Spatiotemporal Analysis Using Remote Sensing Data

P.Kalyani

Research Scholar, Dept. of Computer Science, S.V. University, Tirupati, Asst. Professor, PCET, Nellore

P.Govindarajulu

Professor , Dept. of Computer Science, S.V. University, Tirupati

Abstract

Spatiotemporal land use patterns represent the subsets of features whose instances are frequently located together in geo-graphic space. The dominance of ideology, state control and economic planning on Urban planning and developed was reduced after the economic reforms in 1978.The shift from a planned economy to a market economy is challenging Indian Urban planning. These macro political and economic changes require that urban planning methods and techniques incorporate process oriented planning. These for India, new planning approaches require the need to understand the complicated urban land development process. Geographic information system and remote sensing provided the advance techniques and methods for studying urban land development and assist urban planning. To find the spatiotemporal land use patterns of urban areas in different time periods and the changes to be detected by using land cover classification.

Keywords: *GIS, Remote sensing, Spatiotemporal patterns, land use change, spatial pattern analysis, urban planning.*

1. Introduction

Mega cities the largest category of urban agglomeration, attract considerable attention because of their population size, economic, socio-cultural, environmental and political influence and geographical complexity. Until 1975 there were just three mega cities in the world. The number of so-called mega cities increased in the period from 1975 until today from 4 t0 22, mostly in less developed regions [14].The number of cities increased to 27 mega cities until 2015 [11].The population development of the world is expected to increase continuously from 6.7 billion to 9.3 billion in 2050. But a heavy increase of mega cities creates a serious problem in India. The population of India (today 1.2 billion) has grown two and half times, but the urban population has grown nearly five times. The number of Indian mega cities will double from the current three (Mumbai, Delhi and Kolkata) to six by the year 2021, (new additions will be Bangalore, Chennai and Hyderabad), when India will have the largest concentration of mega cities in the world [5].

Then the number of six mega cities (Mumbai, Delhi, Kolkata, Bangalore, Chennai and Hyderabad) is increased by twelve by the year 2015 (new Ahmadabad, Pune, Surat, Kanpur, Jaipur and Lucknow) [26]. With the rapid increase of urban growth, makes us to face lot of socio-economic, environmental and political problems. This phenomenon will necessitate advanced methodologies such as space technologies, which help city planners, economists, environmentalists, ecologists and resource managers solve the problems which accompany such growth [12]. Urban planners need information about the rate of growth, pattern and extent of sprawl to provide the basic amenities such as water, sanitation and electricity etc. Since planners currently lack such information, most of the sprawl areas lack basic infrastructure facilities.

On the last decade, earth observation sensors developed to a stage where global maps have been made possible on low resolution (LR) from 250m to 2 Km [19]. Examples are global urban extent maps based on e.g., DMSP-OLS night-time lights imagery [7] ,MODIS data [4][20].A list, analysis and comparison of the various available global data sets is presented and discussed by Potere and Schneider [18]. However, most of them are provided for a single time step, and the cause geometric resolution is a clear restriction tracing the small-scale urban outlines, extents and patterns. Even though higher resolution sensors systems are available e.g., Land sat, spot, Rapid Eye, IRS, IKONOS, Quick Bird, World View-I and II. The provision of a global coverage or at least of a large amount of cities – is not an easy task. Limitations such as cloud coverage, on bound storage capacity, sensor utilization and sharing of the same source with other EO projects cause a several years lasting acquisition period. Furthermore, data costs and processing effort are significant. Thu, a global coverage at the scale covered by the medium (MR: here defined as on 10m to 100m) and high resolution (HR: 1M-10m) to very high resolution (VHR: <1m). EO sensors are inexistence.

Research studies on long term monitoring of the spatial effects of the urbanization are mostly based on MR (Medium Resolution) data from sensors such as Land sat or spot, having lower geometric resolution and thus allow for fewer thematic details. Different studies have also shows that radar imagery is an excellent basis for classifying, monitoring and analyzing urban conglomerations and their development overtime especially in cases of large area mapping [6].Using of MSS[Multi Spectral Scanner) data ,ETM (Enhanced Thematic Mapped data) and & Terra SAR-X Strip map data is used for monitoring urbanization in mega cities from space for analysis of 22 to 27 mega cities and their number is constantly increasing [11].Temporal and spatial

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urban sprawl, re-densification and urban development in the tremendously growing six mega cities to 12 mega cities in India, and became the largest urban agglomerations [26].
In India, by using Quick bird data of VHR (Very High Resolution <=1M i.e., 0.61M) with a sub-meter geo-metric resolution is applied for the multi-scale urban analysis of the Hyderabad metropolitan area of deriving parameters such as houses, streets, shadows, vegetation, bare soil etc., [24] [16] [17]. For the analysis of the urban patterns, first we have to classify the obtained data. The classification of the various land-sat scenes is based on an object-oriented classification procedure [23]. The first step is a multi-resolution segmentation. The second step is a hierarchical thematic classification procedure allowing mapping four different thematic classes, namely ‘water’, ‘vegetation’, ‘undeveloped land’ and ‘urban’ [2] [3].
In this paper focused on the object-oriented hierarchical approach with remote sensing, to support urban management with area-wide and up-to-date datasets in Hyderabad.

Objectives:

The main objective of the survey is to investigate the dynamics of the urban landscapes in response to rapid urbanization among the most populated and the fastest growing cities

More specifically, our objects are two:

- Characterize intra-level urban landscape transformations between time periods.
- Quantify relations between landscape transformations, urbanization patterns.

2. Study Area

To show the applicability of our approach, we will use Hyderabad, the capital of the Indian state of Andhra Pradesh, is a sprawling metropolis and cosmopolitan city with a population of 5.8 million in 2004 and a current growth rate of 2.42 percent per year. The city’s population is expected to achieve 10 to 13 million in 2020 turning it into one of the megacities of tomorrow [15].
There are a number of Industrial and commercial estates in the Hyderabad district and about belonging to the Hyderabad agglomerations which were mainly established .Main sectors include chemical and bulk drug, metals, timber, plastics, rubber and textile industry as well as electronic industry. Hyderabad hosts several major companies and public sector enterprises with central research and training institutions as well as universities and professional colleges. The dynamic city has emerged as a knowledge hub making rapid strides in information technology, biotechnology and medical care but also in tourism.
“Megacities are undergoing new dynamics and, as a consequence are facing new spatial and organizational challenges” [1]. The performance in megacities is seen as a key factor regarding global sustainable development .First targets for future development are set in Hyderabad’, master plan and in the “City Development Strategy” of 2003 [15] (established by the “ Cities Alliance” together with the UN-HABITAT and facilitated by the Administrative staff college of India, ASCI).
In our study, Hyderabad is used to detect the urban growth. The fig (1) TOPO sheet of Hyderabad is from NRSC, Hyderabad. The LISS-III data of the year 1997[27], 2007[28] and 2013[29] fig (2) (3) (4) is collected from NRSC; Hyderabad is used for high resolution analysis.

3. Data and Methods

3.1 Data:

The Land sat program represents a series of earth observation satellites that have been continuously available since 1972.Therefore this system allows for an analysis of extended time series. It started with the Multispectral-scanner(MSS) featuring a geometric resolution of 59 meters and a spectral resolution of four bands(green, red, two near infrared bands).Since 1982 the thematic Mapper(TM) has operated with 30 m geometric resolution and seven spectral bands. Since 1999 the Enhanced Thematic Mapper (ETM) has operated with an additional panchromatic band and 15m geometric resolution. Since 2002 Ikonos data of with 1m geometric resolution and since 2005 Quick bird data with 0.61m geometric resolution for finding the illegal constructions in the inner city [24].With its field of view of 185 KM the satellite is able to survey the large metropolitan areas of the study sites-thus covering in dependence of their spatial position entire areas and no cloud coverage.

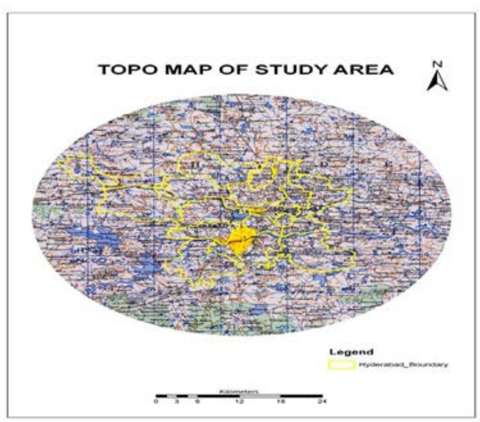


Fig1. TOPO map of Hyderabad

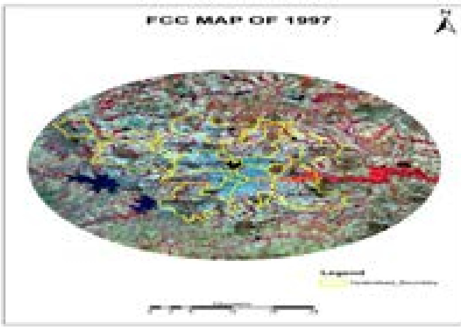


Fig2. LISS data of Hyderabad 1997

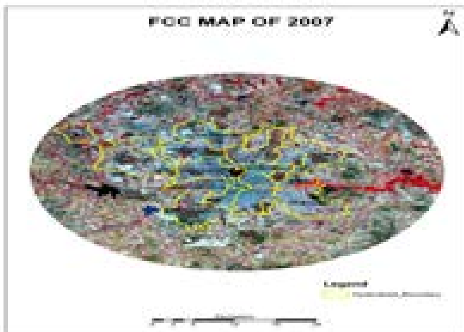


Fig3. LISS data of Hyderabad 2007

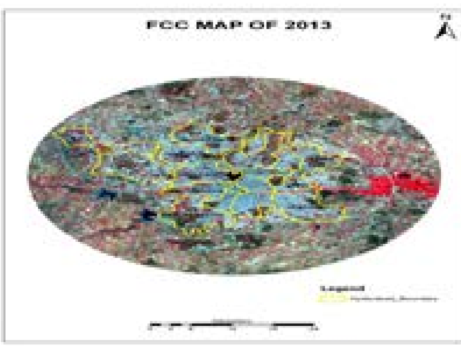


Fig4. LISS data of Hyderabad 2013

Table1: Data

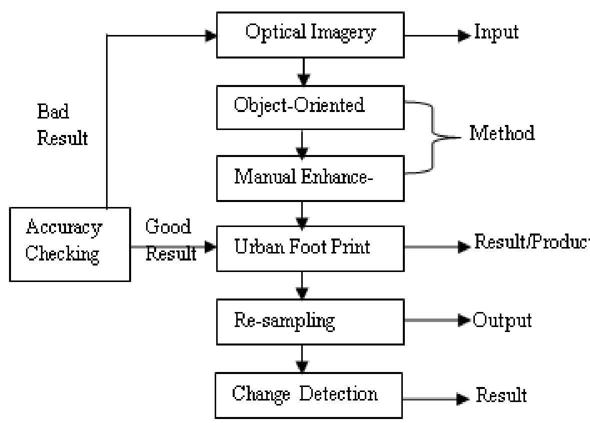
S. No	Satellites	Sensors	Date	Resolution	No. bands
1	IRS-P6	LISS-III	Feb.1997	23.5 m	3
2	IRS-P6	LISS-III	Feb.2007	23.5 m	3
3	IRS-P6	LISS-III	Jan. 2013	23.5 m	3

The level of description with Landsat features is not flooded with microscopic detail, but re-gives nevertheless the specific features of the urban system. For this purpose, the requirements for the differentiation of classes are limited to the classification of built-up and non-built-up areas.

3.2 Methodologies for Land cover classification:

One of the primary obstacles to Urban land cover classification from optical data sets is the diversity and spectral heterogeneity of urban reflectance[9][10][21][22][30].Small(2005) shows that urban land cover is extremely variable at a variety of spatial scales; he also shows intra-urban spectral variability due to a diversity of materials used for man-made structures as well as interurban variability as a result of socio-economic, cultural, historical and Environmental differences among 28 different cities across the world.
Having this obstacle in mind, we developed a user interface with a fixed processing chain with a pre-defined feature set **fig (5),** but the possibility to interactively adapt classification thresholds to the specific spectral characteristics of the particular imagery [3].

Figure 5–Flow chart of methodology for land use/land cover and change detection



The developed service chain is a semi-automatic classification procedure implemented as Defines Architect Solution. With this concept, we aimed at a straight forward classification approach being consistent, traceable and transparent for a large variety of optical Land Sat scenes at different times and parts of the world. The classification of the various Land Sat scenes is based on an object-oriented classification procedure. The first step is a multi-resolution segmentation **fig (6)** bottom up regions merging technique starting with one pixel objects. Throughout a pair wise clustering process, underlying optimization procedure minimizes the weighted heterogeneity of n h resulting image objects, where n is the size of a segment and an h, a parameter of heterogeneity. In each step, that pair of adjacent image objects is merged which results in the smallest growth of the defined heterogeneity. If the smallest growth exceeds the threshold defined by the scale parameter, the process

stops doing. So, multi-resolution segmentation allows adjustments of the scale parameter between 5 and 20 in dependence of the structure of the city.
The second step is a hierarchical thematic classification procedure allowing mapping four different thematic classes namely, 'water' , 'vegetation', 'undeveloped land' and 'urban' [1].However, in this study only the urban areas are considered. The methodology contains a hierarchical decision tree structure shown in figure Decision Tree.
Decision trees are compared of hierarchically structured decisions, which have to be traced, when classifying each segment @ pixel of an image [11].

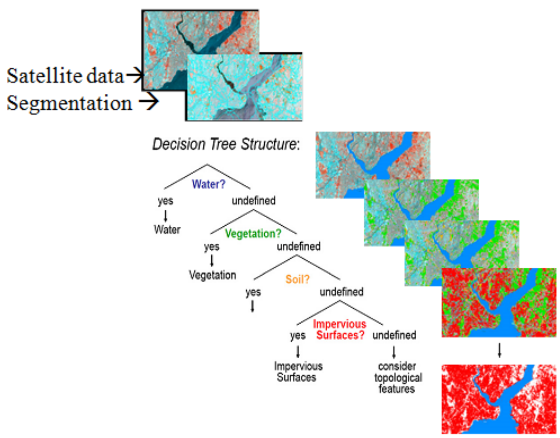


Fig 6: Schematic overview of the step-wise hierarchical structure of the classification algorithm for Land sat data

LISS data of Hyderabad for 1997, 2007 and 2013 respectively were used for the detection of recent changes of the urban extension. The data was enhanced before classification using histogram equalization in ERDAS Image 9.2 to improve the image quality and to achieve better classification accuracy. A land cover classification extracting the classes' built-up areas, non-built-up areas, vegetation and water was performed separately on both images. The main goal is to identify the urban built-up areas to measure the changes of the urban extension over the time interval. For that purpose the classification methodology is based on an object-oriented hierarchical approach. The object-oriented methodology was used to combine spectral features with shape, neighborhood and texture features [24].
A comparative analysis of land cover classification analysis [13] of land cover classifications for times t1, t2 and t3 (1997, 2007 and 2013) performed independently fig (7) (8) (9) was therefore implemented to monitor and analyze the land cover changes in the metropolitan area of Hyderabad. Pixel wise change detection was implemented to checking the land cover classes individually of the three available years.

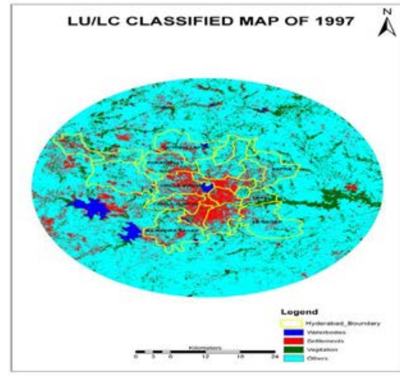


Fig7. Land use Classification of Hyderabad in 1997

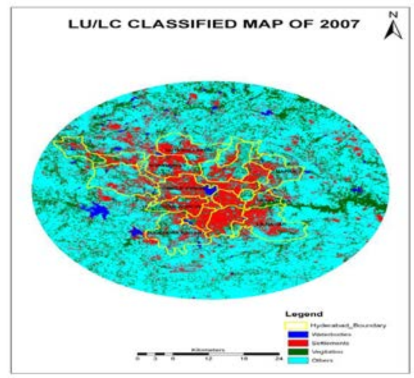


Fig8. Land use Classification of Hyderabad in 2007

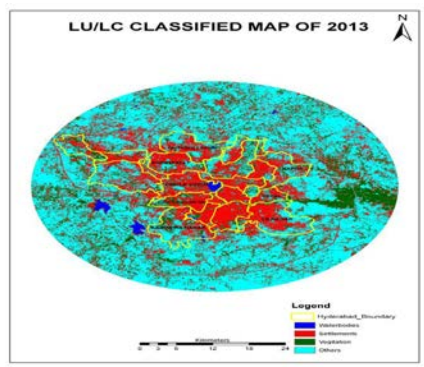


Fig9. Land use Classification of Hyderabad in 2013

4. Results, Change Detection and Discussions

The change detection allows identifying, localizing and quantifying the pattern and dimension of urban sprawl overtime. Since 1975 the population development and thus, the rate of urbanization in the mega cities outside the high developed countries were enormous [11]. At a first glance, a number of trends are immediately clear in terms of spatial dynamics of urbanization over the time period observed is the highest in developing countries. Beyond this, the spatial extents in developed countries are noticeably larger with respect to the absolute population.

The first and the most natural analysis is the measurement of spatial urban expansion over time. The quantification of urban growth for the metropolitan areas of the mega cities are calculates as relative growth.

The urban analysis aims at a holistic understanding of the dynamics of urban growth process. The different perspectives on the city of Hyderabad are caused through the different data types. The different remote sensing data contribute to a multi-level perspective within an interdisciplinary GIS database to support the information basis for sustainable urban development.

Here we used the images of Hyderabad of the year's 1997[27], 2007[28] and 2013[29] for the detection of recent changes of the urban extension. The contribution of remote sensing to the planning of sustainable urban development is two-fold. On the one end hand a spatial overview on the extension of the city and its structure change over time is presented. On the other hand a highly detailed analysis of the urban structure.

The main goal is to identify the urban built-up areas to measure the changes of the urban extension over the time interval. A comparative analysis of land covers classification for times t1, t2 and t3 performed independently was therefore implemented to monitor and analyze the land use patterns in the metropolitan area of Hyderabad. Pixel wise change detection was implemented checking the land cover classes individually of the three available years.

In figure (7) (8) (9), we find the urban sprawl of Hyderabad in the years of 1997, 2007 and 20013. In particular, the urban sprawl in the periphery and densification process in Hyderabad. New developments arise on the outskirts of Hyderabad. Nevertheless, focal points emerge in the northeast as well as in the southeast shows in the results.

Table 2:Land use of Hyderabad in different areas[Hectares] in the years 1997,2007,2013

year	Water bodies[area in hectares]	Settlements[area in hectares]	Vegetation [area in hectares]	Others[area in hectares]
1997	3294.6624	31249.2672	26994.2976	202669.8048
2007	3992.8896	47093.472	42101.3376	171019.5264
2013	1395.9936	76800.9024	33425.7984	152584.5312

From the table (2), it is concluded that the different areas of land use in different time periods. It can be seen in the form of diagrammatically representation, which can be very visible to us. And it can also helpful to detect the changes very easily.

From the above results, there is a lot of changes from 1997 to2013.The water bodies decreases from 2007 to 2013 i.e. two times decreases. And settlements increases 2.2 times from the year 1997 to 2013.The vegetation is decreases from 2007 to 2013.Next the others means non-build-up areas is decreases a lot from 1997 to 2013.Overall we consider that ,there is a lot of increases in the manmade structures i.e. urban areas on the earth. The great urban expansion in Hyderabad is represented by a 2.2 times increase in the build-up areas during the time period being monitored. This resulted in the establishment of satellite towns or suburbs around the existing city centre of Hyderabad, which was demonstrated by the rapid development of residential zones in the new suburb of Hyderabad and creation of multi-center cities. The results presented with the problems faced by the rapid urban growth, and to meet the challenges of sustainable development, it is suggested that the use of remote-sensing and GIS in conjunction with geo-spatial data is of vital importance.

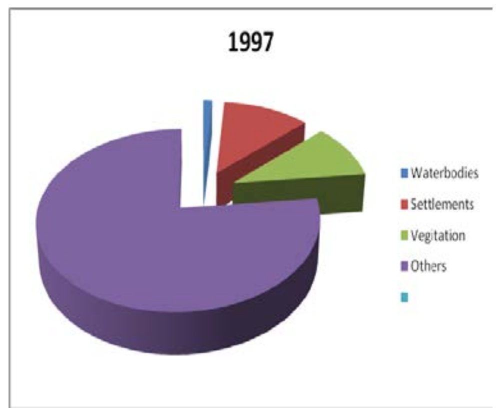


Fig10. : Land use of Hyderabad in 1997

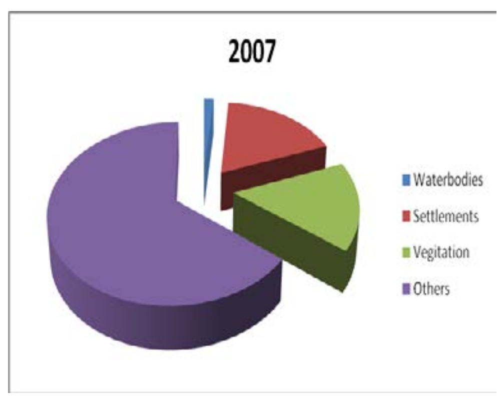


Fig11. Land use of Hyderabad in 2007

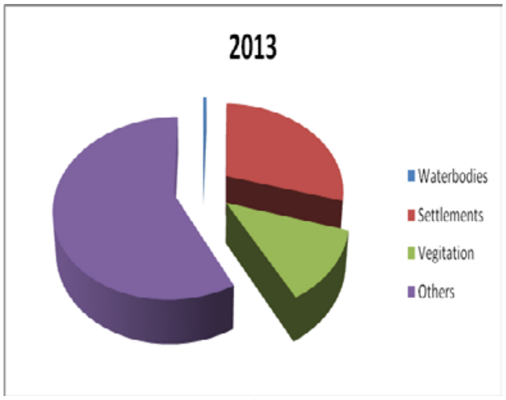


Fig12. :Land use of Hyderabad in 2013

5. Conclusions

Urbanization is primarily a complex of functional changes, it occurs near cities as well as in the rural countryside. The major problems associated with the urban centers in India are that of unplanned expansion, changing land use / land cover areas. It is regarded as a diffusion wave of changing life-style mainly controlled by the changing accessibility of places offering new opportunities. The integration of remote sensing and GIS provides a useful method for analyzing urban growth patterns, and for examining the changes in the urban land use over time. The results of this study show the relationship between certain changes of spatial land use pattern and a particular type of city planning policies. High-resolution satellite imagery (IKONOS, Quick bird) can also be used to monitor urban expansion and illegal construction over a period of time [24].Monitoring of urban sprawl over a period of time in large areas, better to use the radar data [11]i.e., TERRASAR-X data , it is easy to classify[8] .

The great urban expansion in Hyderabad is represented by a 2.2 times increase in the build-up areas during the time period being monitored. This resulted in the establishment of satellite towns or suburbs around the existing city centre of Hyderabad, which was demonstrated by the rapid development of residential zones in the new suburb of Hyderabad and creation of multi-center cities. The results presented with the problems faced by the rapid urban growth, and to meet the challenges of sustainable development, it is suggested that the use of remote-sensing and GIS in conjunction with geo-spatial data is of vital importance. Top priority should be given to the issues related to the planned development of the city. The administrative, technical and managerial staff of the urban local bodies needs to be strengthened. The officials of various government departments should be given thorough exposure and training of remote sensing and GIS for its application implementation in the urban management plans.

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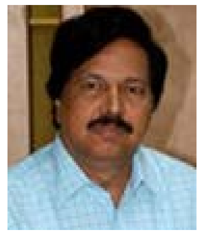
P. Kalyani received BC.A and M.C.A degrees from Sri Venkateswara University in 2003 and 2006 respectively. She is a Research Scholar in the department of Computer Science, Sri Venkateswara University, Tirupati, A.P, India. She is working as Assistant professor in PCET, ,Nellore,A.P, India. Her research focus is on Data Mining.



P.Govindarajulu, Professor, Dept of Computer Science, Sri Venkateswara University, Tirupati, India. He received his M.Tech, IIT Madras (Chennai), Ph.D. IIT Bombay (Mumbai). His area of research: Databases, Data Mining, ImageProcessing, Intelligent Systems and Software Engineering,Parallel Computing.