IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 5 Ver. I (May. 2016), PP 44-49
www.iosrjournals.org

Quantifying Spatio-Temporal Changes in Urban Area of Gulbarga City Using Remote Sensing and Spatial Metrics

Mrs. ABHILASHA KUMARI, Dr. SULOCHANA SHEKHAR#*
**Research Scholar, #Associate Professor& Dean*
School of Earth Sciences
Central University of Karnataka
Kadaganchi, Aland Road, Kalaburagi
Karnataka, India.
(ewm.abhilasha&sulogis) @gmail.com

Abstract: *Due to dramatic increase in urban population and allied urban problems it is essential to have urban planning and management at local level. For this urban planners and decision-makers need efficient tools to quantify, evaluate and compare the impact of alternative plans and designs so that more informed choices can be made. Gulbarga one of the developing city of Karnataka, it is important to know the extent growth rate of the urban area and to know the landscape fragmentation. The objective of the paper is to analyze the extent and rate of spatio-temporal urban growth of Gulbarga city using multi-temporal satellite images and to quantify the spatio-temporal pattern of urban growth and landscape fragmentation using spatial metrics. This identifies the patterns of sprawl and subsequently predicts the nature of future sprawl. This paper also attempts to describe some of the landscape metrics required for quantifying sprawl for Gulbarga region, so that it will help urban planner to plan city as a sustainable city.*
Keywords:*LULC; spatial metrics; remote sensing; urban growth.*

I. Introduction

Urban sprawl is a universal phenomenon which is taking place all over the world and one necessary for human development which has been occurring much faster in developing countries than in developed countries. Due to dramatic increase in urban population and allied urban problems it is essential to have urban planning and management at local level. Urban sprawl is often raised to as an extent of metropolitan areas into adjacent rural landscapes that increases traffic problems, depletes local resources, and destroys open space (Peiser, 2001). Due to dramatic increase in urban population and allied urban problems it is essential to have urban planning and management at local level. For this urban planners and decision-makers need efficient tools to quantify, evaluate and compare the impact of alternative plans and designs so that more informed choices can be made.

Unplanned urbanization has fetched huge environmental impacts and industrialized various problems in modern growing cities in India. The urban pattern growth analysis aids in understanding the core effects of urbanization such as sprawl, loss of rural land (Huang et al., 2009) and complexhabitations. The lack of prior visualization of sprawl regions leads to unproductive administration as these areas are not documented in the administrative policy documents and hence deprived of basic amenities. Sprawl refers to disordered and unplanned growth of urban areas often used to describe the awareness of an unsuitable development (Sudhira et al., 2003; Sudhira et al., 2004).

Environmental problems related with urban sprawl demands better techniques to understand the spatial patterns of temporal urbanization for sustainable management of natural resources in promptly urbanizing regions (Lambin et al, 2000).

Gulbarga is one of the developing city of Karnataka. It is one of the industrially backward districts of the state It is located in the North Eastern part of Karnataka bordering Maharashtra in the North and Andhra Pradesh in the East, Bijapur District in the West, Yadgir district is in the South, which was recently bifurcated from the existing Gulbarga district (Brief Industrial Profile of Gulbarga District Government of India Ministry of MSME).It is important to know the extentof the growth rate of the urban area and to know the landscape fragmentation. For monitoring and assessment of urbanization it is essential to quantify its landscape pattern and its temporal changes. To address this objective, multi-stage remote sensing images and related landscape metrics were used to generate indicators and measurements of urban land cover changes in the Gulbarga city. The study had the following objectives: (1) To analyze the extent and rate of spatio-temporal urban growth using multi-temporal satellite images (2) To quantify the spatio-temporal pattern of urban growth and landscape fragmentation using spatial metrics.

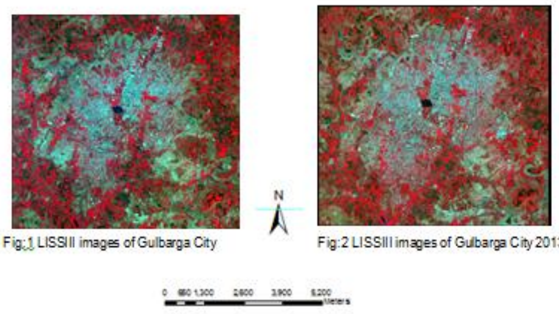

Fig:1 LISSIII images of Gulbarga City   Fig:2 LISSIII images of Gulbarga City 2013

Remote sensing and GIS data from the different source has been used in this paper. Two images of LISSIV i.e., of 5m resolution, of the year 2007 and 2013 were used to detect urban land cover change patterns of the study area. Most GIS data such as location of satellite towns, lake, city centers, hospital, and existing build up areas are derived VRH Google Earth image based on the information gathered from local experts during fieldwork period. Some secondary data are collected from the literature review and open source websites and important information and data are gathered from field work.

Following software has been used to fulfill the objectives:

- Erdas Imagine9.2
- ArcGIS 10
- Frag Stats tool 4.1

II. Methodology

A stepwise normative gradient approach was adopted to understand the dynamics city, which includes (i) first step to derive land use and land cover (ii) understanding the change in the land use dynamics using Landscape metrics analysis.

To fulfill the first step supervised classification was performed using maximum likelihood function to classify the images as built-up and non-built-up. The accuracy assessment showed over 75% for all the two images which was considered to be good enough to proceed with the analysis.

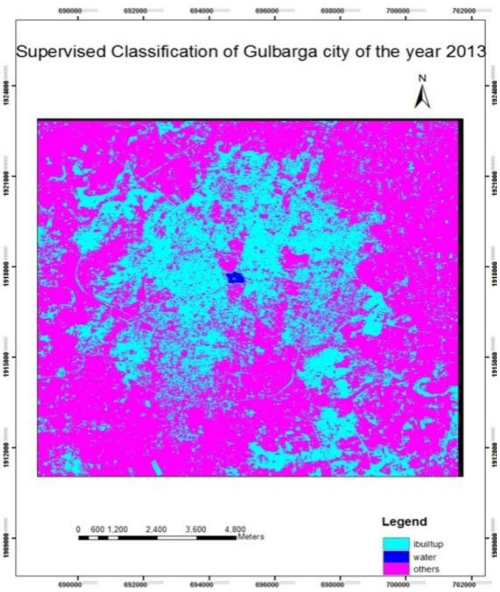

Fig:-3

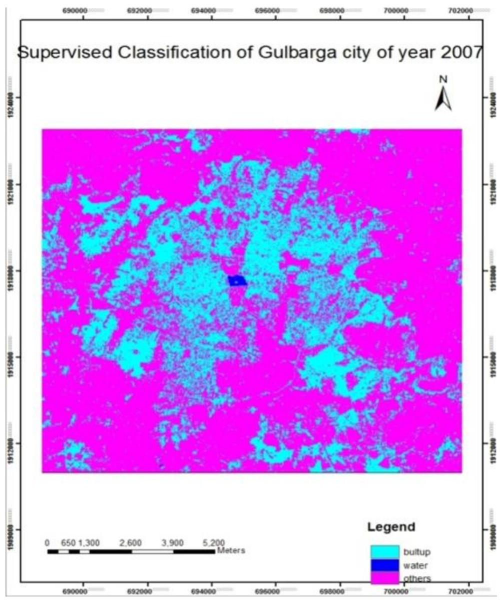

Fig:-4

Figure 3 &4 shows the supervised classification of Gulbarga city with legend built-up area, water and others. This classification is done in Erdas Imagine 2014 version.

Following is the methodology used for the study:

Table: 1 Methodology

III. Selection And Calculation Of Spatial Metrics

Applied to fields of research outside landscape ecology and across different kinds of environment (in particular urban areas), the methodologies and assumptions of landscape metrics is more generally referred to as "spatial metrics". The term "spatial metrics" can be defined as measurements derived from the digital analysis of thematic-categorical maps exhibiting spatial heterogeneity at a specific scale and resolution. (Herold et al., 2005).Landscape metrics are algorithmic program that quantify specific spatial characteristics of patches, classes of patches, or entire landscape mosaics. Many landscape metrics have been developed to quantify landscape structure and spatial heterogeneity based on landscape composition and configuration.

Seven class-level parameters quantifying the urban footprint at each time are calculated using fragstat tool:
1. CA: absolute urban area
2. PLAND: Percentage of Landscape
3. NP: number of patches
4. PD: Patch density
5. LPI: Largest patch Index
6. TE: Total Edge
7. ED: Edge density

3.1 Class area

CA is a simple metrics used to describe the pattern of urban growth in spatial metrics computation which also known as total area implying the total area covered by a land cover class in hectares. This indicates how much of the landscape is comprised of a particular patch type. In addition to its direct It indicates the sum of the areas (m2) of all the patches of the corresponding patch type, divided by 10000(to convert to hectares), i.e., total class area

$$CA = \sum_{J=1}^{n} a_{ij} \left[\frac{1}{1000}\right] \qquad (1)$$

3.2 Percentageoflandscape (PLAND)

PLAND quantifies the proportional ratio of each patch type in the landscape. It equalsthesumofthearea (m^2) ofallpatchesofthecorrespondingpatchtype, dividedbythetotallandscapearea (m^2), and multiplied by 100 (toconverttopercentage).

$$PLAND= P_i=\frac{\sum_{J=1}^{n} aij}{A}(100) \qquad (2)$$

3.3 Thenumberofurbanpatches

It is the measure of discontinuous urban areas or individual urban units in the landscape (Gezahegn Awake Abebe, 2013). Due to the rapid urban cores development, the number of patch is expected to increase due to the emergence of new fragmented urban patches around the cores. Number of patches indicates the diversity or richness of the landscape. In other word it gives a simple measure of the extent of subdivision or fragmentation of the patch type.

$$NP = n_i \quad (3)$$

Where
n_i= number of patches in the landscape of patch type
NP≥, without limit
NP=1 when the landscape contain only one patch of the corresponding patch type;

3.4 Patchdensity (PD)

It isone more measure of landscape fragmentation of the patches of a land cover class which specifies the density of the fragmented urban units within a quantified area. Values of this indicator are affected by the size of the pixel and also the minimum mapping unit since this is the significant factor for describing individual patches. This usually expresses number of patches on a per unit area basis that facilitates comparisons among landscapes of the varying size. The patch density of the Gulbarga city of the year 2007 and 2013 is showing the increase at the rate of 8.56%.

$$PD = \frac{n_i}{A}(10{,}000)(100) \quad (4)$$

3.5 Largest patch index

LPI equals the area(m^2) ofthelargestpatchesofthecorrespondingpatchtypedividedbythetotallandscapearea (m^2), multipliedby 100 (toconverttoapercentage); i.e. LPI equalsthepercentageofthelandscapecomprisedbythelargestpatch.

$$LPI = \frac{max^{\,n}{}_{j=1}\, a_{ij}}{A}(100)(5)$$

3.6 Edge density

ED is the indicator of urban expansion level which measures the total length of the edge of the urban patches. Edge density equals the sum of the lengths (m) of all edge segments in the landscape, divided by the total landscape area (m^2), multiplied by 10,000(to convert to hectares) (McGarigal Marks., 1995, p.89). In the figure 10 the edge density is increasing at the rate of 9.34.

$$ED = \frac{\sum_{k=1}^{m} e_{ik}}{A}(10{,}000)(6)$$

IV. Results And Discussion

Table 2:Values of spatial metrics obtained from standard analysis

Year	Class Area (CA)	Percentage of Landscape (PLAND) (%)	Number of patches	Patch density	Largest Patch Index(LPI)	Total Edge(TE)	Edge Density(ED)
2007	4529.9850	29.0169	23060.00	147.714	17.28	4316790.00	276.5120
2013	5065.7225	32.81	26631.00	172.49	22.22	4569770.00	295.9961

Reference: the above table is obtained by running the classified supervised images in a fragstat 4.2 software.

The total urban class area of Gulbarga city increased from 4529.9850 hectare to 5065.7225 hectare during 2007-2013, with an annual urban expansion area of 0.26sq.km per year, which also means the expanded area was6.67 times of the original urban area in 2000.

A comparison of the two year standard output indicates an overall increase in the urban area from past six years. The values of PLAND also confirm the same with the area of built-up. This approves the growth of urbanization in Gulbarga city. The number of patches is simultaneously increasing from 23060 to 26631 which indicate growth of many small urban patches in this period. Largest patch Index also increases throughout. The synoptic analysis of the indices over the entire landscape shows a rise in patchiness for built-up in throughout the temporal period.

The more are the number of patches, signifies the growth of the urban area in a fragmented way(Kohli, 2006). Number of patches is a measure of discrete urban areas in the landscape and is expected to increase during periods of rapid urban nuclei development and may decrease if urban areas expand and merge into continuous urban fabric. (Seto and Frakias, 2005). This spatial signature gives the information about the process of the growth of urban sprawl.

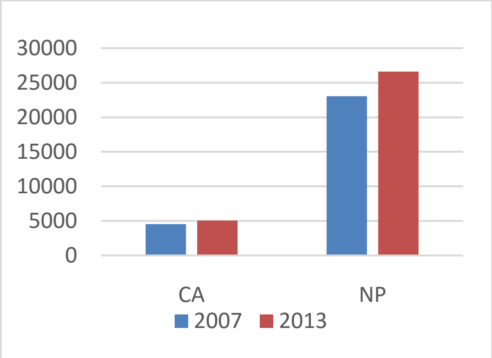

Fig: 5 the class area and the number of patch

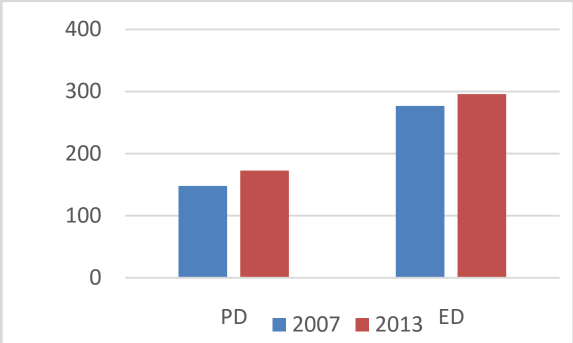

Fig:6 Patchdensities and the edge density

In the figure 5 the number of patches indicating the fragmentation of the built up and also showing the growth of the built up from 2007 to 2013 by 8.65%

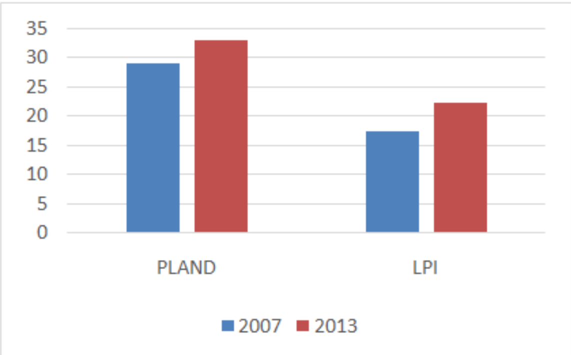

Fig: 7 PercentageoflandscapeandtheLargestpatch index

The PLAND and LPI of the Gulbarga city is showing the 8.84% increase from 2007 to 2013 and 7.77% to the same year difference respectively.

V. Conclusion

From the above study we conclude that the urban sprawl is growing continuously from the year 2007 to 2013 in a patchy way. The urban sprawl is occurring in a fragmented way. To explain the spatial pattern for urban development, the percentage of landscape, number of patches etc. is useful. The technique adopted provides the quantitative analysis of spatial pattern of urban development considering a number of parameters and gradient analysis linking the spatial information with the local areas.

This paper demonstrates urban expansion of Gulbarga city, and identifies the temporal and spatial developmentpatterns by using multi-temporal remote sensing images and GIS tool. Various analysts have made considerable progress in quantifying the urban sprawl pattern.The urban sprawl is one of the potential threats to sustainable development where urban planning with effective resource utilization and distribution of infrastructure initiatives are key concerns. Thus proof of identity and analysis of the patterns of sprawl would help in effective land use planning in urban area. It is important to study and understand the trend of urban sprawls, which ultimately focus for urban landscape planning and environmental management.

Result gives confirmation that the spatial signature of the same metric is different for different years and for different metrics. This could reveal temporal pattern as well as the spatial pattern providing reliable and detailed information.

The study successfully achieves the objectives of extracting quantitative information on spatial pattern and analyzing the spatio-temporal gradient for land cover change. The technique adopted in the present study provides the quantifiable analysis of spatial pattern of urban development.

Acknowledgement

The authors express gratitude to the University Grants Commission (UGC) for the financial support to undertake this study. Authors are thankful to the research scholars from the School of Earth Sciences, Central University of Karnataka for their support and encouragements. And last but not the least to Mr. Deepak Kumar for their moral support.

References

[1] Peiser, R,(2001) "Decomposing urban sprawl", Town Planning Review, 72(3), 275–298.
[2] Huang, B., Zhang, L., and Wu, B. (2009). Spatiotemporal analysis of rural–urban land conversion. International Journal of Geographical Information Science, 23 (3), 379-398.
[3] Sudhira, H. S., Ramachandra, T. V. and Jagadish, K. S. (2004). Urban sprawl: metrics, dynamics and modelling using GIS. International Journal of Applied Earth Observation Geoinform, **5,** 29–39.
[4] Sudhira, H. S., Ramachandra, T. V. and Jagadish, K. S. (2003). Urban sprawl pattern recognition and modeling using GIS, Paper presented at Map India, January 28- 31, 2003, New Delhi.
[5] Lambin E. F., Rounsevell, M.D. A. and Geist, H. J. (2000). Are agricultural land-use models able to predict changes in land-use intensity? Agriculture, Ecosystems and Environment, 82, 321-331.
[6] Yetao Yang, Qiming Zhou, Jianya Gong, "Gradient Analysis of Landscape Pattern Spatial-Temporal Changes in Beijing Metropolitan Area, China", 1-2
[7] DivyaniKohli, (2006), Spatio-Temporal Gradient Modelling of Land Cover change, 33-35
[8] Gezahegn Awake Abebe, Quantifying urban growth pattern in developing countries using remote sensing and spatial metrics, 30-33
[9] McGarigal, k, &Marks.B.J (1995). Fragstat: spatial pattern analysis program for quantifying landscape structure.
[10] "Brief Industrial Profile of Gulbarga District" Government of India Ministry of MSME
[11] Herold, M., Couclelis, H. and Clarke, K.C., 2005. The role of spatial metrics in the analysis and modeling of urban land use change. Computers, Environment and Urban systems 29:369-378