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LAND USE ASSESSMENT AND URBAN GROWTH MONITORING IN HYDERABAD REGION, INDIA.

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ABSTRACT
Over the past two decades, India has registered a tremendous urban population growth and urban expansion. It is a matter of concern since urbanization has direct impact on local environment and surrounding ecology. Hyderabad, capital of Telangana, has experienced rapid urban growth over last few decades due to introduction of many IT sectors and industries in that region. This communication attempts to analyse spatio-temporal pattern of land use and land cover changes of landscape in Hyderabad Metropolitan region. Multi-temporal satellite images were obtained from the year 1989-2014. The results of land cover analysis showed a clear vegetation cover degradation from 95.64 in 1989 to 61.15 in 2014. Further results of land use analysis suggested rapid increase in urban area by converting agricultural and other land use types. The obtained results will assist researchers, planners and government bodies to arrive at sustainable land use planning and to develop strategies for resources management.

Keywords: Urbanisation, Hyderabad, spatio-temporal, land use.

INTRODUCTION

An area which is formed by undergoing various levels of changes from forest cover, agricultural fields or rural landscapes turned into transitional regions before constituting areas dominated by built up or paved surfaces is collectively known as urban areas (Dupont, 2005). The rural-urban transition zone is the area located at the outskirts of any core urban area. India has seen significant growth in urban areas especially in these transition zones, resulting in unprecedented land use land cover changes. These changes bring an inevitable effect on biodiversity, human-animal conflicts, urban heat islands and complicated impacts on pollution levels, changing rainfall patterns and flooding regimes (Bronstert et al. 2002, McCuen et al. 2003). Urban sprawl is the direct outcome of urbanisation. Sprawl is defined as the haphazard growth of urban areas in the urban-rural fringes, which often leads to shortage of resources. The major causes of urban sprawl are migration, infrastructure establishments and service facilities. Migration of people from rural areas to fringe and core city area is quite common in major metropolis of India, reason being a lot of job opportunities and better way of lifestyle than compared to any of the rural sectors. Infrastructure establishments such as industries, roads, railway stations, metro stations etc. along with service facilities like hospitals, educational institutes, banking etc. have severe impacts on migration. Population is considered as the chief factor for driving urbanisation. An urbanised area can be termed as one or more places and the adjacent densely populated surrounding area that together have a minimum population of 50,000. Mega cities are the cities with 10 million or more residents (United Nations, 2015). China and India remain the two largest countries in the world, each with more than 1 billion people, representing 19 and 18 % of the world's population, respectively. But by 2022, the population of India is expected to surpass that of China. These statistics suggests an immediate attention to study spatio-temporal dynamics of urbanisation and urban sprawl which is the core idea of this research communication.

Off late, numerous literatures suggest using remote sensing data and GIS for land use and land cover analysis, formulation, application and evaluation (Coppin et al., 2004, Dewan and Yamaguchi, 2009, Lu et al., 2004 and Singh, 1989). Satellite data are primarily valuable in large areas under study and where the changes are very rapid (Blodget et al. 1991). Huge satellite digital data archive provides an opportunity to understand historical LULC change for a region. Since, Hyderabad is projected as one of the megacity (World Bank, 2007), it is very much needed to study the land use pattern which could help in predicting future urban growth. Considering the above mentioned facts, the main objectives of this research effort is to understand land cover and land use changes temporally over a period of 24 years using remote sensing and GIS technologies.

STUDY AREA AND DATA

Presently Hyderabad is capital city for Telangana state and de facto capital for Andhra Pradesh after partition in the year 2014. The city is located along the banks of river Musi and surrounded by many lakes like Himayat sagar, Hussain sagar etc. With creation of special economic zones at Gachibowli, Pocharam, Manikonda etc. dedicated to information technology have encouraged companies from across India and around the world to set up operations. Latitude values ranges from 17˚12'51'' to 17˚42'26'' and longitude values 78˚12'34'' to 78˚45'29'' as depicted in figure 1. Erstwhile Hyderabad urban development authority (HUDA) was expanded in 2008 to form Hyderabad metropolitan area (HMA) covering 7100 km^2 and population of 7.74 million (2011). HMA covers a total of 5 districts namely Hyderabad, Ranga Reddy, Medak, Mahboobnagar and Nalgonda.

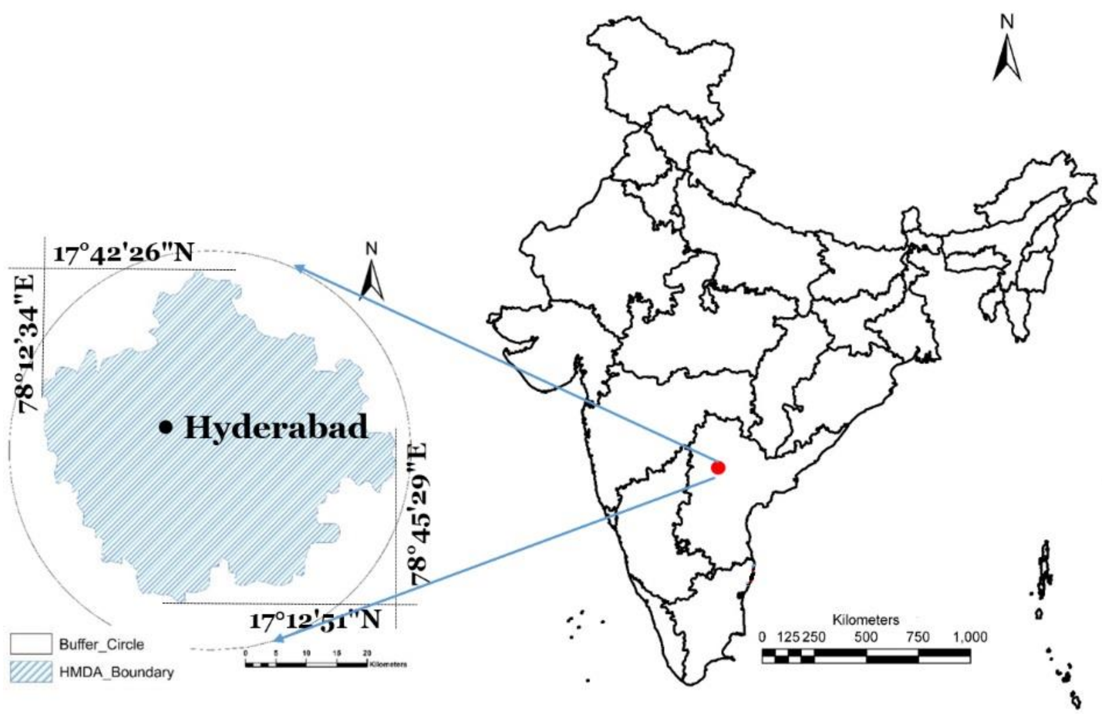

Figure 1: Study area – Hyderabad region

A set of Landsat 5 (TM), Landsat 7 (ETM+) and Landsat 8 (OLI-TIRS) data were downloaded from USGS Earth Explorer (http://earthexplorer.usgs.gov/) website. A circular buffer zone of 10Km form centroid of central business district was considered for analysis as shown in figure 1. Data used are as listed in table 1.

Table 1: Materials and data used for the analysis.

DATA	YEAR	PURPOSE
Landsat 5 TM (30m)	1989 and 1999	Land use and Land cover analysis.
Landsat 7 ETM+ (30m)	2009	
Landsat 8 OLI-TIRS (30m)	2014	
Google earth		Geo-correction, classification and validation. Collection of point, line and polygon data.
Boundary maps and raster layers.		To create agents and constraints data sets based on City Development Plans.
Survey of India Toposheets and Bhuvan data.		Base layers of the administrative boundary.
Field visit data – Using GPS		Geo-correction and generating validation data sets.

METHOD

Pre-processing: This procedure involved geo-registration of data performed with the help of known location points so as to achieve higher accuracies. Co-ordinates of known locations were extracted from places like road intersections, edges of huge permanent structures like dams, bridges etc. with the help of GPS or Google earth (places which were inaccessible). Images were cropped pertaining to study regions. Histogram equalization was performed wherever necessary to maintain the dynamic range. Landsat images were co-registered to WGS 1984 and UTM zone 44.

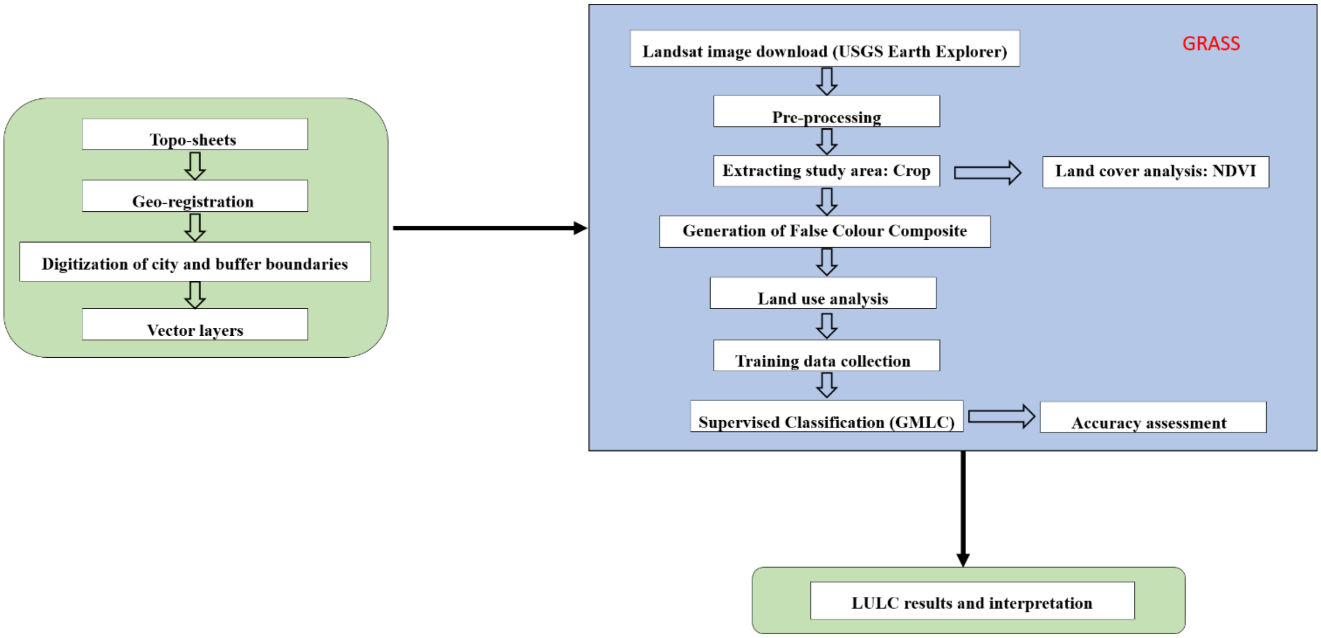

Figure 2: Landuse assessment and urban growth method – flow chart.

REMOTE SENSING DATA ANALYSIS

After image pre-processing, Land cover analysis was performed using the band combinations red and near-infrared. Land cover analysis clearly gives the differences between vegetation and non-vegetation category. It is obtained by performing normalized difference vegetation index (NDVI). NDVI value ranges from -1 to +1. Values greater than +0.1 indicates vegetation and thicker tree cover as the value nears to +1 (Ramachandra et al., 2013). Further, to understand the landscape better land use analysis was carried out. It involved the generation of false colour composites using the bands: green, red and near-infrared. The next step involved classification of the multi-spectral remote sensing data, which was carried through supervised Gaussian maximum likelihood classifier (GMLC). GMLC algorithm is known to fetch accurate results since it considers cost functions as well as probability density functions (Duda et al., 2000). Land use classification was done with the help of open source software called GRASS (http://grass.osgeo.org/) under four categories shown in table 2.

Table 2: Land use categories.

Category	Features involved
Urban	Houses, buildings, road features, paved surfaces etc.
Vegetation	Trees, Gardens and forest
Water body	Sea, Lakes, tanks, river and estuaries
Others	Fallow/barren land, open fields, quarry site, dry river/lake basin etc.

A classification is not complete until its accuracy is assessed. Congalton et al., (1999) has shown that classification accuracy can be obtained by preparation of error matrix or confusion matrix. Overall accuracy and Kappa were computed. The classification accuracy was tested for the classified images using training data samples collected with the help of GPS and google earth.

RESULT AND DISCUSSION

Land cover analysis was performed for the year 1989, 1999, 2009 and 2014. The outcome of land cover analysis showed clear indication of vegetation deterioration from 1989 to 2014. Figure 3 shows the temporal variation in vegetation cover. Increase in non-vegetation categories i.e. bare soil, barren land, quarry site, rocky fields etc. can be easily visualized. The results undoubtedly suggest at least 35% of vegetation has been converted into other category of land uses from 1989 to 2014. To understand land use changes, especially to estimate the percentage built-up area, which is a key metric to measure urban growth and sprawl, was determined by classifying the image further into four categories as listed in table 2. Land use analysis results are depicted in figure 4. Results revealed the steep increase in built up areas pertaining to Malakpet, Madapur, Bollaram, Kukkatpally, Cherlapally etc. showing 93% (1989-1999), 319% (1999-2009) and 56% (2009-2014). Significant changes are observed in all the categories especially the urban land use shows tremendous change during the year 1999 to 2009. This rapid change can be related to the industry oriented policy measures and importance for the information technology sector given in Hyderabad region during 2000's. Other category has been consistently decreasing from 90.50% in 1989 to 72.59% in 2014.Water bodies have also seen an alarming rate of decline from 3.75% to 1.84%. Confusion matrix was generated to estimate overall accuracy and Kappa statistic (table 5). Overall accuracy varied from 87% to 94% in Hyderabad region. These higher accuracy levels showed all the classified images were in good terms with respect to reference maps selected.

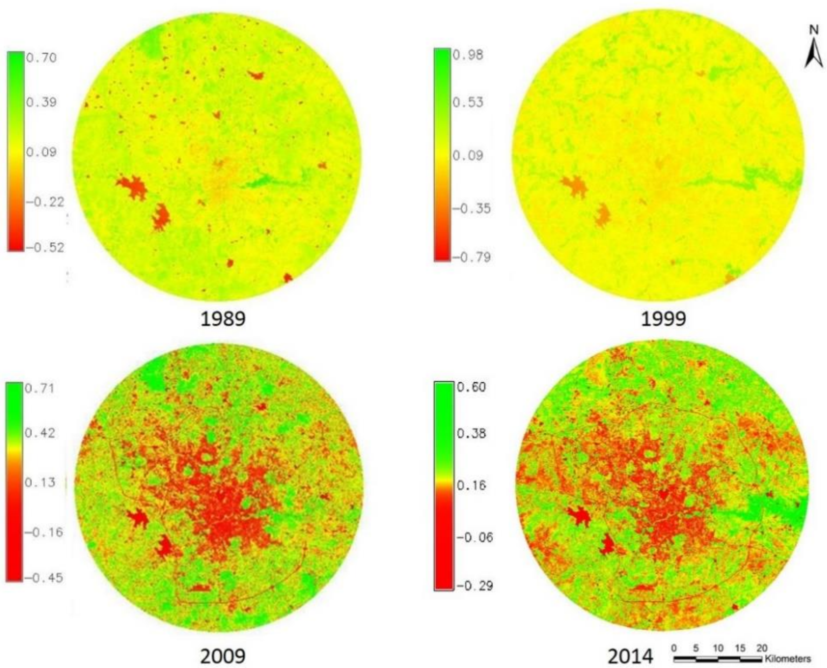

Figure 3: Temporal variation of vegetation cover (1989-2014)

Table 3: Land cover change statistics.

Year	Vegetation (%)	Non-Vegetation (%)
1989	95.64	4.36
1999	93.28	6.72
2009	82.67	17.4
2014	61.15	38.85

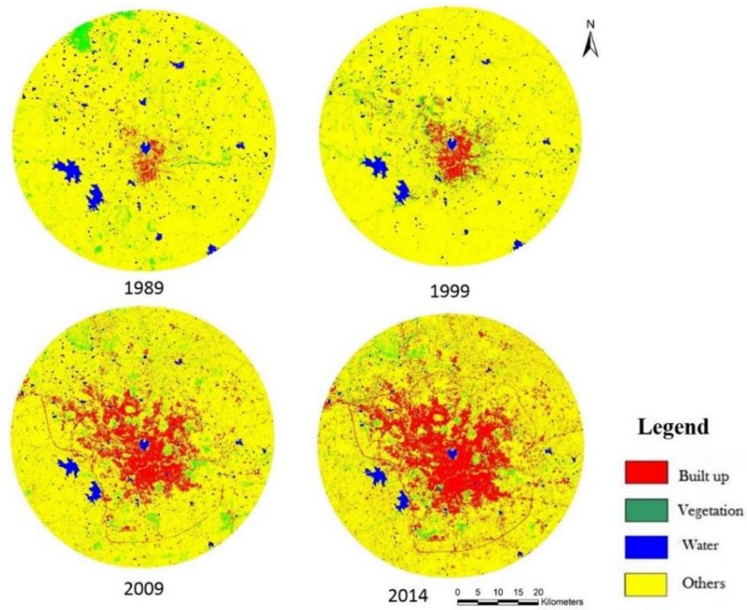

Figure 4: Land use analysis (1989-2014)

Table 4: Land use analysis statistics.

Category/ Year	1989	1999	2009	2014
Built up	1.75	3.39	14.21	22.19
Vegetation	4.00	3.53	3.83	3.38
Water	3.75	2.89	2.46	1.84
Others	90.50	90.19	79.50	72.59

CONCLUSION

The efficiency of urban settlements largely depends on regional planning, services provided and efficient management of available resources. With rapid urbanisation in developing countries, urban sprawl has become a vital point of research. Results depicting loss of vegetation cover from land cover analysis points at the rate of environmental degradation, imbalance in the native ecosystem and therefore calls for an immediate action. While the statistics from land use analysis insists to focus on the hotspots of possible urban agglomeration within the metropolitan development boundary. The results obtained helps the urban planners and modellers to identify and predict significant areas of urban growth and therefore to strategize for sustainable development for optimum resource utilization. These plans could be adapted to control or mitigate the negative potential impacts on the urban environment.

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Online resources

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2. http://grass.osgeo.org/