A Review Paper on Urban Sprawl Assessment using Shannon's Entropy

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Abstract - *Urban sprawl is an issue that has allocated many discussions to itself in academic, policy making and government departments. Although sprawl is an American phenomenon, however it ought to be indicated that it is unique by using environmental, economic, social and political situations. In latest decades, urban boom has no longer been adopted with residents needs and due to this process; many lands were applied for construction. Regarding to mentioned issues in cities, this text tries to surveys the consequences of sprawl by way of precise cognition of characteristics and reasons and introduces appropriate guidelines at the give up on it. Controlling travels, participation in providing infrastructures costs, controlling boom and protection of lands and redevelopment of inner-core regions are a number of proposed policies.*

Key Words: Urban Sprawl, Shannon's Entropy, Compact City.

1. INTRODUCTION

The study of urbanisation has interest from a wide range of experts. The multidisciplinary scope of the theme invokes the interest from ecologists, to urban planners and civil engineers, to sociologists, to administrators and policy makers, and finally the common man. This is because of the large amount of activities and processes that take place in the urban ecosystems every day. Thus when the early humans evolved they settled on the banks of the rivers that downed the advent of civilisations. An unplanned increase in the population complimented with creativeness, humans were able to invent wheel and light fire, created settlements and started lived in forests too. An unprecedented population growth and migration, an increased urban population and urbanisation is unplanned. More towns and cities bloomed with a change in the land use along the many of landscapes and ecosystems found on earth. Today, humans can boast of living under a wide range of climatic and environmental conditions. This has further led to humans contributing the urban centres at almost every corner of the earth. These urban ecosystems are a consequence of urbanisation through rapid industrial centres and flourishing up of suburban colonies, also became heart of economic, social, cultural, and political activities.

1.1 Urban sprawl - spatial and temporal changes: pattern assessment

Mapping urban sprawl provides a "picture" of where this type of growth is occurring, and helps to identify the environmental and natural resources threatened by such sprawls, and suggests the likely future directions and patterns of sprawling growth. Analysing the sprawl over a period of time will help in understanding the nature and growth of this phenomenon. Ultimately the power to manage a sprawl resides with local municipal governments that vary considerably in terms of will and ability to address sprawl issues.

1.2 Consequences of Urban Sprawl

There is no doubt that urban sprawl exists in most of the cities nowadays. For many, a suburban home or apartment is a very comfortable place to live in. To those who have recently escaped from the inner city, the suburbs are wonderful places. For most people the rise in affluence has meant a better, not a worst, existence, and they look upon their much despised 'suburban middle-class lives' as fulfillment rather than deprivation." The consequences and significance of such sprawling, average or good are evaluated, based on its socio-economic and environmental impact. Urban sprawl, according to Cornell University's Department of Development Sociology, "is generally defined as the increased development of land in suburban and rural areas outside of their respective urban centres." Sprawl is most often characterized by low-density development marked by detached single-family homes, strip malls and reliance on the automobile for transportation. Urbanists, particularly those associated with "new urbanism" and "smart growth" movements, have roundly criticized urban sprawl for a variety of reasons

2. Measuring Urban Sprawl

To understand the complexity of a dynamic phenomenon such as urban sprawl; land use change, urban sprawl pattern and computation of sprawl indicator indices were determined. Mapping urban sprawl provides a picture where this type of expansion is occurring, and also helps to identify the ecological situation threatened by such sprawl

The characteristics of land use / land cover, drainage network, roads and railway network and the administrative boundaries from the toposheets were

digitized. Individual layers for each character were digitized.

The standard processes for the analyses of satellite imagery such as extraction, restoration, classification, and enhancement were applied for the present study. The Maximum Likelihood Classifier (MLC) was employed for the image classification. The original classification of land-use of five categories was aggregated to vegetation, built-up (residential & commercial), agricultural lands and open land and water bodies. Area under built-up theme was recognized and the whole built-up was digitized; this vector layer gave the urban area of 2000 to 2018. Further, by applying vector analyses, the built-up area under each ward was calculated.

3. Built-up area as an indicator of urban sprawl

The percentage of an area covered by impervious surfaces such as asphalt and concrete is a straightforward measure of development (Barnes et al, 2001). It can be safely considered that developed areas have greater proportions of impervious surfaces, i.e. the built-up areas as compared to the lesser-developed areas. The proportion of the total population in a region to the total built-up of the region is a measure of quantifying sprawl.

Considering the built-up area as a potential and fairly accurate parameter of urban sprawl has resulted in making considerable hypothesis on this phenomenon. Since the sprawl is characterized by an increase in the built-up area along the urban and rural fringe, this attribute gives considerable information for understanding the behavior of such sprawls. This is also influenced by parameters such as population density, population growth rate, etc.

4. Shannon's Entropy

The term Entropy is most frequently used while describing the quantity efficiency of elements. Entropy is related to the expansion of the spatial variable in a given area or limit, which was given by Shannon's Entropy. This method is useful to measure and distinguish types of sprawl. The Entropy method is beneficial with GIS because of simplicity and uncomplicated integration. As an important exercise, the Shannon's entropy approach (Yeh and Li, 2001 and S. Shekhar 2005) was quantified to detect the urban sprawl phenomenon. Entropy value varies from 0 to 1. If the distribution of built-up is most concentrated in one area, the lowest Entropy value is 0. Distribution of built-up across space will give the maximum Entropy value 1. This Entropy (E_t) method could be calculated using following formula given in figure 1.

$$E_t = \frac{\sum_{j=1}^{m} PDj\left(\log\left(\frac{1}{PDj}\right)\right)}{\log(m)}$$

Where $PDj = \frac{Dj}{\sum_{j=1}^{m} Dj}$

Fig -1: Formula of Shannon's Entropy

Dj is the density of land growth. That equals to quantity of Built-up land divided by the total quantity of land in the j th zone in the total of m zones. While using Entropy to measure the distribution of a physical occurrence, the difference on entropy among two different time periods of time can be used to indicate the change in the amount of circulation of urban sprawl.

$$\Delta E_t = E_t(y+1) - E_t(y)$$

Where ΔE_t is the difference of the relative entropy values between two time periods, $E_t(y+1)$ is the relative entropy value at time period $y+1$, $E_t(y)$ is the relative entropy value at time period y.

5. THE ON-GOING RISE OF URBAN SPRAWL

In one of study, the calculation of Shannon's entropy measure indicated that Solapur city continue to sprawl from 1992 to 2012. The entropy value for 1992 is lower than that of 2012. Table 1 shows relative entropy. The analysis of entropy value shows that, urban sprawl in Solapur city is far serious. The Shannon's entropy values shows above 0.5, it means a higher rate of urban sprawl. The force behind the urban sprawl is rapid population growth. The city development plan should prepare according to sprawl.

Table -1: Shannon's Entropy values of Solapur city

Sr.No	Year	Entropy (Et)	△ Et
1	2002-1992	0.7888	0.0285
2	2012-2002	0.8173	0.0396
3	2012	0.8569	

Therefore this increase in entropy suggests that Solapur city is in sprawling state. This way we can quantify the sprawl for any city based on it built up area and Shannon's entropy. The causes of urban sprawl in city:

1) Extension of CBD boundary.
2) Population growth.
3) Peak land value in core area.
5) Transport facilities.
6) Highways passing through the city.
7) Increase in real estate business.

3. CONCLUSIONS

In this research paper, assessment for urban was carried out to identify the potential future growth of Solapur city. To quantify the urban sprawl, Shannon's entropy was calculated for year of 1992, 2002 and 2012 which was 0.78, 0.81 and 0.85 respectively. These increases in value of Shannon's entropy suggest that city has been sprawling at higher rate. Studies also indicate that from year 2002-2012 city has been sprawl much more that previous decade. Values are near to one which suggests city is not less compact and more sprawl. Major reason which causes

this sprawl were also indentified which are population growth and high prices of land in CBD are of city along with that less connectivity to city.

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