Mapping and evaluation of urban sprawl using an integrated approach of Remote Sensing and GIS Technique (Review)

Manish K Tiwari
Research Scholar
manrs.2008@gmail.com
Centre for Remote Sensing and GIS Maulana Azad National Institute of Technology (MANIT) Bhopal M.P. India

Dr. Aruna Saxena
Proff. & Head TNP
saxena.aroona@gmail.com
Centre for Remote Sensing and GIS Maulana Azad National Institute of Technology (MANIT) Bhopal M.P. India

Dr. Vivek Katare
Head Landuse Division
katarevivek@yahoo.com
M.P. Council of Science & Technology (MPCST)
Bhopal M.P. India

ABSTRACT

Rapid urban development and increasing land use changes due to population and economic growth in selected landscapes is being witnessed of late in India and other developing countries the cities are expanding in all directions resulting in large-scale urban sprawl and changes in urban land use. The spatial pattern of such changes is clearly noticed on the urban fringes or city peripheral rural areas, than in the city centre. In fact, this is reflected in changing urban land use patterns. There is an urgent need to accurately describe land use changes for planning and sustainable management. In the recent times, Remote Sensing and GIS is gaining importance as vital tool in the analysis and integration of spatio-temporal data's.

Keywords: - Urban Sprawl, Landuse/Landcover, Remote Sensing, GIS.

INTRODUCTION

Urban sprawl is a worldwide phenomenon. In developed countries about 3,000 sq Km area of agricultural land is covered every year by urban growth. Japan has lost about 7.3 percent of its agricultural land to buildings and roads. European countries like Norway and the Netherlands have lost 1.6 percent and 4.3 percent respectively. (O.E.C.D.1979). Similarly Allen, (1980) reported that the U.S.A. and Canada have lost 4,800 Sq km. of prime cropland under roads, building and reservoirs and other non-farm uses. In India also 180,000 sq km (5.5 percent of the total area) is under other non-agricultural uses, which only includes land under industrial uses, residential, commercial, transportation and vacant land. Deshpande (1992) has recognized the process of urban sprawl like the "floating water" which occupies every place available for its spread. Prakash (1985) has identified sprawl as "haphazard physical explosion", while markedly has described it as not only "haphazard" but as "disorderly and discontinuous development". According to the Oxford Dictionary, the word sprawl is defined as 'to spread out or stretch out (something) in a wide or

straggling manner'. Longman Dictionary of Contemporary English defines sprawl as follows: 'To stretch out awkwardly or to spread ungracefully, e.g., the city sprawls for miles in each direction'. Awkard and irregular spatial growth of a town or city mainly due to increase in population can be termed as urban sprawl. Hence, any area, which is under the jurisdiction of a municipal corporation, cantonment, or any notified town, and exceeds its administrative boundary and grows outward without any check, is considered to be a sprawl. The area, which the increasing population occupies, will indicate the nature and type of sprawl. The cities are growing in all directions resulting into changes in urban land use, reflected on the border or peripheral rural areas as compared to that of the city centre. In the midst of urban and industrial expansion, there is increasing pressure on important resources predominantly in the metropolitan cities. Urban spread out has been blamed for disorganized use of land resources and energy and large scale intrusion onto the agricultural lands. As the cities enlarge, agricultural land and habitats like forest etc. are transformed into land for housing, roads, industry etc.

The result is increase in the built up area and related changes in the urban land use patterns, causing loss of productive agricultural lands, forest cover, other forms of greenery, loss in surface water bodies, depletion in ground water aquifers and increasing levels of air and water pollution; causing environmental problems.

Thus the problem of expanding of city centers is complex and Complicated Land use change is the end result of numerous interacting factors arising from different levels of associations of human-environment systems, which differs in time and space. Driving forces can be slow with long turnover times, which decide the boundaries of sustainability. Changes are generally driven by a combination of factors that work progressively and factors that happen irregularly. Thus it is necessary to measure and monitor land use changes over space and time for sustainability. The accessibility of high resolution data has been helpful for mapping spatial features, providing dependable, suitable, and precise data. GIS provides diverse methods to create spatial planning scenario for decision making.

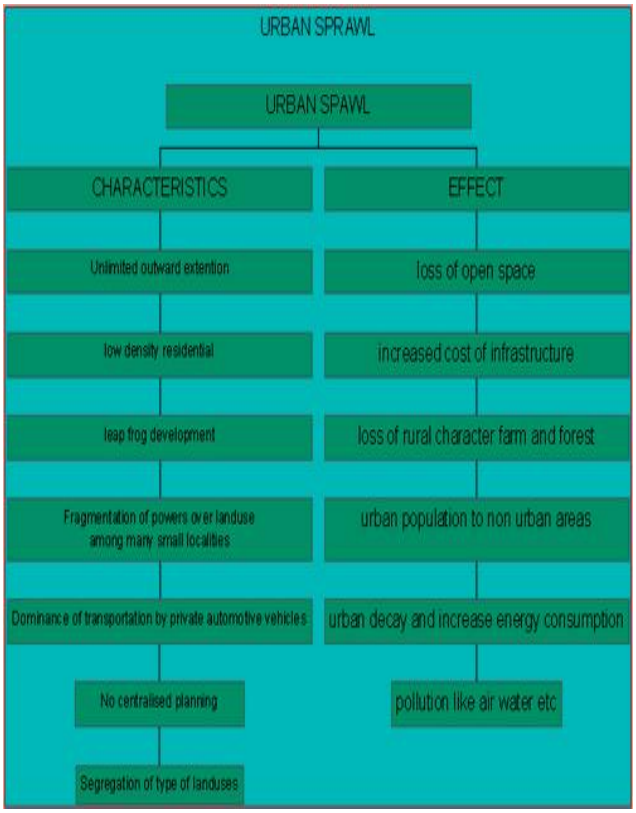
DEFINITIONS OF URBAN SPRAWL

Opinions are far from various on the concept of urban sprawl. However, in the present study urban sprawl has been considered as the aerial extension of urban area over the adjacent rural area. It can be measured in term of acres of land or in terms of percentage, which are known as actual sprawl or percentage sprawl respectively. The percent sprawl refers to the percentage increase in the aerial strength of the urban center over a period of time. There are few definition which are non-technical in nature but do convey the meaning of the word sprawl. According to the Oxford Dictionary, the word sprawl refers 'to spread out or stretch out

(something) in a wide or straggling manner' while the Longman Dictionary of Contemporary English defines sprawl as: 'To stretch out awkwardly or to spread ungracefully, e.g. the city sprawls for miles in each direction'. A ward and irregular spatial growth of a town or city mainly due to increase in population can be termed as urban sprawl. Hence, any area, which is under the jurisdiction of a municipality corporation, cantonment, or any notified town, which exceeds its administrative boundary and grows outward without any check, is considered to be a sprawl. The process and pattern, in which the increasing population occupies, will indicate the nature and type of sprawl.

The infilling of vacant land within any area is an example of under-bound sprawl. Although there are many definitions of sprawl, a central component of most definitions and of most people's understanding of "Sprawl is the spreading out of a city and its suburbs over more and more rural land at the periphery of an urban area. This involves the conversion of open space (rural land) into built-up, developed land over time".

CHARACTERISTICS AND EFFECT OF URBAN SPRAWL



TYPES OF SPRAWL

Urban sprawl may be classified on various bases both qualitative as well as quantitative. In the present study the urban sprawl of the research area is mainly classified qualitatively on the basis of:

(A) The geometry of growth.

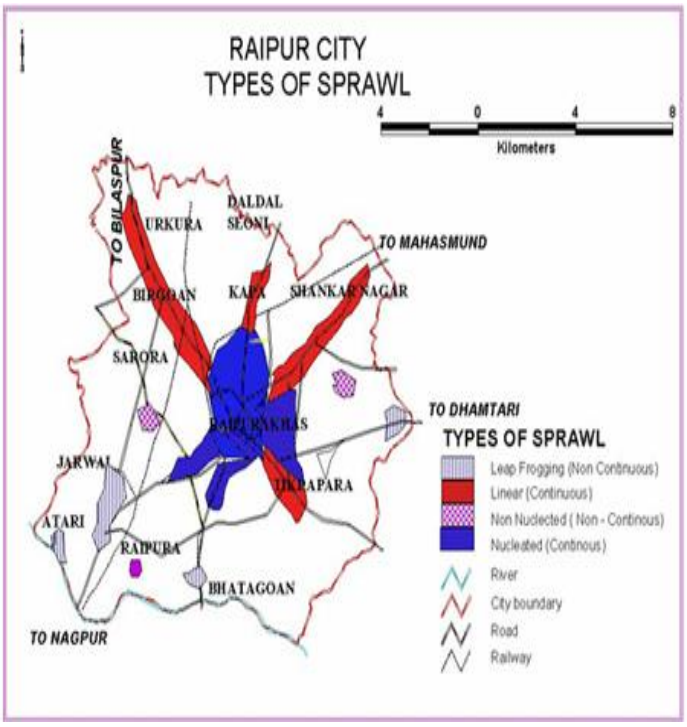
(B) Density of built up land.

(C) Involvement of nature or man and.

(D) spilled out of built up area with respect to administrative boundary.

EXAMPLE OF THE TYPES OF SPRAWL

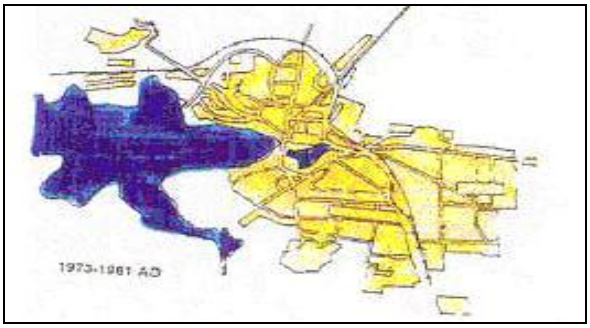
A brief account of these is given here and attempt has been made to show four types of urban sprawl in Raipur city.

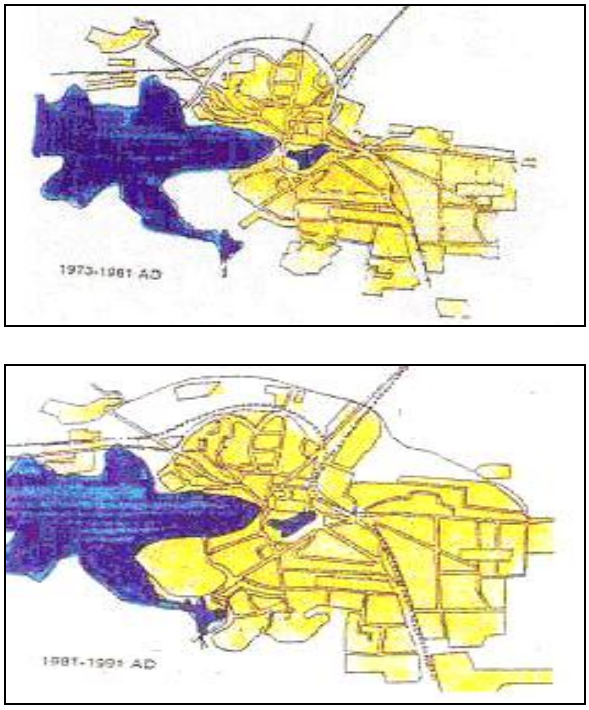


CONCEPTUAL FRAMEWORK

The level of urbanization refers to the increase in the proportion of people living in towns and cities, while urbanization is considered to be an important process of socio-economic development and cultural transformation. All over the world cities and towns are expanding by natural increase and in migration. Urbanization occurs because people move from rural areas (countryside) to urban areas (towns and cities).

It usually occurs more when a country is still developing. The process of urbanization expresses itself through a distinct set of land use and type of human behavior. It brings about phenomenal socio-economic transformation in the surrounding rural areas. The propagation of urban influence is not uniform. It has marked differential radial tendency measurable in terms of demographic component and land use assemblages. The future prospect of the city or town depends on that belt where the operational part of the process of urbanization has already commenced during the preceding two decades. The inexorable growth of urban population in the coming decades presents a rare opportunity to assure acceptable standards of living for the urban people. Urban encroachment is a process of actuation and occupation of lands for the expansion of urban activities/ functions. Such encroachment adds to the town / city area which has been taken over from the surrounding rural lands. The acquired land is generally utilized for non-agriculture purpose. The land left unutilized is generally devoted to crops meant for city markets such as vegetables and cash crops. In this process periphery of the city had been continuously advancing, bringing the villages of rural areas in the urban fold. The expansion of the city has turned many nucleated settlements with farming as their dominant economic activity into villages absolutely dependent on the city.





Example of the urban development area in Bhopal city

AIM AND OBJECTIVES

The basic aim and objectives of the study is to examine the process of urban sprawl and transformations of occupational pattern. In order to understand their processes, causes and consequences the following aims and objectives of the study are outlined:

1. To evaluate the urban sprawl of Metropolitan Region into using Resource sat-I (IRS-P6) data.
2. To examine the land-use/land-cover changes from Survey of India (SOI) toposheet in 1980 to recent satellite data in 2008 and to assess the rate of urban growth during this time period.
3. Utilizing the spatial and temporal data into an integrated GIS technology proves to be an efficient management system for planning and decision-making program.

These objectives are attained through the following approach: Collateral data: temporal population data from the government agencies, cadastral data from land records department and toposheets from Survey of India.

- Creation of GIS layers: digitization of built up area, drainage network and village boundaries from the toposheets (1980) for the study area.
- Remote sensing data from National Remote Sensing Agency, Hyderabad.
- Geo-correction of remote sensing data and collection of training data.
- Application of image processing techniques (temporal data – RS data) to identify the spatial changes in built up area over the period, and Environmental Modeling of these changes.

METHODOLOGY

Application of Remote Sensing technology have been identified and used as an important tool to monitor land use and surface changes. Satellite remote sensing collects multi-spectral, multi-resolution, multi-temporal data providing valuable information for understanding and monitoring the process of urban land cover changes. As it is in the digital format, it can be brought into GIS, to provide

a suitable platform for data analysis, update and retrieval. Land use can be captured both in terms of geographic location and absolute area. The growth profile obtained helps in formulation of development policies.

Data Collection

The data collection was carried out in two phases. This involved primary data collection and secondary data collection. The nature of these data and their source are shown Table 1.

Table 1: Primary and secondary data details for the study area

Segment	Details	Source
Primary Data	Toposheets	Survey of India, Scale 1:50000
	Satellite Imagery	National Remote Sensing agency (NRSA), Hyderabad
Secondary Data	Demographic details from Primary Census abstracts for different years.	Directorate of census operations, Census of India
	Village maps for the study area.	Directorate of survey settlement and Land Records, government of India

The toposheet of 1:25000 used for the current study area has the following features:

- Land use / land cover
- Drainage, water bodies, irrigation systems
- Contours and slopes
- Land geomorphology and soils
- Roads and rail network
- Administrative boundaries

Flowchart of the proposed methodology

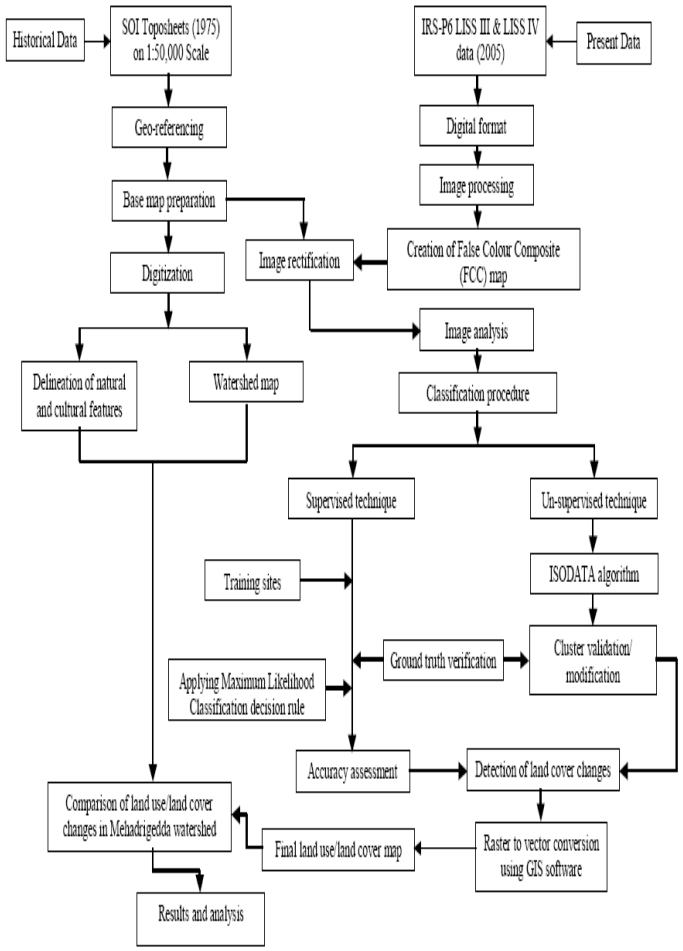


Figure 5. Flow chart showing methodology adopted for the study.

Measuring Urban Sprawl

To understand the complexity of a dynamic phenomenon such as urban sprawl; land use change analyses, urban sprawl pattern and computation of sprawl indicator indices were determined. 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 highway passing between the two cities was digitized separately and a buffer

region of 4 km around this was created using Arc GIS 9.1. This buffer region demarcates the study region around the highway. Urban sprawl over the period of three decades (1980-2008) was determined by computing the area of all the settlements from the digitized toposheets of 1980 and comparing it with the area obtained from the classified satellite imagery for the built-up theme. The vector layers were digitized from the toposheets of 1980, included themes as; highway in the buffer region, built-up area, drainage (sea, rivers, streams and water bodies), administrative boundaries, and road network. The toposheets as mentioned in first geo-registered. Since urban sprawl is a process, which can affect even the smallest of villages, each and every village was analyzed. Details of villages like taluk it belongs to, village name, population density, distance to the cities, were extracted from census books of 1979 & 1991 and were added to the attribute database. The area under built-up (for 1980) was later added to this attribute database after digitization of the toposheets for the built-up feature for each village. Satellite image – IRS data for 2008 was procured from NRSA, Hyderabad. The standard processes for the analyses of satellite imagery such as extraction, restoration, classification, and enhancement were applied for the current study. The Maximum Likelihood Classifier (MLC) was employed for the image classification. The original classification of land-use of 16 categories was aggregated to vegetation, built-up (residential & commercial), agricultural lands & open, and water bodies. Area under built-up theme was recognized and the whole built-up theme from that imagery was digitized; this vector layer gave the urban area of 2008. Further, by applying vector analyses, the built-up area under each village was calculated.

Conclusion

In the course of urban spread, valuable land is being converted for building, industry, transport facilities etc. Land being inadequate, government may need to develop policies to maintain it for intensive cropping and encourage peri-urban agriculture. An absence of any land use planning may lead to land degradation. Un-planned decisions may result into misery for large segment of the local population and destruction of valuable eco-system. Techniques for the planning and management of land resources specifically integrated and holistic will check long term quality of the land for human use, their prevention or resolution of social conflicts related to land use, and the conversion of ecosystem.

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