Volume-3, Issue-7, July-2014 • ISSN No 2277 - 8160

Research Paper | Environmental Science

Land Cover Classification of Bangalore Metro Using Satellite Imageries - A Comparative Study

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ABSTRACT

Land Use is an major element in temporal studies of urban imagery, its precise and revised information is indispensable for understanding the environmental consequences of corresponding changes. Impervious surface ratio (ISR) and green cover ratio (GCR are important elements in determining urban environments, which can be employed to assess urban flood phenomenon, vegetation percentage. In the current study temporal study of BBMP is made by procuring satellite imagery 0f 1992, 2000, 2005 and 2010. The imageries are classified into four classes like Water, Built ups, Vegetation and Others by superwised classification.. The overall classification accuracy of 90.56% was achieved for the four urban land cover types. The different imageries from 1992 to 2010 showed phenomenal variation in vegetation cover over the years. The Green cover shows initial increase from 1992 to 2000 and then we could observe rapid depletion from 2005 to 2010. The Impervious surface ratio shows more than 50% increase from 1992 to 2010 and the increase is more prominent in the periphery of the city.

KEYWORDS : BBMP, Satellite images, Land use, Green cover

INTRODUCTION

Land-use/ land-cover ch are one of the main driving force of global environmental transformation and is presently the burning area of debate on sustainable development of cities. These changes have extensive range consequence on environmental and landscape characteristics like the quality of air, water, land resources, ecosystem processes and function and the climate system through inconsistency in greenhouse gases.

Urban growth and land use study is very useful to local government and urban planner for the amelioration of sustainable development. Urban growth in the periphery of metropolitan areas has long been considered a symbol of provincial economic power, but its benefits are progressively more balanced against ecosystem impacts, which includes degradation of air and water quality and loss of farmland and forests and many other socio-economic effects.

To comprehend the landscape dynamics, geographical information systems (GIS) and remote sensing bestow with a cost effective and precise substitute. Digital change detection techniques based on multi-temporal and multi- spectral remotely sensed data have shown a great potential in understanding landscape dynamics and observe differences in land use and land cover patterns over time.

In the current study the combined remotely sensed data is employed to investigate urban growth dynamics of Bangalore Metropolitan (BBMP) from 1992 to 2010. The main objective of this study is to outline the land use/land cover changes of city with stress on green cover. In the current study Superwised classification method is used to recognize the four categories of land use like Water, Built up, Vegetation and Others. ISR and GCR ratios are employed to acquaint with details of impervious surface and green cover respectively.

THE STUDY AREA:

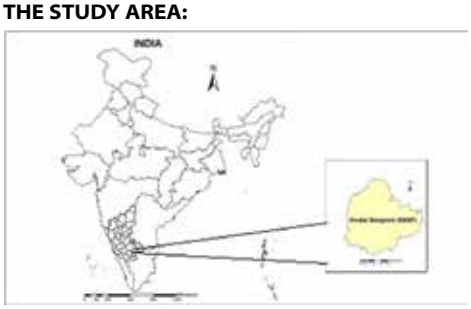


Fig 1.

The study area Greater Bangalore (BBMP) is situated between latitude parallels of 12°39'00" N & 13°1'00" N and longitude meridians of 77°22'00" E and 77°52'00" E at an average elevation of 900 mts above mean sea level and has an area of 800 Km^2 and supports 80 lakh population (2011 census). Administratively BBMP is divided into 8 Zones (Byatarayanapura, Mahadevapura, Bommanahalli, R.R Nagar, Dasarahalli, West, South and East zone).

MATERIAL and METHODS:

Data products

Satellite	Sensor	Bands	Spatial Resolution	Year of Acquisition
Landsat	TM	4, 3, 2	30	1992
IRS	LISS III	1, 2, 3	23.5	2000
IRS	LISS III	1, 2, 3	23.5	2005
IRS	LISS IV	4,3,2	23.5	2010

Geographical data: Topographical map: scale: 1/50000; the co-ordinate system of the baseline data map is applied for geometric correction of 4 satellite images. Erdas 9.2 and ArcGis 9.0 were used for image processing and further analysis.

METHODS:

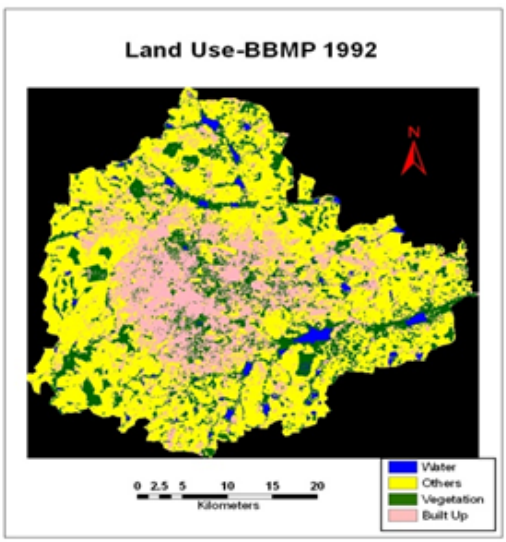
The multi-temporal remote-sensing approach was utilized as the spatial basis for mapping land use/land cover changes in the BBMP.

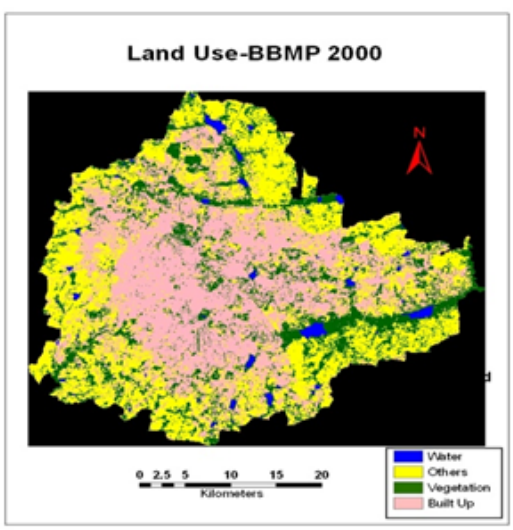
The research involves the following main steps:

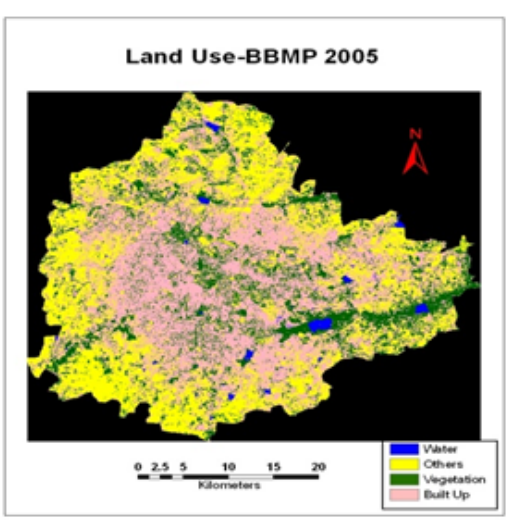
1. Geometric correction and pre-processing for enhancing imagery data: Images are geometrically rectified to the UTM (WGS 84 datum) coordinate system.
2. Superwised classification: Superwised classification is done by maximum likelihood method, here pixel categorization process is done by numerical description of various land cover types present in the scene. The land cover types are broadly divided into Built ups, Vegetation, Water and Others.
3. The percentage of impervious surface (ISR) in study area is calculated by following equation: $ISR = A^i * 100\ \%/ A^{i}+p$ Where Ai is the area of impervious surface of study area, and Ai+p is the total area of study area.
4. The percentage of Green Cover surface (GCR) in study area is calculated by following equation: $GCR = A^g * 100\% / A^{g}+u$ Where Ag is the area of green cover surface in study area and Ag+u is the total area in study area.
5. Scatter plot was constructed to find the correlation between GCR and ISR ratio of all four satellite imageries.

RESULTS AND DISCUSSIONS

The change analysis presented in this paper is focused on defining the effect of urbanization on natural resources, taking the statistics extracted from the four land use maps of the BBMP from 1992 to 2010 using GIS. The four land use classes include Water, Vegetation, Built up and Others, where Others class includes agricultural fields, stone quarries, fallow lands and open fields.







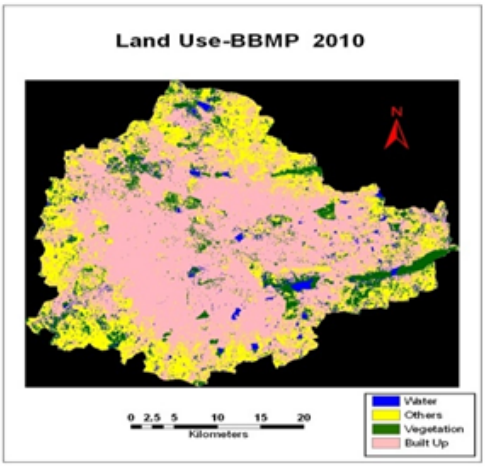


Fig. 2. Land cover map of BBMP (1992, 2000, 2005 and 2010)

The vegetation pattern showed lot of variation across the BBMP, depending in part on the location, population density, development intensity and surrounding natural vegetation cover. The high percentage of vegetation was observed in 2000 imagery, but in subsequent years there was decrease and the most noticeable reduction was observed between 2005 and 2010 (Fig 2). Large percentage of decrease was noticed in the plantation and the forest areas in the city periphery. The built-up areas showed steady increase from 1992 to 2000, but it was more conspicuous between 2005 and 2010 where the 34% enhancement was observed. Population migration is one of the main reason for this spurt where the population of the city swell by 30 % between 2001 and 2011. This is in line with Ramachandra and Uttam Kumar (2009) where they reported increasing urbanisation process from 2000 to 2006 than in 1973 or 1992, indicating higher entropy value. In Bangalore city alone, about 2,000-3,000 trees have been cut from 2006 to 2009 for various developmental works (urban Forest report of Bangalore 2010).

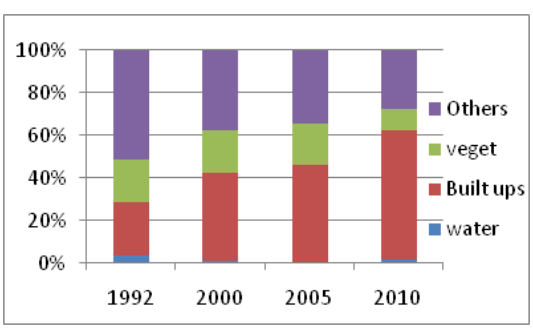


Fig. 3. Percentage of different land covers in Superwised BBMP imageries

The percentage water covered area varied from 3.5 in 1992 to 1.53 in 2000 and was 0.91 and 1.9 in 2005 and 2010 respectively, thus showing considerable fluctuation (Fig, 3). The increased water cover observed from 2000 to 2010 can be attributed to large scale lake rejuvenation programme taken up by lake development authority set up by state government. Others including agricultural fields, open grounds and quarried areas covered large percentage of BBMP area which was around 52 % in 1992 has come down to 27.17 in 2010 , which can be mainly attributed to the abrupt increase in built up area, large scale encroachment and formation of layouts in the city periphery from 2005 to 2010.

Table 1. The Overall accuracy % and Kappa Statistics for different years

Year	Overall Accuracy %	Kappa Statistics
1992	96.3	0.9510
2000	92.59	0.9031

2005	92.31	0.8891
2010	86.36	0.8240

Table 2. The Producer's accuracy and User's Accuracy for different classes of Imageries.

Class	Producer's Accuracy				User's Accuracy			
	1992	2000	2005	2010	1992	2000	2005	2010
Water	100	100	100	75	88.89	100	66.67	100
Built Up	100	85.71	100	100	100	87.5	100	100
Vegetation	100	100	92.31	85.71	100	85.71	100	100
Others	80	83.33	100	75	100	100	100	75

The overall accuracy and Kappa coefficient (Table 1 & 2) in the current paper shows that the pixels on an average are classified into the correct classes (overall accuracy) and the classification data is highly useful.

In the present study we could observe incessant enhancement in impervious surface ratio (ISR) from 1992 to 2010. The ISR ratio was 25.33 in 1992 was increased to 40.71 in 2000, and 44.91 in 2005 and then we could perceive sudden rise to 60. 2 in 2010. This can be attributed to high density of population where 41.3 % population in 1991 has increased to 65.5 % in 2011, as one of the main reasons that resulted in this high impervious surface ratio (ISR) which has increased overall land surface temperature of the city. High ISR will directly cause urban flood (Schueler, 1994; Arnold et al., 1996; Zandbergen, 1998; Bodamer, 2001; Carlson, 2004; Brander et al., 2004) and indirectly increase urban heat island phenomenon (Lin et al., 2005; Sun and Lin, 2006; Xian and Crane, 2006).

The Green cover ratio (GCR) in the current study showed continuous decrease from 1992 to 2010. The Green cover ratio (GCR) was 20.67 in 1992 has come down to 10.19 in 2010 thus showing more than 50% decrease. The unscrupulous increase in the developmental works along with newly built ring roads, high population growth and the large scale expansion of the BBMP area are mainly responsible for this. Green cover, very frequent in old bungalows are shrunk and are replaced by high-rise apartments and malls. Roadside trees have been cut to widen roads and build flyovers. Similar observation was made by Nagendra and Gopal, (2010), in their study on urban forestry of Bangalore, where they reported rapid urbanization combining with large scale destruction of tens of thousands of street trees and the clearing of vegetated plots, wetlands and other natural habitats within the city to make way for buildings, industries and infrastructure projects as the reason for large scale decrease in green cover. Green cover ratio (GCR) is one of the important indexes for assessing urban heat island phenomenon (Lin et al., 2005; Sun and Lin, 2006), urban eco-environment and urban open space(Ong B. L., 2003). Extensive urban park and green cover is very useful to lower urban air temperature. GCR represents plane quantity of vegetation. Parks contributed to conserve the urban environment and arrest air pollution through green spaces. In recognition of the importance of urban forestry, the U.S. Conference of Mayors in their City Policy Associates 2008 report, recognized "the invaluable role of urban forests in the protection of public health and the reduction of harmful greenhouse gases".

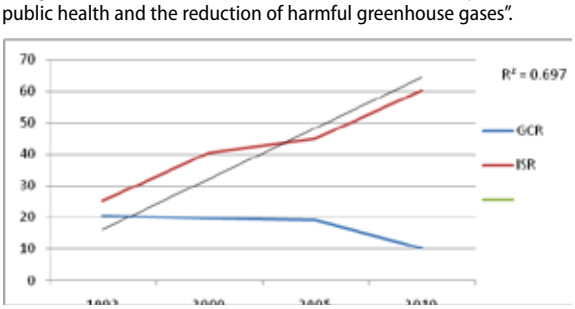


Fig. 4 Scatterplots of ISR vs. GCR for different imageries of BBMP.

Visual analysis of the scatter plots (Fig. 3) to determine the correlation between the ISR and GCR of BBMP showed significant correlation (R= -0.697) between GCR and ISR. This clearly indicate that increase in impermeable surfaces has direct effect on green cover of the study area.

The intense urbanization observed in North and South East of the city. It was established that a severe environmental degradation occurred in peripheral areas of city as a result of land use changes and human activities from 2005 to 2010. The south and eastern part of the city was characterised by increased residential and commercial layouts. The green cover percentage shows gradual decrease as we move from inner core to outskirts of the city. Green cover can serve as an indicator of the extent to which vegetations are providing critical services to local residents.

The corroboration of present study comprising different imageries from 1992 to 2010 help to show temporal variation in vegetation cover over the years. The Green cover shows initial increase from 1992 to 2000 and then we could observe rapid depletion from 2005 to 2010. The Impervious surface ratio shows more than 50% increase from 1992 to 2010 and the increase is more evident in the periphery of the city, where large number of agricultural fields, barren lands and lakes are converted into built ups due to large scale expansion of BBMP area and setting up of IT corridors and the ring roads linking different corners of the city.

SUMMARY AND CONCLUSION

Land cover is an significant element in change studies and its precise and updated information is indispensable for understanding the factors, causes and environmental consequences of similar changes. In consonance with above results, there are several policies recommended to increase the green cover ratio in this paper: planting more native trees, to maintain and establish lakes, and to improve the pervious performance of roads and pavements especially in high population area and to increase GCR value appropriate area should be reserved. Precautions should be taken to keep the sustainability of the resources like water, forest and agricultural areas. Such studies aim to contribute managers, decision makers and urban planners on land use /cover changes and help them to define a policy to contain uncontrolled urban sprawl driven by frenzied population migration.

Except few studies (Sudha and Ravindran 2000 and Nagendra and Gopal, 2010) Tthere is a lack of reliable data on the availability and determinants of green open space of BBMP. To achieve environmental sustainability, city should increase both its percent green open space and m2 of urban green open space per capita. A model should be prepared to audit green open space to accurately classify the green assets and develop common green open space strategies and infrastructure. Big Parks and lakes which are once symbols of Bangalore are witnessing large scale decline in the last decade . It is very much essential to create urban green space and adopt a systematic approach to the conception and maintenance of lakes, parks and green spaces and to restrain frequent flooding of lower regions of city during rainy season, so that Bangalore can retain its position as green city.

The results presented proved that Landsat can provides quick monitoring of large areas with no cost data and gives accurate information to map and analyze in land cover and land use investigations.

ACKNOWLEDGEMENT

I am very grateful to Department of Science and Technology, New Delhi, for funding this Project.

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