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QUANTIFYING URBAN SPRAWL: A CASE STUDY OF VADODARA TALUKA

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Abstract- Urban Sprawl or growth/expansion is one form of land use and land cover change in which rural areas are transformed into urban area and has been used to describe the urban environment since the mid 20th Century. It is also referred as irresponsible, and often poorly planned development that destroys green space, increases traffic, contributes to air pollution, leads to congestion with crowding and does not contribute significantly to revenue, a major concern. Methods to detect , model, and interpret urban sprawl has been addressed in recent years and are of importance to city planners , land use managers and ecologist as a component of sustainable development strategy. The integration of Remote sensing (RS) and Geographical Information System (GIS) technique is an effective tool for detecting urban sprawl and modelling. The present study aims at quantifying urban sprawl using Entropy Approach. It reflects the concentration or dispersion of spatial variable in a specified area.
Keywords- Urban sprawl, RS, GIS, Modelling, Entropy

Introduction

Urban sprawl, which is characterized by haphazard patchwork of development leads to an improper development in any city usually, happens due to land-use/land cover conversion in which the growth rate of urbanized land significantly exceeds the rate of population growth over a specified time period, with a dominance of low-density impervious surfaces [3]. Sprawl is a relatively wasteful method of urbanization, characterized by uniform low density. It is often clumsy and extends along the fringes of urban areas with unbelievable pace. Commonly, sprawl invades upon prime agricultural and resource land in the process. Land is often developed in a fragmented and piecemeal fashion, with much of the intervening space left vacant or in uses with little functionality. Sprawled areas of the city are in general ,over-reliant on the automobile for access to resources and community facilities. Aesthetically, these areas are often regarded as displeasing.

Therefore, to understand the urban growth, the city should be properly monitored from the past to present through different time series data. It is primarily because the information on the existing land cover/land use plays a major role for urban planning and management [16]. To sustain urban growth, development should be planned in a sustainable manner to fulfill all the facilities like infrastructure, drainage, water supply, sanitation etc. For the purpose of sustainability; urban areas have to be properly monitored to maintain an internal equilibrium [2].

Yeh et al [15] used Shannon's entropy, which reflects the concentration of dispersion of spatial variable in a specified area, to measure and differentiate types of sprawl. This measure is based on the notion that landscape entropy, or disorganisation, increases with sprawl. The urban land uses are viewed as interrupting and fragmenting previously homogenous rural landscapes, thereby increasing landscape disorganisation. [7] used Shannon's entropy for characterising urban sprawl of Hyderabad City. In an attempt to map the sprawling trends and changes in the urban core, [5] used Landsat-MSS and IRS LISS-II data through visual interpretation techniques for analysis and identified the trends of emergence of sprawl along transportation network for Surat and Ahmedabad cities. [10] used GIS, remote sensing, and landscape metric techniques to quantify urban sprawl by measuring densities and spatial distributions of built-up land. Using landscape metrics that show densities of urban land and connectivity of that land, the authors were able to reasonably classify different types of urban sprawl: cluster, leapfrog, and linear [10]. This technique for quantifying urban sprawl is extremely adequate based on the assumption that it is the pattern and spatial distribution of urbanization that is the key component to urban sprawl. An attempt to monitor the urban growth over a time based upon density gradient method and evaluates its usefulness to monitor the urban dynamics with a specific case study of Indore city [1].

Pattern and extent of sprawl could be modeled with the help of spatial and temporal data. GIS and remote sensing data along with collateral data help in analyzing the growth, pattern and extent of sprawl. With the spatial and temporal analyses along with modelling it is possible to identify the pattern of sprawl and subsequently predict the nature of future sprawl. This work brings out the extent of sprawl taking place over a

period of nearly three decades using GIS and Remote Sensing. The study also attempts quantifying sprawl integrating Entropy Approach.

Methodology

Study area

The study is confined to Vadodara Taluka which lies between 22°05' and 22° 30'north and 73°0' and 73°25'east longitude comprising 672 sq.km. area. In 2001, out of 17.06 lakh population in Vadodara taluka, 87.5% lived in the urban area and 12.5% population in rural area (Census 2001). Rapid urban development and increasing population and economic growth is observed in the area. There is thus, increased pressure on land, water and environment. Many problems of the fragmented conversion of land use are experienced. The cause of such changes may be many and varied, but the important ones are the industrial development and growing pressure on land.

DATA

The study involves two sets of data:

1. Remote sensing Data: Land Sat data of 1978, 1990 and 2001 is used for identifying urban sprawl
2. Collateral data: SOI sheets , Population data (Census records of 1981,1991 and 2001)

Entropy Measurements

The Shannon's entropy can be computed to detect and quantify the urban sprawl phenomenon. The Shannon's entropy $\mathbf{H_n}$ is given by

$H' = -\sum P_i * \log_e (P_i)$

Where

P_i=Proportion of the variable in the i^{th} zone (proportion of built up area in village to the total built up area for a given period)

n= Total number of villages in the taluka

The value ranges from 0 to Log n

Where Log n =Maximum limit of Entropy

Here if the value is closer to zero-than the distribution is very compact, if the value closer to

Log (n) than the distribution is dispersed and large value of entropy indicates urban sprawl[11].

Built-up area is generally considered as the parameter of quantifying urban sprawl [3, 13], It is quantified by considering the impervious or the built-up as the key feature of sprawl, which is delineated using toposheets or through the data acquired remotely. It can be safely considered that developed areas have greater proportion of impervious surface s i.e. the built up area compared to lesser developed areas. Further, the population in the region also influence sprawl. The proportion of the total population in the region to the total built up of the region measure of quantifying sprawl.

There were several categories of land use classes and all classes like (air port, industrial, dense and sparse built up area were merged as built up area for years 1978,1990 & 2001) while fallow land, waste land, water bodies were not included in built up area. By intersecting 1978, 1990 and 2001 maps with base map of villages total area and no. of villages where land use change is observed is quantified.

Result and discussion

The inexorable growth of urban population in the coming decades presents a rare opportunity to assure an acceptable standard of living for the urban people [4]. Despite extensive efforts to improve the living conditions and basic amenities of the urban population, the number of badly sheltered lives in villages, still the urban growth has reached phenomenal proportions and continued to present almost impossible problems for the urban planners.

The result shows that built up area in 1978 was 72.66 sq.km which has increased to 158.09 sq.km by 2001 i.e. an increase of 84.93 sq.km in 23 years and on an average at rate of 3.9 sq.km/yr **Fig.(1):**. whereas it is seen the rate of growth of built-up area has increased at a rate of 4.5 sq.km/yr during 1990-2001 which may be attributed to the development of economic sources and city infrastructure **(Table 1).** The population increase rate was 43080/year in the period of 1990-2001. The entropy values are presented in **(Table 2.)** It is observed that the values are ranging from 1.50to 2.16. **Fig.(2).**

Conclusion

The calculated Shannon's entropy for built up area of the taluka confirms that the development is more or less compact as the entropy for 2001 is 2.16 < 4.03(i.e. Log n value). Thus, there is sufficient of scope to control the future growth. Driving forces like population growth, economic growth, unsuccessful enforcement of land use planning will else lead to possible considerable impacts on environment in general and. agriculture in particular, if the growth is not regulated.

The study shows that entropy is a good indicator to identify and quantify the spatial evils of land development. The study also demonstrates the potential of RS and GIS techniques in the spatio-temporal analysis of urban growth trends and their consequences on the lands adjoining the urban areas.

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Fig.(1): Urban Sprawl in Vadodara Taluka

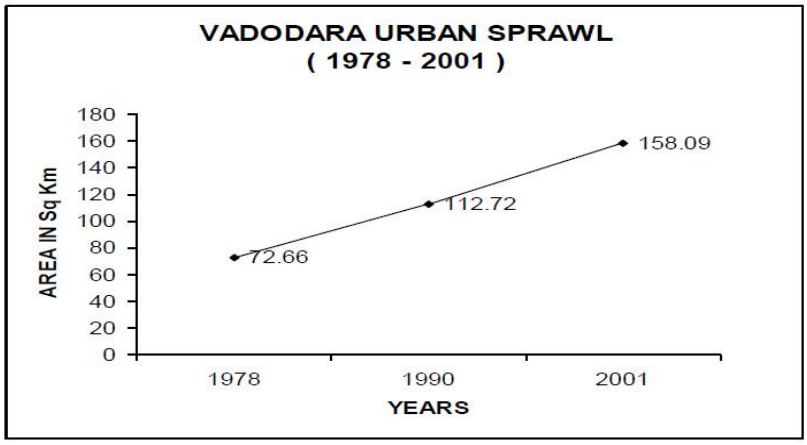

Fig.(2): Entropy Change in Vadodara Taluka (1978-2001)

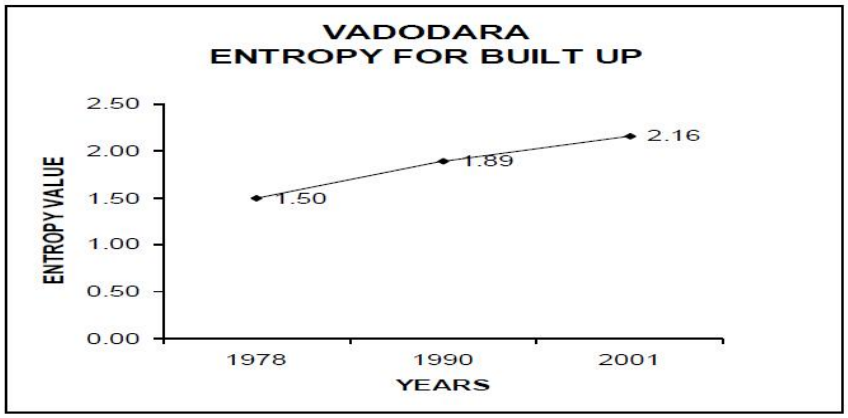

Table.1. Built-up Area in the Vadodara Taluka

Year	Built up Area (sq km)	Change Built up Area (sq km)
1978	72.66	-
1990	112.72	40.06
2001	158.09	45.37

Table .2. Shannon's Entropy

Year	Area (sq km)	No of Villages (N)	Entropy H'	Ln (N)	H/Ln (N)
1978	72.66	22	1.50	3.09	0.48
1990	112.72	42	1.89	3.74	0.51
2001	158.09	56	2.16	4.03	0.54