International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072

Urban Sprawl Analysis Using GIS Applications for Jabalpur City

Vivek Garg[1], Dr. Alok Sharma[2]

[1,2] *Department of Planning & Architecture, M.I.T.S., Gwalior*

Abstract - *Urban sprawl is the uncontrolled and uncoordinated outgrowth of towns and cities. The process of urban sprawl can be described by change in pattern over time, like proportional increase in built-up surface to population leading to rapid urbanspatial expansion. The current research addresses the issue of urban sprawl in the context of Jabalpur, India. We propose a theoretical framework to analyse the interaction of planning and governance on the extent of outgrowth and level of services. Reviewing the different indicator frameworks, we also propose urban sprawl indicators and operationalize the same for Jabalpur. The interaction of different indicators with respect to the core city and the outgrowth is determinedbymulti-dimensional scaling. The analyses reveal the underlying patterns - similarities (and dissimilarities) that relate with the different governance structures. Subsequently, we attempt to understand the process of sprawl. This might help one to understand the dynamics that lead to such outgrowths. An attempt was made to capture the dynamics using systems approach and finally the insights gainedwere translated into agent-basedland-use model. The aim of the study is to find out the land cover change caused due to different activities in Jabalpur City and its surroundings. The main trajectories of land use change are based on nine types of land use data derived fromthe remotely sensed images. The buffer analysis is done to interpret urban growth The process was used to calculate the mean relative and distributed entropy in the both buffer types. Entropy approach shows that the urban development of Jabalpur city is going on unplanned manner and it is random in nature. The study is potentially useful for administrators and planner in Jabalpur and as case study, of value and interest to a broader community*.

***Key Words*: Land use/cover change, Urban growth, Remote sensing, Gis, Shannon's entropy, Spatial forms of urban Sprawl**

1. INTRODUCTION

The rapid pace of world's urban population growth, especially in developing countries, is one of the major challenges for governments and planning agencies. Today, 3.9 billion people—54 percent of the world's population—reside in urban areas and is expected to reach 6.3 billion in 2050, with nearly 90 percent of the future urban population increase being in developing world cities (United Nations, 2015).

The definition of an urban area is normally based upon the number of residents, population density, percent of people dependent upon non-agricultural income and provision of public utilities and services. The term 'urban' has its origin from the Roman word Urbanus, which adopted the meaning 'city dweller' in Latin. The precise definition of an urban area can vary from country to country. Some countries define an urban area as any place with a population of 2,500 or more while some other countries set a minimum population of 20,000 as a criterion. In general, there are no universal standards and therefore each country develops its own set of criteria for recognising urban areas. In India, an area is designated as urban if the population is more than 5000 with a population density of more than 400 persons per sq. km and at least 75 percent of the population is involved in non-agricultural occupations.

India's urban population grew at an average rate of 1.26 percent per annum during 2010 to 2015 (United Nations Population Division 2017). It is projected that the country's urban population would increase from 31.2 percent in 2011 to about 41.4 percent by 2030 (United Nations). By 2011, there were 53 urban agglomerations (cities having a population of more than one million), as compared to 35 urban agglomerations of 2001. The number of urban agglomerations and towns has increased from 4369 in 2001 to 5100 in 2011 (Census of India, 2011). Among the 5000 plus Urban agglomerations, about 43 percent of its population resides in just 53 urban areas. Currently, the Indian economy is experiencing a strange transformation (with about 68.8 percent of the population in rural areas contributing to about 28 percent of GDP) to services based economy (with about 31.2 percent of the population in urban areas contributing a significant proportion of the services sector contribution to GDP).

Towns and cities are expanding in certain pockets with a change in the land-use along the highways and in the immediate vicinity of the cities. This outgrowth along highways and roads connecting a city and in the periphery of the cities is caused by the uncontrolled and uncoordinated urban growth. This dispersed development outsidecompact urban and rural centres that is along highways and in rural Countryside is referred to as sprawl. Sprawl generally refers to some type of development with impacts such as losses of agricultural lands, open spaces, and ecologically sensitive habitats in and around the urban areas. These regions lack basic amenities due to the unplanned growth and lack of prior information and forecasts of such growth during policy, planning and decision-making.

Shannon (1948) did the conception of entropy. The second law of thermodynamics states that thermodynamic degradation is unalterable over time. The disorder, disorganization the disorder, disorganization or randomness

of organization of a system is known as its entropy (Miller, 1969). Urbanization has become one of the main factors of land degradation, mainly due to the quality of the agricultural lands that have been urbanized (Santibanez & Royo, 2002). This leads to inadequate infrastructure facilities, water scarcity and traffic congestion. Recent land use changes will be helpful to alternate infrastructure and services such as proper zoning conveyance, medical facilities, and designing of schools. The purpose of this study is to analyse land use change in the Jabalpur City area and to find its urban sprawl direction. The intent is to assess the land use change and to use the entropy approach to find the degree of randomness.

2. Description of study area

Jabalpur (formerly Jubbulpore) is a tier 2 city in the state of Madhya Pradesh, India. Jabalpur word combines Arabic word Jabal(meaning- rock) and Sanskrit word-Pur(meaning- city). Though some people propagate that it was anciently named as Jabalipuram after Saint Jabali, there are no historical, mythological or folklore evidence in support of this. It is one of the most famous cities of Madhya Pradesh. According to the 2011 census, it is the third-largest urban agglomeration in Madhya Pradesh, and the country's 30th-largest urban agglomeration. The High Court of MP is in Jabalpur and so are many Government administrative headquarters. It is one of the major centers for the production of arms and ammunition and military base in India.

Jabalpur District is located in the Mahakoshal region of Madhya Pradesh, on the divide between the watersheds of Narmada and the Son, but mostly within the valley of the Narmada, which here runs through the famous gorgeknown as the Marble rocks, and falls 30 ft. over a rocky ledge (the *Dhuan Dhar*, or misty shoot). It consists of a long narrow plain running north-east and south-west and shut in on all sides by highlands. This plain, which forms an offshoot from the great valley of the Narmada, is covered in its western and southern portions by a rich alluvial deposit of black cotton soil. At Jabalpur city, the soil is black cotton soil, and water plentiful near the surface.

Jabalpur an important city in the Narmada (eastern) region of Madhya Pradesh is one of the fastest growing cities in the country. As per 2011 censes the population of Jabalpur district is 24.61 lakhs out of which 10.54 lakhs live in Jabalpur city, in 60 wards, covering a gross area of 224.47 sq. km. The city is located on the banks of Narmada River and sprawls over the plains of its tributaries (23° 10' North latitude and 79°57' East longitude). National Highway 12 (Jaipur - Jabalpur road), links the city to many important Cities in the northwest and National Highway No 7 connect the city to Varanasi and Nagpur The broad gauge railwayline to Mumbai and Kolkata (via Allahabad) connect the city to Mumbai and Kolkata. The city is served by only one-flight air services to Delhi.

2.1 Demographic Summary

Initially during 1948, the city is designed for the 40000 people. But later on the it undergoes high growth due to effect of the industries and manufacturing industries. Availability of education and better health care facilities also propel more force for urbanization in the city. During 1961-71, it has the highest growth rate of 176.07% in the country. But after that the growth rate has taken the downward tendency. In the 2011 India census, the Jabalpur city (the area covered by the municipal corporation) recorded a population of 1,081,677. The Jabalpur metropolitan area (urban agglomeration) recorded a population of 1,268,848. The literacy count of the city is 81.07 percent.

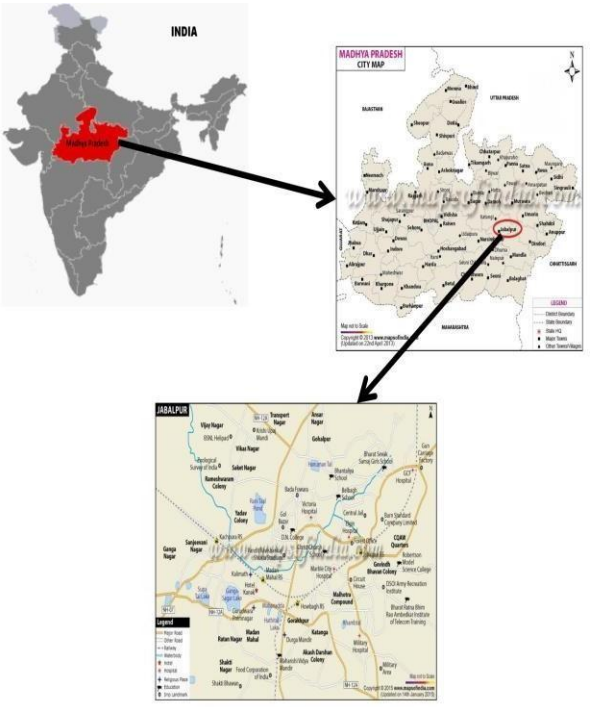

Figure 1: Location map of the study area Jabalpur city (Source: http://www.mapsofindia.com)

3 Methodology

3.1 Creation of Segment Map

Segment map is a data object used to store spatial geographic information that consists of lines. Segments are either codified by IDs, class names or values (height map); this is determined by the domain of the map.

3.2 Creation of Polygon Map

A polygon map is a data object used to store spatial geographic information that consists of polygons, i.e. closed areas including the boundaries making up the areas. The areas are either codified by IDs, class names or values; this is determined by the domain of the map.

3.3 Raster Maps

A raster map is a data object used to store spatial geographic information and remote sensing data as pixels (picture elements) of a certain size. These pixels are either codified by IDs, class names, values or colors; this is determined by the domain of the map.

3.4 Georeference

A georeference defines the relation between rows and columns in a raster map and XY-coordinates. The location of pixels in a raster map is thus defined by a georeference.

Data Exportation and Buffer Analysis

Polygon maps are created for the base maps, areas are calculated with the help of the histogram. All types of land use are taken which are the agricultural, water and residential areas.

3.5 Coordinate System

A coordinate system contains information on the kind of coordinates you are using in your maps; for instance use user-defined coordinates, coordinates defined by a national standard or coordinates of a certain UTM zone.

3.6 Domain

A domain defines, i.e. stores, the information that can be available in a map, a column, etc. A domain defines, i.e. stores, the information that can be available in a map, a column, etc. All elements in a map or column must use one of the classes, IDs, or values of the domain that is used by the map or column if not, these elements will appear as undefined. All ILWIS data objects(maps, tablesandcolumns) have a domain.

3.7 Entropy Approach

Initially Shannon (1948) has developed the concept of entropy and proposed a theory regarding that. He used a mathematical equation related to the thermodynamics. As we can know that entropy is the second law of thermodynamics. It represents degree of randomness. Entropy is degree of randomness and disorganization. When a system changes from a lower to a higher state, the entropy also changes accordingly.

3.8 Land Use Types

In this study, a detailed analysis of the land use types is done and classification successfullyapplied to the polygon maps of Jabalpur. The following land use types are shown in polygon maps:

1. **Agricultural -** Crop land, Fallow land.
2. **Commercial -** Hotels, public houses, restaurants, cafes, sports facilities.
3. **Industrial -** Manufacturing, Wholesale/Warehouse Operations.
4. **Others -** Farm buildings or roads, irrigation ponds.
5. **Public Utility -** electricity generation, electricity retailing, electricity supplies, natural gas supplies, water supplies, Sewage works.
6. **Residential -** Housing.
7. **Transport -** Air, water, and land transport.
8. **Vacant land -** open land.
9. **Waste Land -** Barren or desolate area ofland.
10. **Water –** River, streams, tanks .

3.9 Mathematical Formulae

It is necessary to prove occurrence of this phenomena in Jabalpur city prior to measuring urban sprawl based on its spatial forms. The degree of spatial concentration can be measured by Shannon's Entropy E (Thiel, 1967; Thomas, 1981). The formula is :

$$E=\sum Pilog (1/pi) \quad (1)$$

Where $Pi= mi/\sum mi$ is the probability of occurring of the variable in the ith zone, mi is the observed value of the variable in the ith zone, and n is the number of zones. The value of entropy ranges from o to log (n). Lowest value of the entropy will be zero and maximum will corresponds to log (n). We can also calculate the relative entropy. The relative entropy Er is (Thomas, 1981):

$$Er =\sum Pilog (1/pi)/log(n) \quad (2)$$

If the probability is concentrated in one region, then the Equation (2) would give the lowest value of zero. Otherwise, it would give a maximum value of 1 for an evenly distribution. Eq. (2) is used for the analysis here.

$$\Delta E = E (t + 1) - E (t) \quad (3)$$

In which E is the change in the entropy between time (t+1) and (t). Change of entropy will clearly depict the land development pattern which can be a scattered or concentrated type.

4. Results and discussion

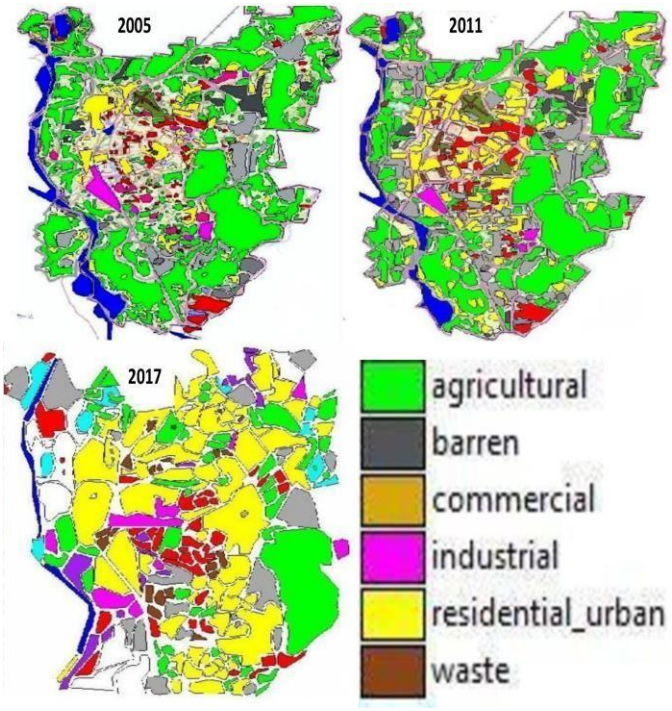

Figure 2: Polygon Map for year 2005, 2011 and 2017

Segment map and polygon map for three years (2005, 2011 and 2017) are created with the help of ILWIS-GIS.

For the year 2005, 2011 and 2017 the land use areas are calculated from the respective polygon maps and put into the table in 2, 3, and 4

Land Type	Area in 2005 (in hectare)	% of total
Agricultural	16857.5	61.3
Commercial	330	1.2
Industrial	701.25	2.55
Other	566.5	2.06
Public Utility	1716	6.24
Residential	2274.5	8.27
Transport	500.5	1.82
Vacant land	2051.5	7.46
Waste Land	607.5	2.21
Water	1894.7	6.89
Total	27500	100

Table 1: Different areas of Year 2005

Area of land use in 2005 is shown below in Table 2. As we can see that agricultural areas contributed the highest areas during this period.

Land Type	Area in 2011 (in hectare)	% of total
Agricultural	11121	40.44
Commercial	577.5	2.1
Industrial	508.75	1.85
Other	2695	9.8
Public Utility	1729.75	6.29
Residential	4422	16.08
Transport	541.75	1.97
Vacant land	3355	12.2
Waste Land	860.75	3.13
Water	1614.25	5.87
Total	27500	100

Table 2: Different areas of Year 2011

During year 2011, trend changes in the land use areas. Agricultural areas have a downward trend while increase in residential and public Utility.

Land Type	Area in 2017 (in hectare)	% of total
Agricultural	5533	20.12
Commercial	794.75	2.89
Industrial	951.5	3.46
Other	1875.5	6.82
Public Utility	2244	8.16
Residential	10873.5	39.54
Transport	759	2.90
Vacant land	3005.75	10.93
Waste Land	1009.25	3.67

Water	415.25	1.51
Total	27500	100

Table 3: Different areas of Year 2017

During year 2017, the trend changes in the land use areas. Agricultural areas have again downward trend while increase in residential area.

4.1 Comparison Of different Years

Further land use change has been calculated from 2005 to 2011 and also from 2011 to 2017.There is negative increase in the agricultural areas, water, while the residential areas bear high growth. Between 2005 to 2017 decrease in agriculture, industrial & water area is seen & increase in residential area while in 2011 to 2017 decrease in agriculture, vacant land, water & other is seen and again residential area bears high growth & also growth in industrial area have seen in Jabalpur. The variation of agricultural area to residential areas has been demonstrated in the buffer regions. In 2005, agriculture region has highest area and after that there is a decrease in areas. During 2011, similar urban growth pattern is found on agriculture periphery. The residential areas has upward trend in 2011 and 2017 while agriculture area is decreasing. In 2017, Residential region has the maximum areas.

Land Type	From 2005 to 2011(%change)	From 2011 to 2017(%change)
Agricultural	-34.02	-50.24
Commercial	75	37.61
Industrial	-27.45	87.02
Other	375.72	-30.40
Public Utility	0.80	29.72
Residential	94.43	145.89
Transport	8.24	47.20
Vacant land	63.53	-10.40
Waste Land	41.62	17.25
Water	-41.80	-74.27

Table 4: Change percent of land use in 3 years

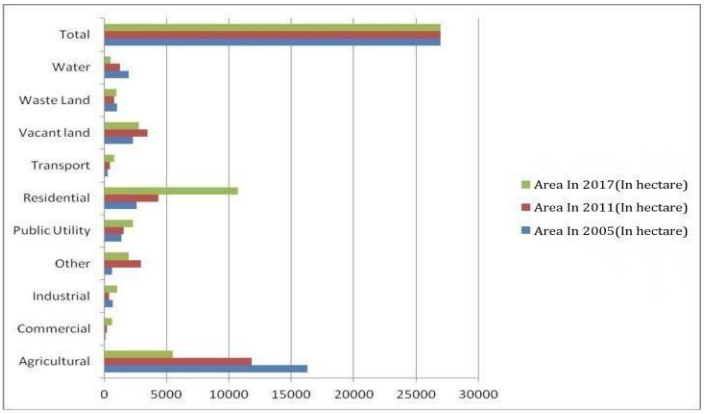

Figure 3: Land use in three different years

4.2 Entropy

Mean relative entropy has been calculated for Years 2005, 2011 and 2017 using equation (2). Further change in entropy is done using equation (3) and entropy values are calculated using equation (1):

Year	Entropy	Change	% change
2005	0.93		
2011	0.96	0.03	3.023
2017	0.98	0.02	2.08

Table 5: Mean Relative Entropy for Buffer Analysis

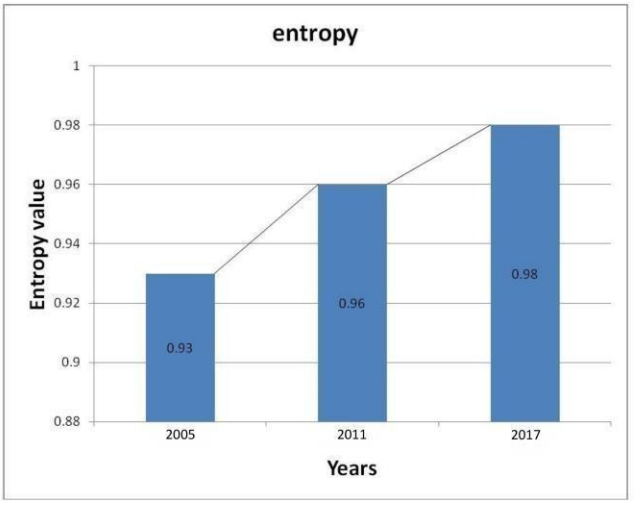

Figure 4: Mean relative entropy value for 2005, 2011 and 2017

The entropy value increases from 0.93 to 0.98 from 2005 to 2017. This indicates that the dispersal of land gradually in Jabalpur.

The Relative entropy value for different regions is tabulated above. And the comparison of relative is demonstrated. We can find that from 2005 to 2017 there is

gradual sprawl or even dispersal of land use. At the outer part of the city, the sprawl is less in 2011 as compared to year 2017. During 2011, the compactness is more as entropy is 0.03. In an overall scenario, the randomness is more in 2017.

3. CONCLUSIONS

The groundwater of Jabalpur is depleting day by day. According to the results, a decrease of 66% in agricultural areas; an increase of 312% in the residential areas has been found from year 2005 to 2017.Entropy Method of buffer analysis shows that the urban development in Jabalpur is random and going in an unplanned manner. The extension of CBD playing vital role to extent the city boundary. The urban sprawl results development of sub urban area.

SUGGESTION

The problems faced due to urban sprawl, it is suggested that the town planners and policy makers should coordinate with the academicians, geographers and NGOs. The city development plan should prepare according to sprawl.

ACKNOWLEDGEMENT

I would like to express my special appreciationand thanks to my advisor Professor Dr. Alok Sharma, you have been a tremendous mentor for me. I would like to thank you for encouraging my research and for allowing me to grow as a research scientist.

REFERENCES

1. V. Merwe and J. Hendrik, "GIS-aided land evaluation and decision making for regulating urban expansion: A South African case study", GeoJournal, Springer, Vol No. 43, 136-145,1997

2. H. Samant and V. Subramanyan, " Land use change in mumbai-Navi Mumbai Cities and its effects on the drainage basins and channels- A study using GIS", Journal of the Indian society of Remote sensing, Vol No. 26,137-178, 1998.

3. B. haack and A. Rafter, "Urban growth analysis and modeling in the kathmandu valley, Nepal", Habitat International, Vol No.30, 1057-1067, 2006.

4. A llen, P.M. and Sanglier, M., "A dynamic model of urban growth: II", Journal of Social and Biological Systems, 2 (4), (1979): 269-278.

5. B esussi E., "System Analysis of Urban Sprawl by Experts, in the case cities", Sprawling Cities And TransporT: from Evaluation to Recommendations (SCATTER), Work package 2, Version 1.0.,(2002).

6. G eertman S., and Stillwell J., "Planning support systems: an inventory of current practice", Computers, Environment and Urban Systems, 28, (2004): 291-310.

7. K hawas, V., "Trend in Urbanization and Urban Growth in the NorthEastern Indian Hills – The Case of Manipur, Sikkim and Tripura", (Ahmedabad, India: Centre for Environmental Planning and Technology, 2003).

8. N ational Institute of Urban Affairs, "Carrying Capacity based Regional Planning", In: B. N. Singh, Shipra Maitra and Rajiv Sharma (Eds.), Urban Environmental Management: The Indian Experience, (New Delhi, India: Human Settlement Management Institute, HUDCO, 1996).

9. A.Ibrahim and M. Sarvestani," Urban spraw pattern recognition using remote sensing and GIS- case study shiraz city, Iran", Urban remote sensing joint event, 2009.

10. P. Wadell, " The Oregon prototype metropolitan land use model", ACSE Conference, Portland,Oregon, 1998

11. Http://wikitravel.org/en/Jabalpur