live and to facilitate all amenities. This has been the way of the world since the beginning. Now, the cities and their suburbs are getting so much overcrowded because of this, that it is becoming impossible to handle the situation, thus it is time to look at the causes and the effects of the urban sprawl and take proper measures to mitigate.

Many towns in India are growing fast due to various infrastructural developments. This study analyses the spatial patterns of Kolkata metropolitan city—the 13th most populous and 8th largest urban agglomeration in the world. It has been one of the most prominent urban areas in eastern India, ranking 3rd most developed after Mumbai and Delhi, which was once considered the capital of India during the erstwhile British rule. Thus, the

study of accurate estimation and monitoring of land use and land cover (LU/LC) changes is said to be very important to have proper planning and utilization of natural resources and their management. The spatial patterns of urbanization of Kolkata with 3 km buffer have been examined in this project using the temporal remote sensing data.

Use of Remote Sensing Techniques:

The modern techniques of remote sensing that contains both aerial as well as satellite based systems, allow us to collect lot of physical data rather easily, with speed and on repetitive basis, and together with GIS helps us to analyse the data spatially, offering possibilities of generating various options thereby enhancing the whole planning process. These information systems also help interpreting physical (spatial) data with other socio-economic data, and thereby providing an important linkage in the total planning process and making it more effective and meaningful.

This domain of planning is of prime importance for a country like India with varied geographic patterns, cultural activities etc. The purpose of using GIS and Remote Sensing is that, maps provide an added dimension to data analysis which brings us one step closer to visualizing the complex forms and associations that characterize real-world development and policy problems.

STUDY AREA:

The metropolitan city of Kolkata, the capital city of West Bengal presents a perfect picture of modern India along with traditional art and culture. This is located in the eastern part of Indian continent with an extent from $22^0$28'00" and $22^0$37'30"N and $88^0$17'30" and $88^0$25'00" E. Kolkata is bounded by districts of North 24 Parganas, South 24 Parganas and Howrah in all sides. Since the past three centuries Kolkata had witnessed great development in all aspects, spreading linearly along the banks of river Hooghly. Kolkata still retains many of its attributes and presently being categorized as one of the well renowned commercial, cultural and educational centre of East India.

Kolkata spreads linearly along the banks of river Hooghly thus most of it is a part of Indo-Gangetic Plain, the soil is predominantly alluvial in nature. The physiography of the study area comprises of the main three structural units: the shelf or platform in the west; the central hinge or slope break and the deep basin in the east and southeast.

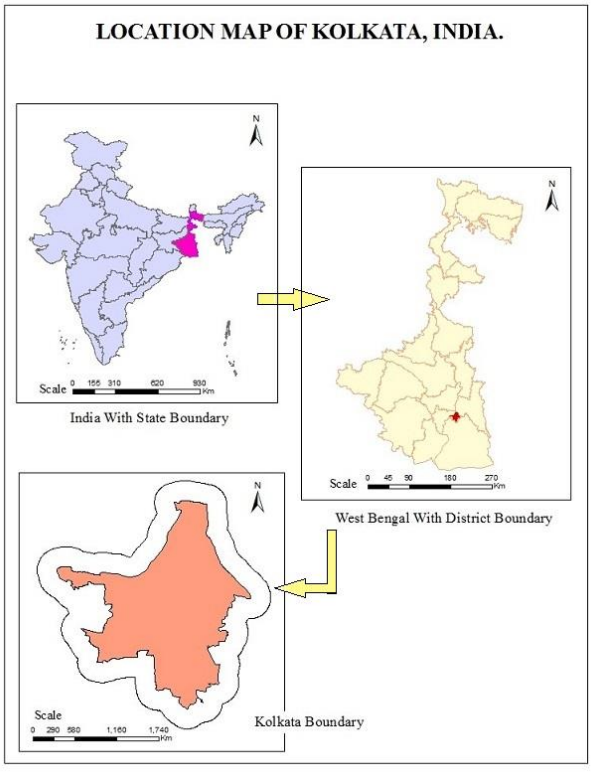

Figure 1: Locational Map of Study Area

The land is watered by the river Hooghly approximately 260km long, is a distributary of river Ganga. This play a major role in the day to day life of Kolkata, for irrigation and human & industry consumption. The river is navigable and a major transport system in the region with a large traffic flow.

Kolkata has a tropical climate. The annual mean temperature is 26.8 °C. Summers are hot and humid and maximum temperatures often exceed 40°C during May and June. Winter tends to last for only about two and a half months, with seasonal lows dipping to 12°C – 14°C between December and January. Kolkata receives rainfall from South-West Monsoon winds. The annual rainfall in Kolkata is said to be 1582mm.

Table 1: Population of Kolkata

Year	Population	Growth Rate(%)	Growth
1970	6,926,000	10.60%	665,000
1975	7,888,000	13.90%	962,000
1980	9,030,000	14.50%	1,142,000
1985	9,946,000	10.10%	916,000
1990	10,890,000	9.50%	944,000
1995	11,924,000	9.50%	1,034,000
2000	13,058,000	9.50%	1,134,000
2005	13,702,000	4.90%	644,000
2010	14,283,000	4.20%	581,000
2015	14,865,000	4.10%	582,000
2017	15,119,000	1.70%	254,000

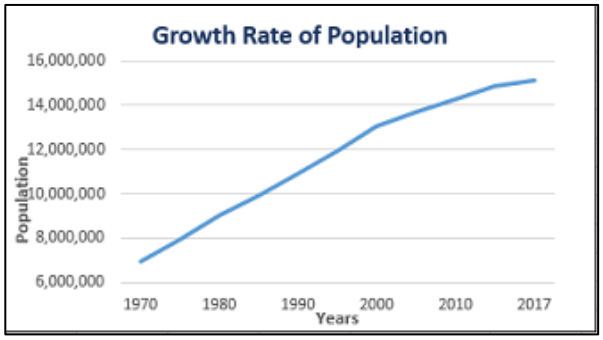

Figure 2: Growth of Population

Kolkata's 2017 population is now being estimated as 15,119,000. In 1950, the population of Kolkata was recorded as 4,513,000. Kolkata has grown by 254,000 in the last year, which represents a 1.70% change.

As it has already been mentioned that Kolkata is the 13th most populous and 8th largest urban agglomeration in the world with a population of 14.11 million (Census 2011). These estimates signify the Urban Agglomeration of Kolkata, which normally includes Kolkata's population and how it is growing.

Kolkata is the main business, commercial and financial hub of eastern India and the north-eastern states. It is said to be the home to the Calcutta Stock Exchange—India's second-largest bourse. This might be one of the biggest reason to attract huge population.

PROBLEM OF STUDY AREA:

The last two decades have observed high growth in population in Kolkata. As a result, more and more people are migrating from rural areas to urban centres, making municipal governance a very complex subject. The complication is more distinct in Kolkata which has one of the highest population densities having several towns, which are planned but with large unplanned settlements.

As a result, providing services to the growing population is becoming increasingly difficult. Moreover, people living in urban slums facing crucial livelihood problems. All these leads to improper management of sewage, rise in pollution and environmental degradation. The situation is becoming more and more critical due to the negative impacts of this growth and urban sprawl. This, in return cause negative impact both the environment and surroundings, polluting and exploiting natural resources. Being the city of Joy, Kolkata attracts lots of tourists

around the world thus well maintainace is very much essential. With such uniqueness, the preparation of GIS-based decision support system for the area is a very challenging work.

OBJECTIVE:

The principal purpose of this study is to quantify the extent of urban sprawl in the city of Kolkata and to show how the city has developed in 40 years i.e. since 1977.

1. To analyse and outline the growth and also the extent of urban sprawl through an analysis of historical maps and satellite images.
2. Secondly, we observe the change that took place through help of LULC map along with the change analysis.
3. The study the change in land use and land cover (LULC) with help of statistical tables and graphs and measure sprawl through Shannon's Entropy.

METHODOLOGY:

Remote sensing and GIS is a unique phenomenon that had played a major role in effective and well-organized mapping and monitoring enormous change of land-use and land-cover. Thus, to achieve the above mentioned objectives the following methodology has been adopted:

Data Acquisition: Primary and secondary data were collected from various sources to delineate the urban growth. Landsat images with temporal variation were used for classifying the land-use. These satellite images were obtained from USGS Earth Explorer site.

1. Landsat-2 (MSS) for year 1977
2. Landsat-8 (OLI & TIRS) for 2017

The satellite images and maps were further processed by help of software like ArcGIS; ERDAS; along with this QGIS and Google Earth were also helpful.

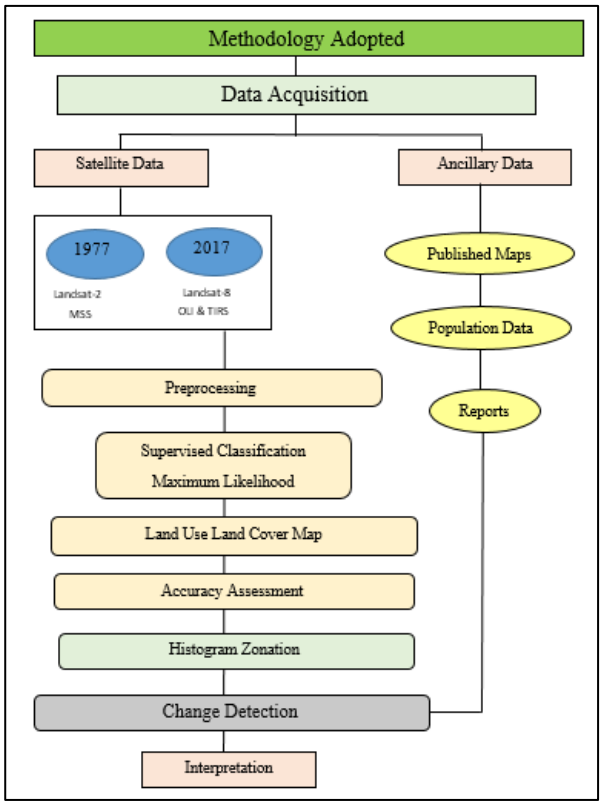

Figure 3: Flowchart showing the Methodology adopted

Pre-processing: The satellite images were co-registered in UTM(WGS-84) and also rectified with respect to 3km buffer of study area. False colour composite (FCC) of all satellite images with 4 bands were generated by stacking and extracting the particular study area from the satellite images. Depending upon the requirement and purpose of image classification, different techniques for image enhancement were applied.

Image Processing: Land-use analysis was carried out by using Supervised Classification Technique- Maximum Likelihood algorithm. Remote sensing data was classified using signatures from training sites that includes all the land-use types. The arrangement of land-use/land-cover classification utilized nine classes.

Accuracy Assessment: This is a method to evaluate the performance of classifiers. This is done by help of kappa coefficients. The overall accuracy of the classification and the kappa coefficient for all the classified imageries were performed.

LULC analysis: The different LULC classes of the study area that is Kolkata and its surrounding periphery were assembled into numerous categories for easy analysis and evaluation of change detection. The LULC classification includes Built up area, Airport, Low Vegetation, Forests/Tree Cover, Agricultural Land, Open Space, Rivers/Streams, Inland Waterbodies.

Post classification methods: This mainly deals with analysing different outcomes from the remotely sensed images. A pure remote sensing based approach as well as a statistical approach can be adopted for the post classification study. Different change map has been generated and area of each land use categories has also been calculated through pure remote sensing based approach.

Shannon's Entropy: To understand the urban growth Shannon's Entropy was computed. This helps to determine whether the growth and urban sprawl was divergent or compact in nature.

The Shannon's entropy, Hn is given by equation:

$$Hn = -\sum Pi \log Pi$$

Where, Pi= proportion of the built-up in the i^{th} zone,

n= total number of zones.

The value of Shannon's Entropy ranges between 0 to Log(n) where the value closer to 0 indicates the distribution is compact else if closer to Log(n) signifying the type to be disperse in nature. The built-up was sub-categorized into 14 zones using multiple ring buffer with 1000m interval. Through this, the density of built-up for each zone was computed.

RESULTS AND DISCUSSION:

The satellite remote sensing has proved to be quite convenient in mapping land use/land cover forms and changes with time. Therefore, this research provides a valuable means to increase the efficiency of land use and land cover, and lessen the negative environmental and societal effects related to LULC.

Land Use and Land Cover Map (1977):

The Land-Use and Land Cover Map of 1977 portrays that the city, Kolkata had its predominance within the central most region. This might be due to presence of well framed infrastructure commercial building as well as river Hooghly that acts as the lifeline for the people residing here. When compared to the portion outside the Kolkata boundary, we find its mostly covered with forests and agricultural lands. This southern part is devoid of built-up and clearly distinct from the rest of the map thus this zone is hardly affected by human activities.

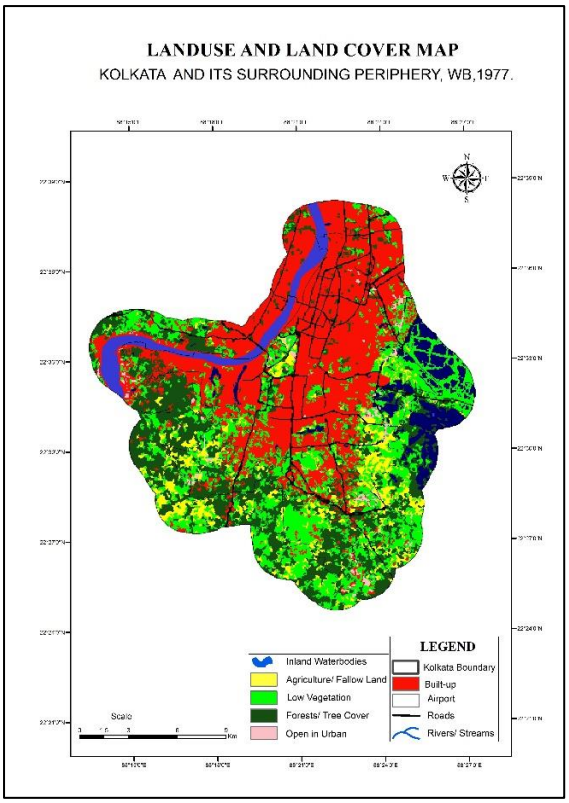

Figure 4:Land-Use and Land Cover Map (1977)

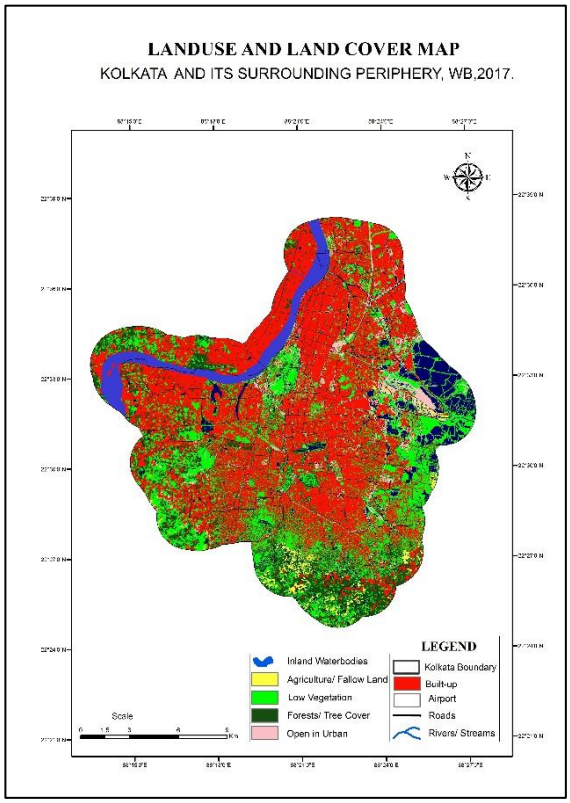

Figure 5: Land-Use and Land Cover Map (2017)

Land Use and Land Cover Map (2017):

In 2017 the change is clearly visible in respect of built-up and vegetation cover. The main city kolkata and a buffer around 3 km surrounding it has almost been covered by the built-up only. The built-up has spread across its boundary. Here, we find there is a remarkable positive change in built-up and the Urban growth and sprawl that had taken place that further lead to the shrinkage of greenery and open spaces initiating negative impact to the region.

The sprawl clearly demonstrates the development that had taken place in Kolkata and specially the surrounding periphery and still it is in the phase of development.

Kolkata is close to becoming the single largest urban patch with no vegetation. This will affect its ecological integrity and alter the micro-climate. The moderate temperatures that the city has had in the past may become extreme. The loss of greenery is extremely worrying.

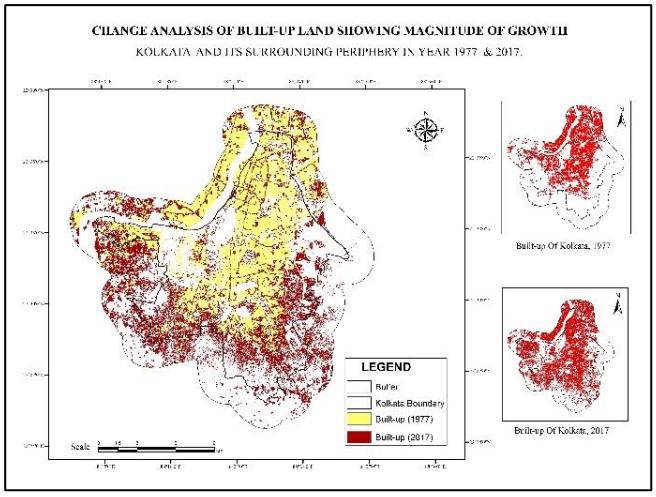

Figure 6: Change in Built-up (1977-2017)

In the last couple of years, a huge development work has been started, not only in the city, but also in the adjoining areas and different municipalities in the form of construction of hospitals, hotels, high rise residential and commercial buildings including housing complexes coming up in large vacant low lying areas.

Initially, the inhabitants were located on high lands and during rains the prevailing low pockets served as temporary reservoirs, from which water found its way through natural drains. Although, the situation deteriorated as the town enlarged in size with the increase in population and consequently, the natural drainage failed to function, the reason might also be due to the decline of the green spaces and tree cover.

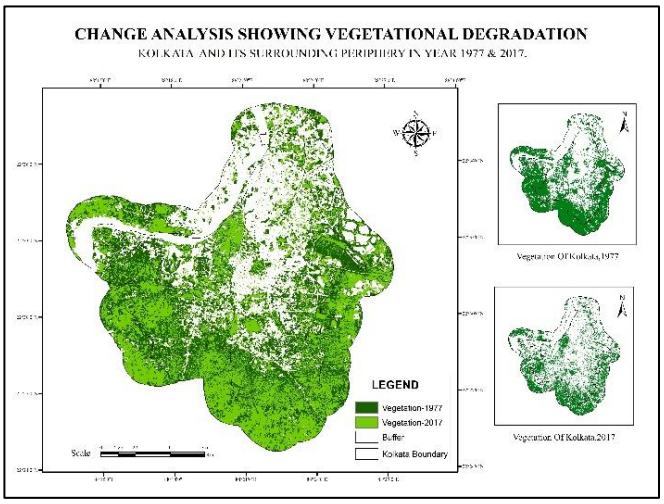

Figure 7: Change in Vegetation (1977-2017)

Accuracy Assessment:

Accuracy Assessment for the study was performed by Error Matrix and Kappa Statistics. The overall classification accuracy and the kappa coefficient was 85.37% for the year 1977 and the overall Kappa statistics is 0.816. For the year 2017 we find that the overall classification accuracy is 87.85% and the Kappa coefficient is 0.826.

Shannon Entropy Estimation:

In order to calculate the Shannon's Entropy, the class for built-up was taken from both the years (1977 and 2017). The required class was categorized in fourteen zones using the multiple ring buffer created. This helps to generate the density of built-up in each zone. Entropy values were then computed from each zones.

Table 2: Shannon's Entropy for Study Area

YEAR	BUILT-UP AREA (sq. Km)	SHANNON'S ENTROPY VALUE	LOG(n)
1977	100.03	1.013	1.146
2017	166.68	1.101	1.146

Shannon's entropy was calculated from the built-up area for each individual zone (n is the total number of Zones i.e., n =14). The entropy values obtained in the study were 1.013 in 1977 and 1.101 in 2017 which are closer to the upper limit of log (n), i.e. 1.146, which shows the degree of dispersion of built-up in the region.

It is clear that the urban area expanded in all directions with more development towards built-up area mainly in the southern portion when built-up 2017 compared to previous year.

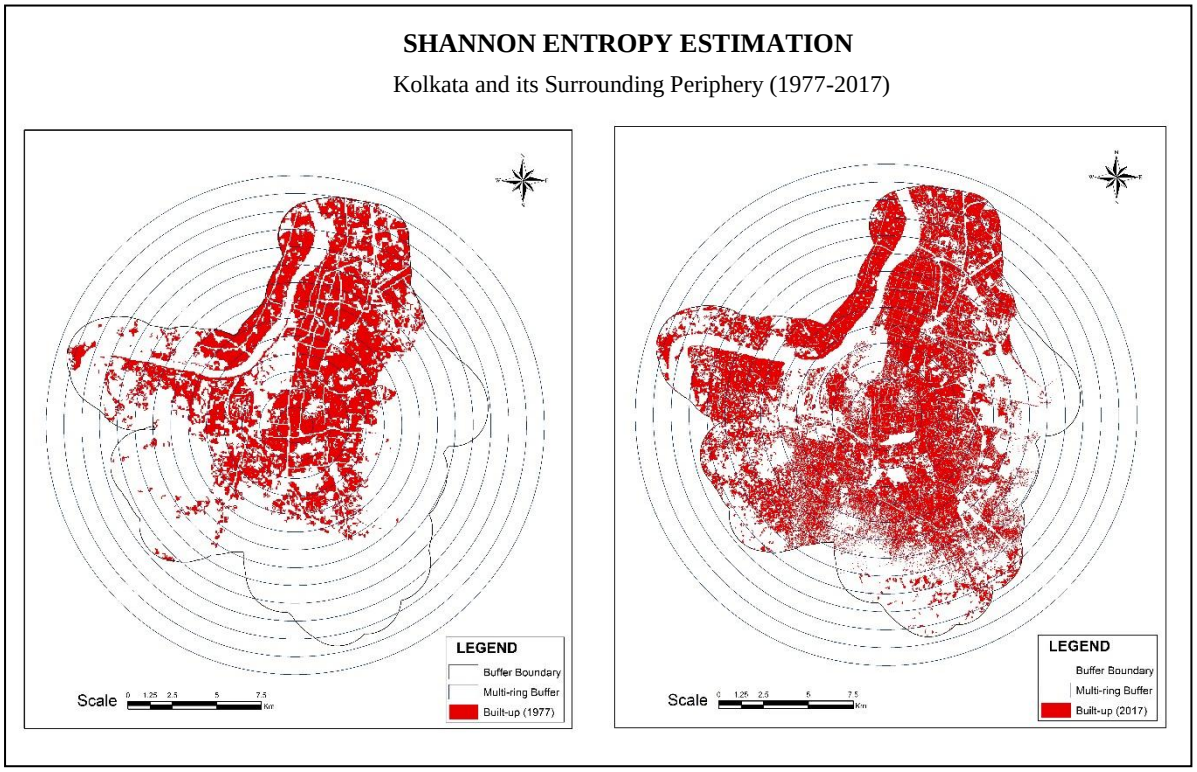

Figure 8: Buffer Zones around Study Area along with the Built-up (1977 & 2017)

The change analysis that was calculated through help of statistical data for Kolkata reveals that the area under built-up has expanded from (100.03) km^2 in 1977 to (166.68) km^2 in the year 2017. The land-use analysis reveals that the area under vegetation and forests has declined from (86.91) km^2, (79.44) km^2 for year 1977 to (79.34) km^2, (39.31) km^2 for year 2017.

Table 3: Change in Area of Land-Use and Land Cover (sq. Km)

Class Name	**1977**	**2017**	**Change**	
Built-up	100.0347	166.6801	66.65	(+)ve
Open Space	13.1154	10.3029	-2.81	(-)ve
Agricultural Land	24.256	4.5119	-19.74	(-)ve
Low Vegetation	86.9191	79.3447	-7.57	(-)ve
Forests	79.4406	39.3191	-40.12	(-)ve

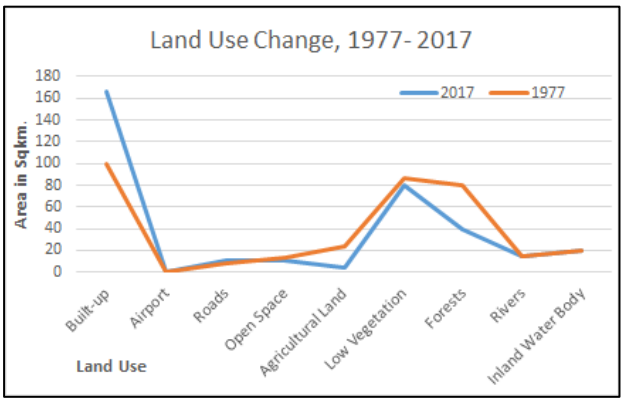

Figure 9: LULC change

CONCLUSION:

Urbanization is universal and recent phenomenon. In present global atmosphere, all nations undergo with the challenges of environment, social, transportation, economy in their respective cities. The urban areas are equipped with infrastructure, public facilities along with that provide employment opportunities compared to the rural areas. Therefore, inhabitants are more attracted to migrate in cities to avail better facilities, enhance their lifestyles and ultimately these activities raise numerous urbanization issues. Cities have major role to develop economic growth and prosperity. The sustainable development of cities largely depends upon their physical, social and institutional infrastructure. This study helps to map the areas with rapid urban development and the spread of sprawl that further helps in taking proper measures of sustainable development.

The study has taken efforts to identify the change of such urban sprawl and land use land cover for 1977 – 2017 that is for period of 40 years. Remote sensing thus is believed to be one of the eligible techniques in monitoring such kind of changes and changing information extracted from satellite image data. This satellite data plays an important role in mapping and quantifying the temporal extension of urban area

REFERENCES:

References from Journals:

1. David A. Mouat, Glenda G. Mahin and Judith Lancaster. 1993 “Remote Sensing Techniques in The Analysis of Change Detection”. Journal of Geocarto International, Vol:8.2 No:39.
2. Chandana Mitra, J. Marshall Shepherd and Thomas R. Jordn. 2012. “Assessment and Dynamics of Urban Growth in The City Kolkata, India”.
3. B. Bhatt, A. K. Gupta, G. Gogoi. 2006 “Application of Remote Sensing and GIS for Detecting Land Use Changes: A Case Study of Vadodara”.
4. Tusi Das, Sarbari Chakraborty, Kaberi Samanta. 2016. “Urban sprawl and urban growth detection analysis: A comparative study of Kolkata municipal corporation and Haora municipal corporation”, International journal of Geomatics and Geosciences, Vol:7.
5. Jyotishman Deka, Om Prakash Tripathi, Mohamed Latif Khan; 2012. Urban growth trend analysis using Shannon Entropy approach – A case study in North-East India. International Journal of Geomatics and Geosciences; Volume 2, No 4.
6. J.S. Rawat, Manish Kumar. 2015 “Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. The Egyptian Journal of Remote Sensing and Space Sciences. Vol:18, No:77-84.
7. Atef F. Al Mashagbah; 2016. The Use of GIS, Remote Sensing and Shannon’s Entropy Statistical Techniques to Analyze and Monitor the Spatial and Temporal Patterns of Urbanization and Sprawl in Zarqa City, Jordan.