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Technical Note

Identification of Urban Sprawl – A Case Study of Vijayawada City, Andhra Pradesh, India

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ABSTRACT

At this moment, India is among the countries of low level of urbanization. As a result, most urban settlements are characterized by shortfalls in stock housing and water supply, urban encroachments in fringe area, inadequate sewerage, traffic congestion, pollution, poverty and social unrest making urban governance a difficult task to maintain healthy urban environment. High rate of urban population growth is a cause of concern among India's urban and town planners for efficient urban planning. Therefore, there is an urgent need to adopt modern technology of Remote Sensing and Geographic Information Systems to collect, to analyze, to model and to link the overall planning process to make planning process more effective and meaningful. Vijayawada is the second largest city in the state of Andhra Pradesh and in the close vicinity of newly constructing Capital, Amaravati of the newly formed state, located on banks of river Krishna is taken as a case study for observation of sprawl using a change detection method. It is found that Shannon's entropy analysis method effective qualitative measure to identify the sprawl of Vijayawada city.

1. Introduction

Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a progressive concentration of population in urban unit. During the last fifty years the population of India has grown two and a half times, but urban India has increased nearly five times. In 2001, 306.9 million Indians (30.5%) were living in nearly 3,700 towns and cities spread across the country, and it is expected to increase to over 400 million and 533 million by 2011 and 2021 respectively. The last two decades have witnessed high population growth in India's urban areas. Urban centers are the hub of the manufacturing, services and trade. As a result, more people are migrating from rural areas to urban centers, making municipal governance a very complex issue.

1.1 Urbanization Scenario and Issues Global and National

The world's population is quickly becoming urbanized as people migrate to the cities. Figure 1 (WORLD RESOURCES INSTITUTE) shows the urban population growth between 1950 and the year 2000. In 1950, less than 30% of the world's population lived in cities which grew to 47% in the year 2000 (2.8 billion people).

According to UN reports, half of the world's 6.7 billion people are expected to live in urban areas by the end of

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2008. The world population is expected to increase to 9.2 billion, by 2050. By that time, urban population is expected to rise from nearly 3.4 billion in 2008 to 6.4billion in 2050. Also, these are global figures , when the data are disaggregated by world region, they show marked differences in the level and pace of urbanization in the Americas, Europe, and Oceania, the proportion of people living in urban areas is already over 70% (Cheng, J. and Masser, I, 2003). Although the figures for Africa and Asia are currently much lower, 39% and 37%, respectively, many cities in those regions will double their populations in the next fifteen years. Developed nations have a higher percentage of urban residents than less developed countries. However, urbanization is occurring rapidly in many less developed in countries, and it is expected that most urban growth will occur in less developed countries during the next decade (Batty, M., Xie Y. and Sun Z., 1999).

1.2 Projected urban rural population in developed and developing countries

The urban population of India according to the population census 2001 was 285 million and 377 million spread over 5161 urban agglomerations/towns. The urban population has been growing at a much higher rate than the total and the rural population as a result; its proportion in the total population has increased from around 11 % in 1901 to about 28 % in 2001 and it was 31.16% in 2011. Cities with over 5 million inhabitants are known as megacities. There were 41 in the year 2000. This number is expected to grow as the population increases in the next few decades (Bosselman, Fred P., 1968). It is predicted that by the year 2015, 50 megacities will exist, and 23 of these are expected to have over 10 million people. Will help the rapid growth of urban areas is the result of two factors (Alberti M., 2005) natural increase in population (excess of births over deaths), and migration to urban areas. Migration is defined as the long-term relocation of an individual, household or group to a new location outside the community of origin. Today, the movement of people from rural to urban areas (internal migration) is most significant. Although smaller than the movement of people within borders, international migration is also increasing (Elena G.I., and Nancy E. B., 2004). Both internal and international migration contribute to urbanization. So, as we understand, although one of the key geographical developments over the last two centuries has been that of urbanization, it has also raised various issues and problems. It is essential for governments, planners and researchers to understand and study the urbanization process and its associated problems.

Modern technologies like Remote Sensing and Geographical Information Systems (GIS) can help resolve some of the urban issues and also acquire best approaches for urban planning, governance and management (Burrough, Peter A. and Rachel A. McDonnell, 1998). Remote Sensing provides reliable base data and its location at regular intervals and provides base for plan monitoring and implementation. In turn the GIS will be used for data maintenance, extraction with variety of inbuilt data manipulation to help the planners and managers for their good governance. Further it helps the merging of graphic and non-graphic information and will be manipulated simultaneously in a related manner. To testify the urban growth magnitude and pattern Vijayawada city of Andhra Pradesh is taken in to consideration as a case study

1.3 Study Area

Vijayawada is located at a Latitude of 160 31' North and Longitude of 800 37' East (figure 1). Vijayawada is one of the thirty-five metropolitan cities in the country, is the second largest city in the state of Andhra Pradesh after Visakhapatnam, located on banks of river Krishna. Vijayawada has historically, culturally, politically, socially and educationally active place in Andhra Pradesh State. The Vijayawada Urban Agglomeration has a population of 1.01 million as per 2001 census and 1.49 million as per 2011 census. Vijayawada is a major road and railway junction connecting north and south India. The Municipality of Vijayawada was constituted on 1st April 1888 with an area of 30 sq. Km, and was upgraded as a selection grade in the year 1960. The municipality was upgraded to a corporation in 1981. With the merger of Gunadala, Patamata and Bhavanipuram village panchayats, and two villages Payakapuram and KundavariKandrika in the corporation in 1985, the total area of the corporation went up to 58 sq. km. The city is divided into 59 political wards. An elected body headed by the Mayor performs the administration of the Corporation.

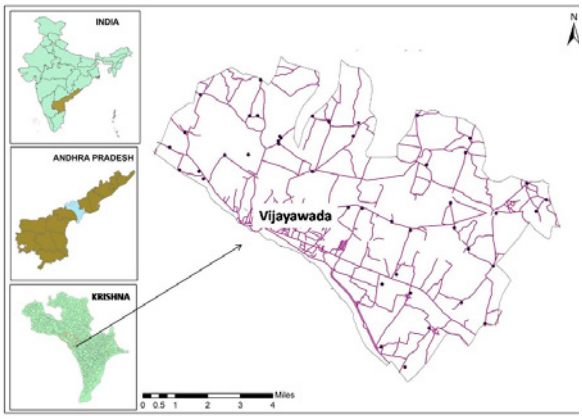

Fig. 1. Study area

2. Data, Products and Procedures

To achieve the above objects, the following necessary data and its supplements are taken into consideration. Further a systematic methodology and procedure is developed to obtain a desirable results of the study.

2.1 Data Products

The Perspective Plan is a long term (20-25 years) written document supported by necessary maps and diagrams providing the state government with the goals, policies, strategies and general programmes of the urban local authority regarding spatio-economic development of the settlement under its governance (Barr. S., and Barnsley, M., 2000).

Table 1. shows guidelines by Ministry of urban development(MUD), Government of India(GOI) for required mapping scale for various plans. In this study Survey of India Topo sheets of scale 1:50,000, numbers 65D10, 65D11, 65D14 and 65D15 and the Satellite data product of LISS-IV sensor data for the year 2008 and 2014 were used.

2.2 Urban land use classification criteria

Classifications, therefore, an activity of sub-dividing a group of objects in two or more groups, i.e.to arrange objects in to classes according to some system or principle (Aggrey Daniel MainaThuo, 2010). This can be based on activity, economic function, physical appearance, or simple land cover. The guidelines could be:

- The classification system should be applicable overall area covering both city core and its surroundings.
- Classification should be suitable for using remotely sensed data obtained at different time periods.
- The minimum interpretation accuracy and reliability in the identification of land use should be about 85percent subject to level of (Barnsley, M.J., and. Barr, S.L., 1997) classification of different land uses.
- The nomenclature, definition and frame work to the extent possible should be compatible with existing terminologies adopted in planning agencies.
- Classification should be easier to understand and flexible.
- Aggregation of similar or multiple land use classes should be possible at different levels of requirement.
- The classes must be mutually exclusive, i.e. any geographical individual can only fall into one class.
- Wherever possible, it must be based upon quantitative criteria. The flow chart of methodology for the present study is shown in figure 2.

3. Results and analysis

3.1 Land use land cover analysis

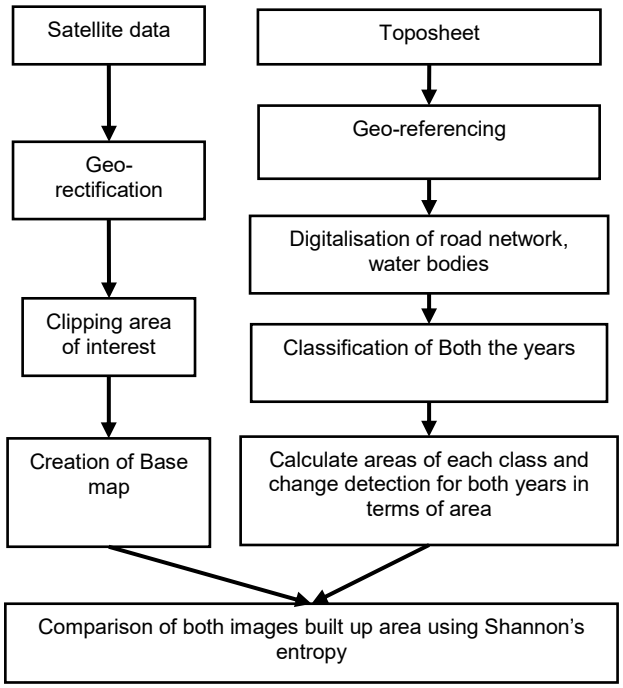

Fig. 2. Flowchart of this study

Table 1. Mapping scale for varies plans (Source: Urban Development Plans Formulation & Implementation (UDPFI) Guide lines prepared MUD, GOI 1996)

S. No	Map Type/Planning Exercise	Size of	Planning area	Data source
		Metropolitan	Small and Medium	
1.	Map of Regional Setting	1:250,000 1:100,000	1:1,000,000 1:250,000	Satellite Data, Census Data & Collateral Maps
2.	Perspective Plan	1:1,000,000 1:250,000	1:100,000 1: 50,000	
3	Development Plan	1: 25,000 1:50,000	1: 25,000 1: 10,000	Collateral Maps & Ground truth

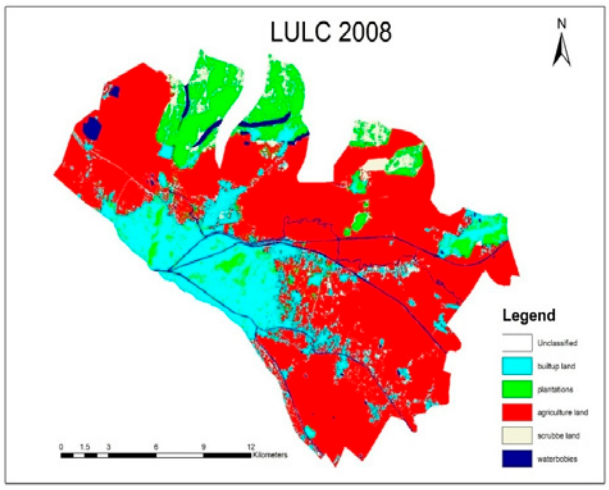

Fig. 3. Land use Land cover of 2008 data

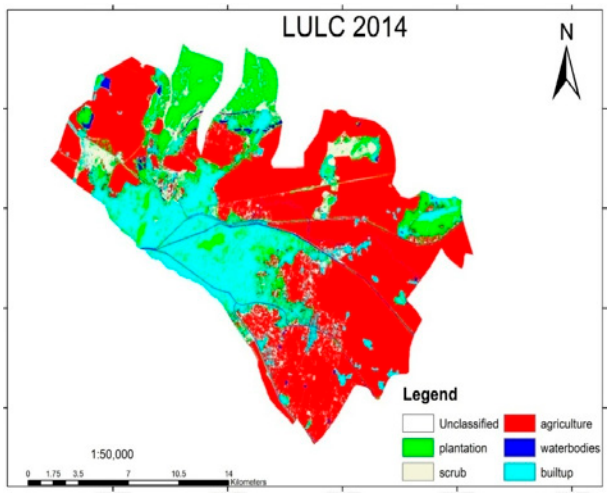

Fig. 4. Land use Land cover of 2014 data

Table 2. Class wise area for 2008 image

Class name	Area in hectares	% Area
Built up	6370.24	18.84
Plantation	3654.01	10.80
Agriculture	20791.00	61.49
Scrub land	1886.97	5.58
Water bodies	1108.12	3.27

Table 3. Class wise area for 2014 image

Class Name	Area in hectares	% Area
Built up	6440.20	19.04
Plantation	5098.34	15.08
Agriculture	19248.20	56.93
Scrub land	2061.09	6.10
Water bodies	962.51	2.85

The classification containing broad classes of information which can be extracted from satellite imageries with minimal assistance from supplemental information is done. This study contained about five land use land cover classes such as Built up land, Agriculture land, water bodies, scrub land and plantation. The digital data classification was done using ERDAS Imagine. By the analysis the classified image of 2008 contains total area of 33810.34 hectares of land in which different classified areal values are shown in the table 2 and the corresponding classified image was shown in figure 3.

Further the Classified image of 2014 contains total area of 33810.34 hectares of land and the corresponding classification and the corresponding areas are show in in the figure 4 and in the Table 3 respectively.

3.2 Land use land cover analysis

Change detection is used to highlight to identify significant differences in imagery acquire data different times playing an important role in the life cycle of GIS features and providing the capability to update feature database on new imagery. (Civco, D.L., 2002).

The Matrix operation from the GIS Analysis menu allows two thematic images or vector files of different years to be compared. By comparing two classified or vector sets of data, we can eliminate false positives due to radiometric differences. For finding out the change detection in the present study areas the LISS-IV images are used. The vector data is created in ArcGIS10.1using Editor Toolandvectordata is attributed according to different classes viz. Crop land, Low dense builtup land, Water body, High dense builtup land, Open scrub land and Rocky barren land by visual interpretation from resolution merge image. The matrix operation in GIS analysis menu present in the ERDAS software is used to find out changes between two seasons (Epstein, J., Payne, K., Kramer, E., 2002). The matrix operation compares all the classes of image with all classes of another image and shows the change or transformation of one class to another class.

The change matrix produced for the present study is shown in the figure 5 and table 4. The change detection matrix for the time period between 2008 and 2014 was produced using pixel by pixel method. The table 4 shows that the area under each of five classes are changed into other category of classes. As seen from the table 4 that the area converted to agriculture class is mostly from the area classified as scrubland. However, the scrubland which was converted into Built up land especially from the densely populated area. In some areas the agricultural land converted into to plantation area that was reflected in the figure and the table. The change matrix analysis specifies qualitative measure of land use change happened to Vijayawada city during the period from 2008 to 2014. Further the change in the built up area during this

Table 4. Change matrix of 2008 and 2014.

Classes 2008/2014	Built up	Plantation	Agriculture	Scrub land	Water body
Built up	4739.22	0	0	0	0
Plantation	838.394	4341.07	1348.78	0	0
Agriculture	704.84	370.113	16803.62	174.12	0
Scrub land	157.74	374.08	996.62	1886.97	0
Water body	0	13.07	99.18	0	962.5

duration indicates that the substantial growth of urban area of the city and it was reflected in the table and figure.

3.3 Urban sprawl measurement

After successfully performing the land use inventory and land use change monitoring, the measurement of urban sprawl that have been taken place was performed using Shannon's entropy analysis method.

Urban sprawl over the period of 2008 to 2014, almost a period seven years was determined by computing the classified areas of land use from 2008 image and comparing it with the areas obtained from the classified cartosat-1 mage. Shannon's entropy was used to capture the amount of sprawl in these time periods. Shannon's entropy (E) can be used to measure the degree of spatial concentration and dispersion exhibited by geographical variable. (Thomas, 1981). This method is used to indicate the degree of urban sprawl by examining whether land development in a region is dispersed or compact. In the present study, three zones viz; east zone, west zone, central zone are separately considered to perform the analysis. The Shannon entropy (H) is computed by:

$$\mathrm{H} = -\sum_{i-1}^{n} P_i \log P_i \qquad [1]$$

Where, H is the value of Shannon's entropy Pi is the proportion of the variable in the ith zone and n is the total number of zones. The value of entropy ranges from zero to log(n). If the distribution is maximally concentrated in one zone, the lowest value, zero, will be obtained. Conversely, an evenly dispersed distribution among the zones will give a maximum value of log(n). Relative or normalized entropy can be used to scale the entropy value into a value that ranges from 0 to 1. Relative entropy Hn, is (Thomas, 1981)

$$\mathrm{H}_n = -\sum_{i-1}^{n} P_i / \log P_i / \log(n) \qquad [2]$$

Normalized Shannon's Entropy value shown in the [2] ranges from 0 to 1. It is such a way that if the calculate Shannon's entropy value is closer to zero: the distribution is very compact and if the value closer to 1 the corresponding distribution is accounted as dispersed (Sudhira et al., 2003). Shannon' s entropy analysis is

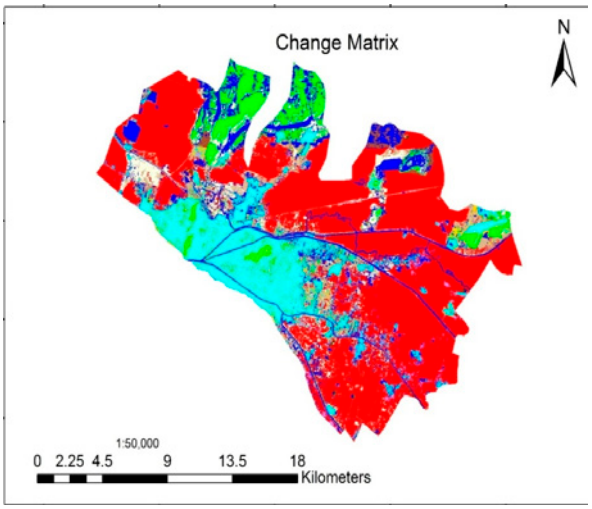

Fig. 5. Change matrix of 2008/2014

computed for Vijayawada city and its fringes areas. The study area is divided into 3 zones viz., Central zone, East zone, West zone. This sets us the number of zones is 3. Considering these zones, the Shannon's entropy is calculated for both the years 2008 and 2014 respectively. The normalized entropy value so obtained for both the years are 0.823 and 0.919 respectively, indicates the urban growth pattern of corresponding year. Therefore, Shannon's entropy(H) for the Vijayawada city showing the higher degree of dispersion of the built up. This means that, over a period of five years the urban growth has been taken dispersed form.

4. Conclusion

Urban sprawl has increasingly become a major issue in the global trend towards urbanization. Faced not only by developed countries but also by developing countries, and by large urban centers and medium and small cities alike, urban sprawl raises social and environmental concerns at the same time that shows a multiplicity of divergent trajectories that somehow defy the dominance of homogeneous characteristics around the world with the population of India increasing as ever, the pressures on land and resources are also increasing. The urban sprawl is seen as one of the potential threats to sustainable development where urban planning with effective resource utilization and allocation of infrastructure initiatives are key

concerns. This study attempts to identify such a sprawl and quantify it by few metrics. The study was carried out along the Vijayawada city and its fringe areas. Using the techniques of GIS and remote sensing the sprawl is identified from the merged images of LISS IV images of the study area. The processed spatial data along, aided to analyze analytically few urban sprawl metrics. Further, the statistical analyses helped in quantifying the same.

In case of Vijayawada city Sprawl spreading across the river Krishna it seems to be leaf frog sprawl patron. Expansion of city more rapid in east zone of poranki, peddapulipaka, chowdavaram and penamaluru. Western zone of Vijayawada sprawl is less but in places of Surayapalem and Rayanapadu can observe less sprawl but it present just near to the new capital of Andhra Pradesh Amaravati so it causes rapid growth of city in coming years.

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