Multi-Scale Urban Analysis Using Remote Sensing and GIS

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Abstract

India experienced a high rate of urbanization during the last five decades leading to concentration of population in the main cities. One of the main city is Hyderabad in India is a sprawling metropolis and an incipient megacity facing structural, environmental, social and economic problems. The objective of this study is to investigate the current pattern of land use to monitor the trends of urban growth in Hyderabad between 1997, 2007 and 2013 using satellite images and GIS. Second object is to enable a highly detailed structural characteristics of specific neighborhoods', thus a multi-scale analysis of the urban area by remote sensing provides up-to-date data of the urban morphology. This enables a value-added and more holistic view to understand urban workflows and their dependencies.

Keywords: GIS, Remote Sensing, Land Use Change, Urban Growth, Multi-Scale Urban Analysis.

1. INTRODUCTION

Urbanization is a complex process of change of rural lifestyles into urban ones. It can be defined as the changes that occur in the territorial and socioeconomic progress of an area, including the general transformation of land use categories from being non-developed to develop [24]. Urbanization is a major trend in recent years all around the world. Currently, almost half of the world's population live in urban areas and the prospect is that 60% of the world's population will be urban by 2030 and the number of megacities will reach 100 by 2025 [3].

Megacities the largest category of urban agglomerations, attract considerable attention because of their population size, economic, socio-cultural, environmental and political influence and geographical complexity. But a heavy increase of mega cities creates a serious problem in India. The population of India 9today 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 [6] . 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) [18].

The economic growth in these cities and the build-up and upgrading of infrastructure does not keep place with the growth in population. Many of the inhabitants are poor and dependent on the so-called informal sector i.e., unregulated, partly illegal constructions in which the workers have no social security and carry out work at their own risk [5]. This phenomenon will necessitate advanced methodologies such as space technologies, which help city planners, economists, environmentalists, ecologists and resource managers solve the problems which a company such

growth[10]. 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. Beside the risks, urban growth can also bring opportunities for sustainable urban development. Infrastructure systems are not sufficient in place yet so there is an opportunity to implement more advanced and environmental friendly systems right from the beginning. Fast growing cities should take advantage of these chances before the problems become unsolvable [2]. New strategies for sustainable urban development should be based on multi-dimensional and holistic concepts. In 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 [16][17]. Examples are global urban extent maps based on e.g., DMSP-OLS night-time lights imagery [8] ,MODIS data [4][18].A list, analysis and comparison of the various available global data sets is presented and discussed by Potere and Schneider [15]. 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[7]. 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 [5].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 [12][14].Temporal and spatial 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 [20].

In India, by using high resolution satellite data with a sub meter geometric resolution is applied for the multi-scale urban analysis of the Hyderabad metropolitan area of deriving sub-parameters such as residential area, commercial, water, public sector etc .In this paper focused on the multi-scale approach with remote sensing, to support urban management with area-wide and up-to-date datasets in Hyderabad.

The main objective of this paper is:

- A time series allows for urban change detection to study urban growth and characteristics overtime.
- At the far end of the multi-level approach satellite data provide highly detailed information of the structural characteristics of the urban morphology.

2. STUDY AREA

There are a number of industrial and commercial estates in the Hyderabad district and about belonging to the Hyderabad agglomerations which were mainly established between 1970's and 1980's. 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. Hyderabad, the capital of the Indian state of Andhra Pradesh is a sprawling metropolis and cosmopolitan city with a population of 7.2 million in 2013 and a current growth rate of 2.46 percent per year. The city's population is expected to achieve 11 to 14 million in 2020 turning it into one of the megacities of tomorrow [13]. "Megacities

are undergoing new dynamics and as a consequence are facing new spatial and organization challenges" [1]. The performance in megacities is seen as a key factor regarding global sustainable development. However the city has to face many challenges today concerning sustainable infrastructure system.

3. DATA AND METHODS

3.1 Data

The satellite images of Hyderabad district, the circle 11 with an area of boundary 100274239.8 sq meters or 10027.4 hectares of land in different time periods 1997, 2007 and 2013 fig[1] [2] [3] are collected from NRSC[21][22][23] is used for the detect the urban growth. The Land sat program represents a series of earth observation satellite 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 Map per (TM) has operated with 30m geometric resolution and seven spectral bands. Since 1999 the enhanced Thematic Map per (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 [17] with its field of view of 185KM 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.

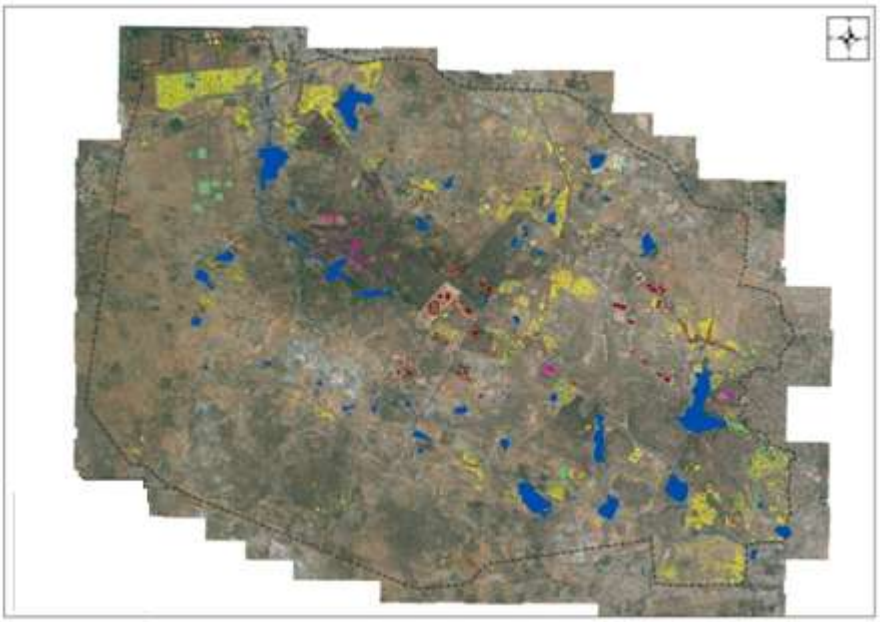

FIGURE 1: 1997 Satellite Images.

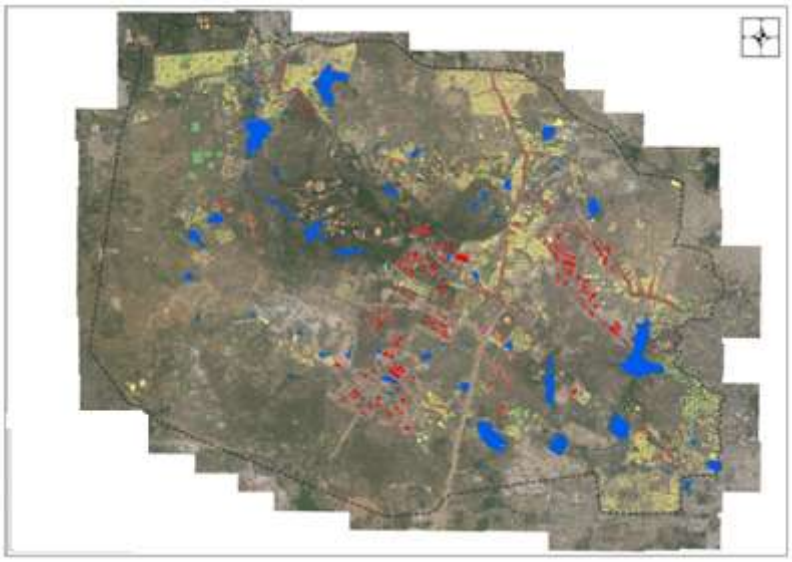

FIGURE 2: 2007 Satellite Images.

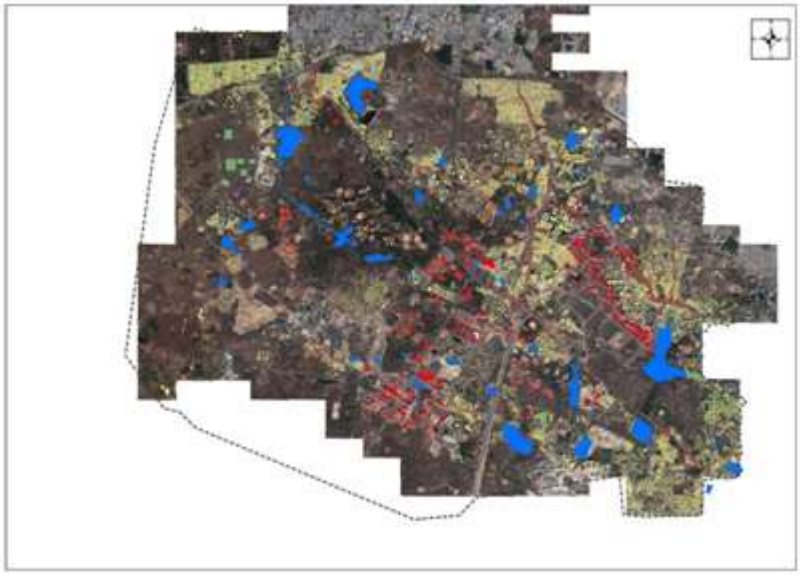

FIGURE 3: 2013 Satellite Images.

The level of description with Land Sat features is not flooded with microscopic detail, but re-gives nevertheless the specific features of the urban system. For this purpose, a high resolution multi-scale urban analysis can be done.

3.2 Methodologies For Land Use /Land Cover Classification:

Satellite image 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 were performed separately on different 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. The object-oriented methodology was used to combine spectral features with shape, neighborhood and texture feature [18] most accurate procedure and presented the advantage of indicating the nature of the changes [11].

In the land use/land cover classification different time periods t1, t2 and t3(1997,2007 and 2013) is used to monitor the land cover changes in the metropolitan area of Hyderabad. A comparative analysis of land cover classification between 1997 &2007, 2007 & 2013 and at last 1997, 2007 & 2013 performed independently was therefore implemented to monitor and analyze the land cover changes in Hyderabad. Pixel wise change detection was implemented in the flow chart fig (4) checking the land cover classes individually of the different available years.

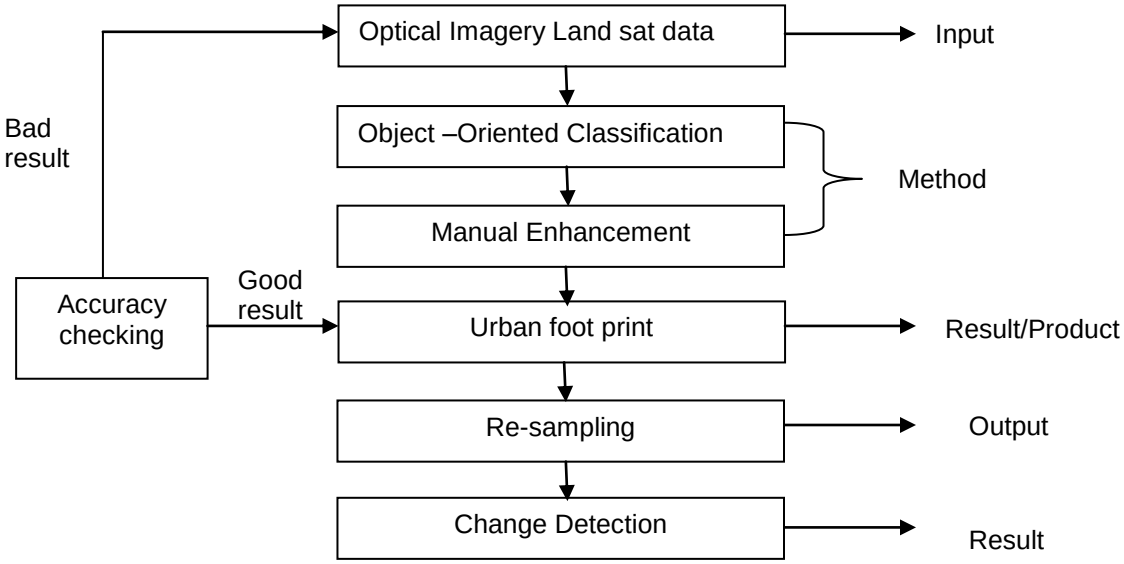

FIGURE4: Flow chart of methodology for land use/ land covers and change detection.

4. RESULTS, COMPARISION AND CHANGE DETECTION:

4.1 Results

Infrastructure for housing and industry, the post classification is not yet sufficient. Each of the disciplines in urban and infrastructure planning need detailed information that cannot directly be measured from space. A detailed analysis of demand is a prerequisite for technical infrastructure planning of both supply and disposal services. Data has been collected for selected neighborhoods by field surveys showing the urban structure, social structure, mobility patterns, energy and water flows. These data will be combine with the one delivered from remote sensing in order to expand this local information to a wider area. For this, Arc GIS analysis is used [19]. A detailed knowledge of their demand and spatial distribution would allow an infrastructure planning that is better adapted to the real needs. It can also serve as basic information for improving urban morphology.

Measuring the development stages of the large Indian urban agglomerations, conclusions about incipient mega cities in the same cultural area like Hyderabad, Bangalore and Chennai may support planning, future modeling and thus decision-making for sustainable and energy efficient urban futures[11 in this journal]. By using Arc GIS, we extract the sub-parameters such as public and semipublic, residential, commercial, open places [Government], water bodies and roads of different time periods in fig [5][6][7] .These methodology presented by [18] was applied to the Quick Bird data of Hyderabad.

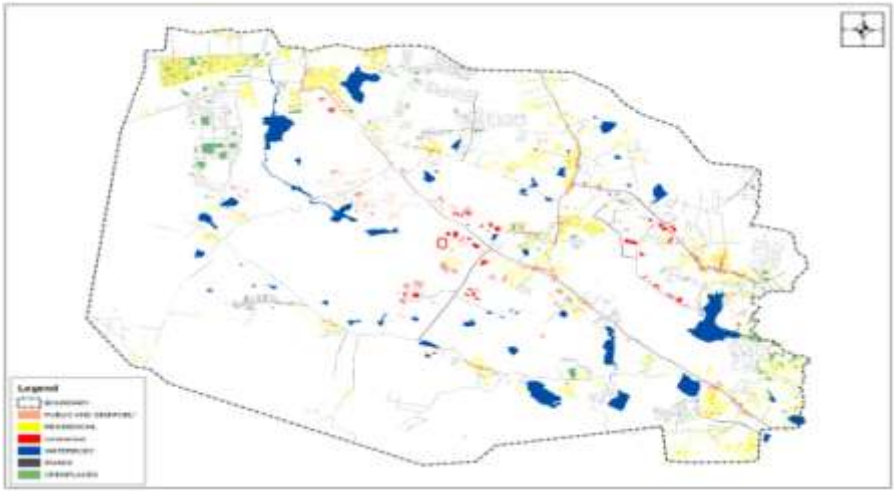

FIGURE 5: 1997 Land Use Classifications.

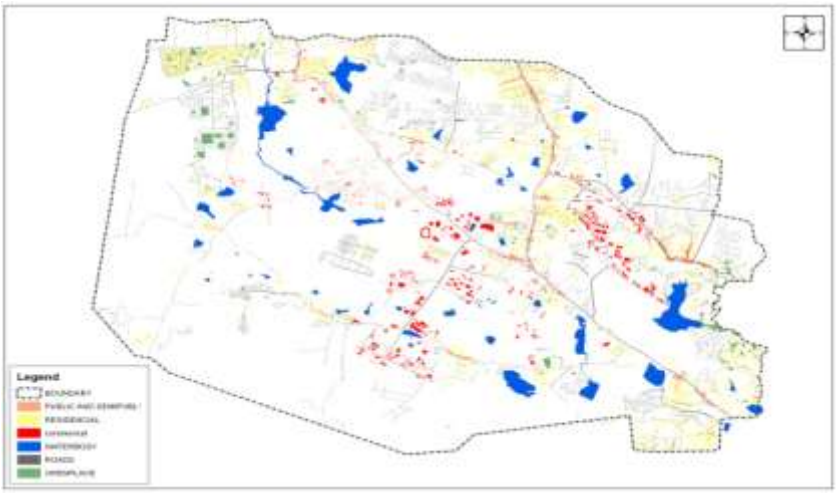

FIGURE 6: 2007 Land Use Classifications.

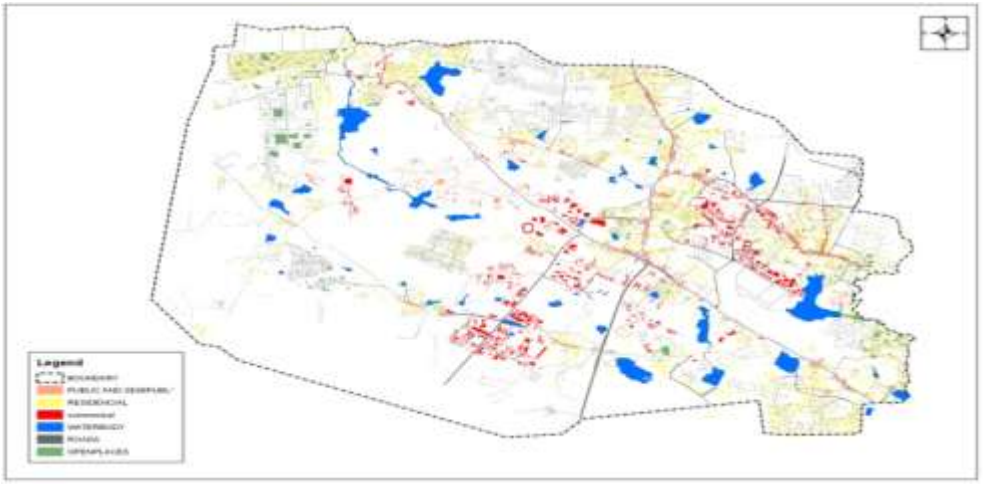

FIGURE 7: 2013 Land Use Classifications.

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In Hyderabad district, the circle 11 with area of boundary 100274239.8 sq meters or 10027.4 hectares of land can be classified in different time periods in the form of table [1] and the graphs[8][9][10] as follows:

	2013	2007	1997
BOUNDARY	10027.42398	10027.42398	10027.42398
PUBLIC AND SEMIPUBLIC	24.334193	22.036094	15.82562
RESIDENCIAL	468.722676	349.327308	207.856569
COMMERICAL	180.119693	125.147652	53.828884
OPENPLACES(GOVERNMENT)	70.812467	70.812467	70.812467
WATERBODY	248.668211	253.456367	255.234342
ROADS	380.429645	223.9829	160.5069

TABLE 1: Area In Hectares.

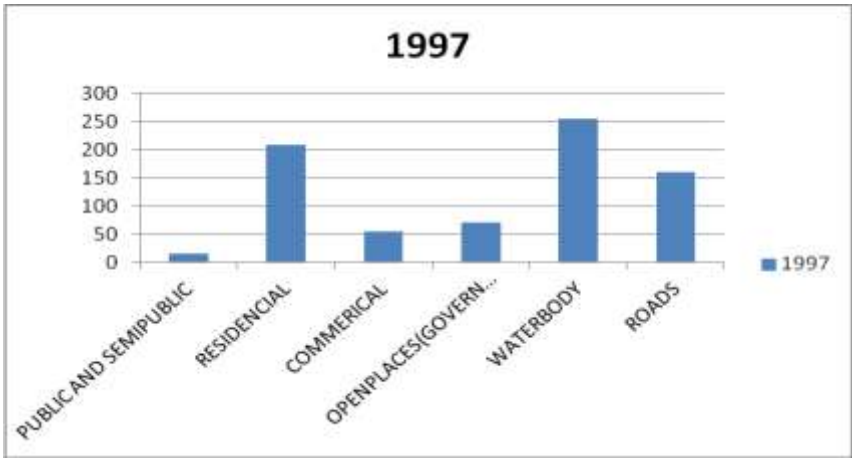

FIGURE 8: Graphical Representation In Year 1997.

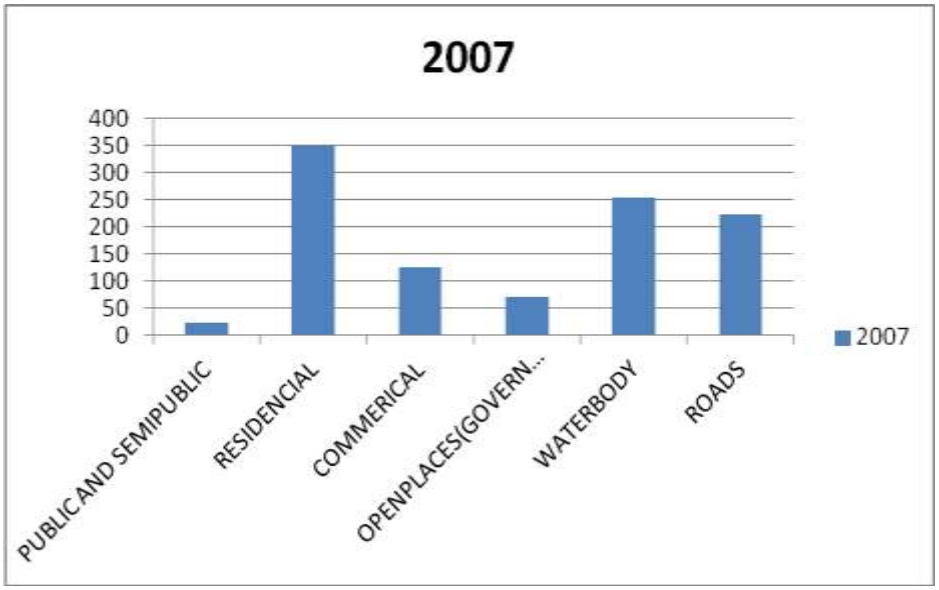

FIGURE 9: Graphical Representation In Year 2007.

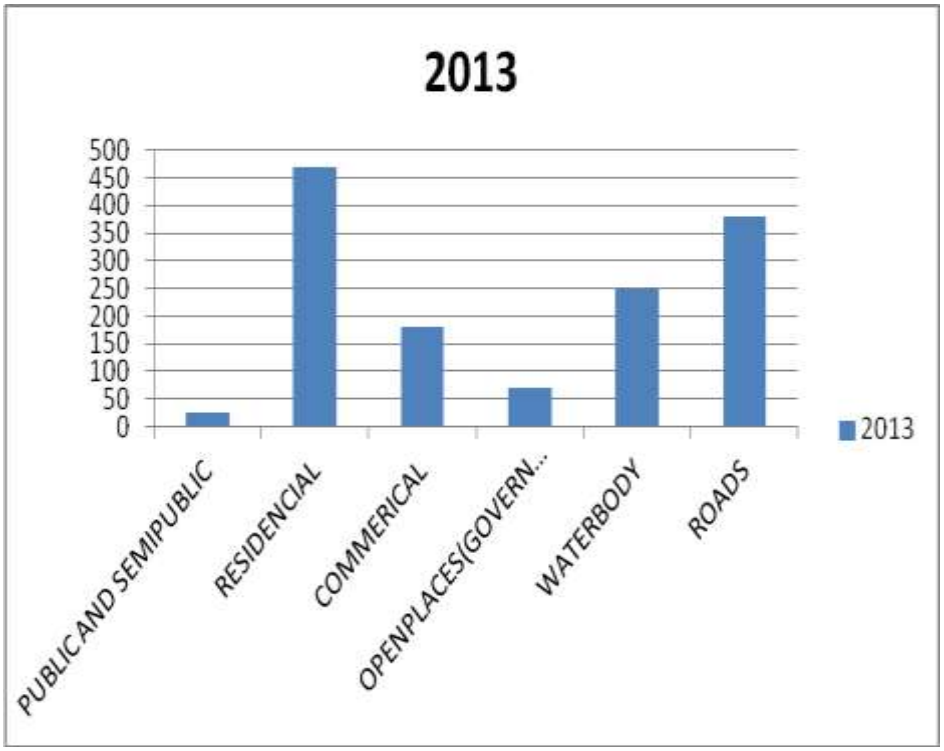

FIGURE 10: Graphical Representation In Year 2013.

4.2 Comparison of Land Use Classification In Different Time Periods

The main goal is to measure the changes of the urban extension over the time interval. A comparative analysis of land cover classification for times between t1, t2 & t3[1997,2007,2013] fig[11] and table[2] performed independently was therefore implemented to monitor and analyze the land use patterns in the metropolitan area of Hyderabad.

	1997	2007	2013
PUBLIC AND SEMIPUBLIC	15.82562	22.036094	24.334193
RESIDENCIAL	207.856569	349.327308	468.722676
COMMERICAL	53.828884	125.147652	180.119693
OPENPLACES(GOVERNMENT)	70.812467	70.812467	70.812467
WATERBODY	248.668211	248.668211	248.668211
ROADS	160.5069	223.9829	380.429645

TABLE 2: Comparision Between 1997, 2007 and 2013.

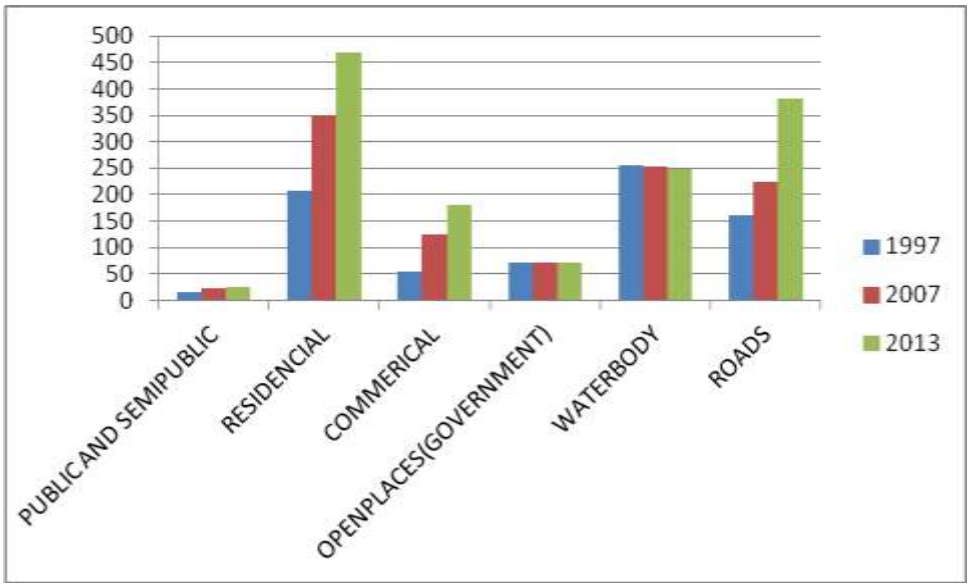

FIGURE 11: Graphical Representation In Year 1997, 2007 and 2013.

4.3 Change Detection

Through the change detection in different time periods Through the change detection in different time periods was implemented for an extraction of sub-parameters such as public and semipublic, residential, commercial, open places [Government], water bodies and roads of different time periods. The pattern of urban expansion in Hyderabad during the time period from 1997 to 2013 was investigated and analyzed using Land sat images and GIS. The analysis shows an increase in residential, commercial and roads which create and many planning and environmental problems. There is no increase in water and open places [government]. In fast growing of residential, commercial and roads created new problems to internal structure of the Hyderabad city. It is suffering from deterioration of landscape biodiversity, traffic jams, air pollution and severe water shortages.

In this analysis there is no increase in open places and water resources, this leads to landscape biodiversity. The water bodies are decreasing year to year. This will cause many diseases and lead to destroy the health and environment. The methodical frame work was inherited, with adjustments on the spectral peculiarity of the particular sense. For validation of the classification results an accuracy assessment has been carried out. The accuracy shows an average of more than 78% of sub-parameters have been classified correctly. This multi-scale analysis of the current status of the neighborhood environment provides useful spatial information for a sustainable urban management [19]. In future enables the calculation of the urban growth and provides necessary information for the analysis of the location and carrying capacity of the neighborhood infrastructure as well as the analysis of accessibilities.

5. CONCLUSION

Urbanization is primarily a complex of functional changes, it occurs near cities as well as in the rural country side. The major problems associated with the urban centers in India are that of unplanned expansion, changing land use /land cover areas [6]. It is recorded as diffusion wave of changing lifestyle mainly controlled by the changing accessibility of places offering new opportunities. To fight 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.

The integration of remote sensing and GIS provides a useful method for examining the changes in the urban land use overtime. 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. The problems and challenges faced by mankind are of national importance, but it has to be dealt at the local level. High resolution satellite data is applied for the multi-scale urban analysis of the Hyderabad metropolitan area of deriving sub-parameters [18]. This paper focused on the multi-scale approach with remote sensing, to support urban management with area-wide and up-to-date datasets. Thus, different perspectives can be highlighted for a broader understanding of urban workflows and its dynamics. This multilayer spatial information allows analyzing and anticipating developments to support future planning strategies.

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