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Application of remote sensing and geographic information system to study land use / land cover changes: a case study of Pune Metropolis

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Abstract- Due to the rapid course of urbanization, the haphazard growth of major cities is one of the challenging situations in front of any country. As unorganized urbanization is becoming the major problem, it requires the immediate solution for sustainable development of urban land. In the emerging scenario it is essential to have updated information on urban growth patterns and its impact on the living environment. The growth and development of cities are likely to continue and therefore there will be a need for proper planning and managing or improving the existing infrastructure facilities. In this juncture, the state of the art technologies Remote Sensing (RS) and Geographic Information System (GIS) can play an imperative role. Pune metropolis is one such rapidly developing city in Maharashtra. This paper explores the study of Urbanization growth of Pune city using RS data and GIS.

Keywords- *Remote Sensing, Geographic Information system, urbanization, land use, Land cover, town planning*

Introduction

Human is the most progressive creature on the earth. For his progress he has made many changes on this earth such as Industrialization, Urbanization etc. had take place. In this competitive world he has migrated himself from rural area to urban cities. Due to this there is huge increase in day by day population in urban cities vis-à-vis there is a huge demand for dwelling places and hence there is huge increment in the growth rate of these cities. This has raised the urban expansion problem all over the world. Growing cities are creating an alarming situation in all countries of the world. Due to the rapid process of urbanization, the haphazard growth of these major cities is one of the challenging situations in front of any country. Many developing countries are facing the critical problems like population growth, poverty and income distribution; unemployment; urbanization and internal migration; agriculture and rural development; and quality education. Among these problems urbanization is becoming the major problem now a days and it requires the immediate solution for sustainable development of urban land. Urbanization, which may be broadly defined as the process of expanding urban influence, has been taking place for more than 6000 years, has increased markedly since the beginning of this century. One distinctive feature of India's urbanization is increasing metropolitanization. India's big cities now account for a large share of total urban population. In 2001, the share of metropolitan cities was 37.8 % up from 32.5% in 1991 and 26.4% in 1981[1]. The trend indicates continued urbanization and metropolitanization in the years to come. It clearly implies that with rapid growth of million plus cities, the problem of land management will be more and more complex as the years pass by. The forces and processes of technological development, globalization and population growth accelerate the dynamics of urbanization process in the developing countries. This "accelerated" phase of urban transition from rural to urban population in developing countries, population from migration and endogenous growth of those large primate cities and industrial location on their fringes are actually expanding the urban areas. This is mainly due to the rapid growth in the IT sector. Although, IT industry in India has more than three decades of history, its take-off into major software industries is a recent phenomenon [2]. Not all cities in India were able to respond quickly to the demands of these new service industries. This is evident from the fact that the larger Metros of India (Mumbai, Delhi, and Kolkata) have not been as successful as the second rung of cities i.e. Hyderabad, Bangalore, Pune and Chennai. Pune, the eighth highly populated metropolitan city of India is undergoing a rapid metamorphism, which would be the interest part of study and hence an attempt has been made. In this juncture, the state of the art technologies Remote Sensing (RS) and Geographic Information System (GIS) can play an imperative role. Remote Sensing is broadly defined as science of acquiring information about a physical phenomenon of an object or surface of the earth measured at a distance without being in physical contact with the object of interest [7]. Geographic Information System is a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems. [6]

Objective

Remote Sensing (RS) for capturing the spatial data, Geographic Information System (GIS) for undertaking integrated analysis, presentation of spatial and associated attribute data and GPS for ground truth verification are found to be of immense use in urban planning. Hence, to study the changing pattern of land use and land cover of Pune city by using RS, GIS, as a tool is the main objective of this paper.

Study Area

Present Pune Municipal Corporation Limit has been selected as the study area. Pune, formerly known as Poona, is the second largest city in the state of Maharashtra in western India, around 160 kilometers southeast of the state capital, Mumbai. It is also the seventh largest city in India. The city of Pune, located in the State of Maharashtra and lies between the North Latitude 18o 30' and 18o 40' and between East Longitude 74o 45' and 74o 59' 00". The study area is included in Survey of India topographic sheet nos. 47 F/10, 11, 14 and 15 on 1:50,000 scale. As per 2001 census of India, the population of Pune urban agglomeration is 3,529,900.[2] Growth in the software and education sectors has led to an influx of skilled labour from across India. The migrating population rose from 43,900 in 2001 to 88,200 in 2005[3]. Almost 40 percent of Pune's population lives in slums. The sharp increase in censorial decade of 1991–2001 can be attributed to absorption of 38 fringe villages into Pune Metropolis[3].

Methodology

The digital remote sensing data was processed and geo referenced in Erdas 9.2 software. Initially the toposheets of year 1972 were scanned and geo referenced and used as base for image registration. The enhanced images were classified into different classes by using Erdas imagine and compared with land use maps. The geo-referenced images were studied for the land use and land cover change analysis in the Arc view environment.

Results and Discussions

Land Use Change From 1992-1999

The satellite imagery soft data has been procured from National Remote Sensing Centre, Hyderabad for preparation of Land use / Land cover layer. The land use changes rather land cover changes were studied from Survey of India toposheets, LISS II image and LANDSAT image. Land use / Land cover layer represents the digital image of the city classified in five land use classes, namely: built up area, barren land, follow land, vegetation and water bodies. The areas under change was measured and presented in a tabular form to get the clear picture of land use and land cover change. In broad terms, between 1992 and 1999, the major change was detected in the barren land use category and significant change in agricultural and commercial use. Except for these three, all other uses showed a decline. In the 1992 land use map of Pune, agricultural land use was 26.11% of the total area of the city and in 1999 it became 32.19%. The increase in agricultural land use in the year 1999 was, mainly due to some area, which was not covered in 1992 shown as agricultural use in 1999. In 1992, barren land was 39.24% and in the land use map of 1999, it was shown as 34.79%. In 1992, water bodies were 1.04% shown and land use for water bodies appeared in 1999 as 0.83%. The area under follow land was 11.40% in the1992 land use map, whereas it was shown as an 8.33% in the 1999.

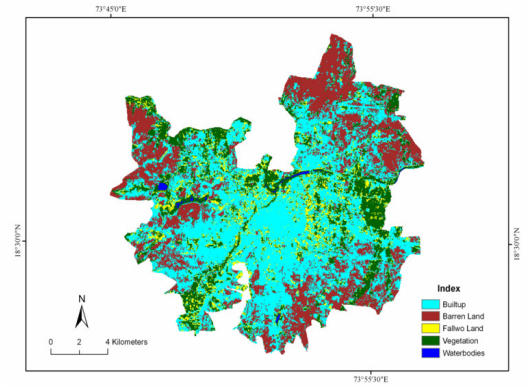

Fig 1-LISS II satellite image of PMC of year 1992

Table 1: Land use changes from 1992-1999

Sr. No	Year	Barren Land	Built up	Fallow Land	Vegetation	Water Bodies	Total
1	1992	39.24	22.21	11.40	26.11	1.04	100.00
2	1999	34.79	23.86	8.33	32.19	0.83	100.00

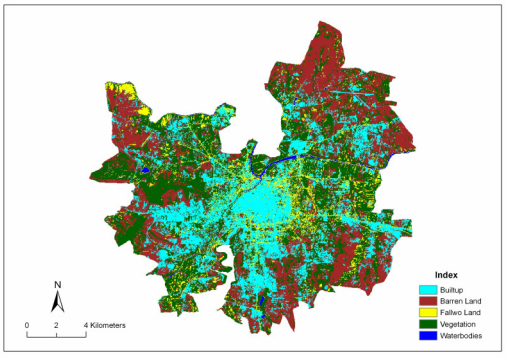

Fig 2- LANDSAT image of PMC of year 1999

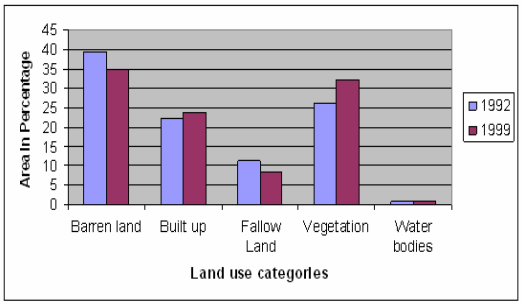

Fig 3- Comparison between Land use distributions – 1992 and 1999

Land Use Change From 1999-2004

In broad terms, between 1999 and 2004, the major change was detected in the built up and vegetation land use category. The land use changes / land cover changes were studied from LANDSAT image and LISS III image.

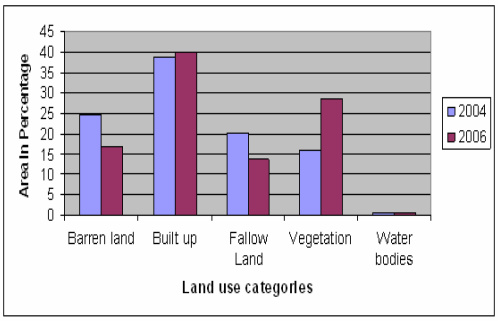

Fig 4- Comparison between Land use distributions – 1999 and 2004

The study mainly concentrated on the built-up area, since that was considered as prime indicator of urban development.

Table 2- Land use changes from 1999-2004

Sr. No	Year	Barren Land	Built up	Fallow Land	Vegetation	Water Bodies	Total
1	1999	34.79	23.86	8.33	32.19	0.83	100.00
2	2004	24.76	38.80	20.16	15.72	0.55	100.00

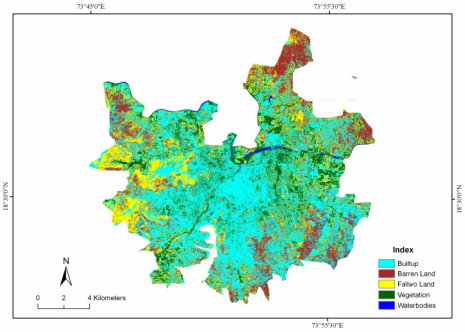

Fig 5- LISSIV image of PMC of year 2004

With the moderate resolution of LISS III, level 1 classification (Major classes) was done with good accuracy [5]. The built-up and vegetation area of 1999 from LANDSAT image was classified in ERDAS imagine environment and was compared with the satellite image of 2004. The total built-up area of PMC during 1999 was just 23.86 % and in 2004, it was38.80 %. Whereas the total vegetation area during 1999 was 32.19% and it was just 15.72% in 2004.

Land Use Change From 2004-2006

The land use changes were studied from LISS III and LISS IV image. The major change was detected in the barren land use category and significant change in agricultural and commercial use. In the 2004 land use map of Pune, agricultural land use was 15.72% of the total area of the city and in 2006 it became 28.74%. The increase in agricultural land use in the year 2006 would be really beneficial for farmers. With this vegetation land use there is bit change in barren and fallow land also found. In 2004, barren land was 24.76% and in the land use map of 2006, it was shown as 17.11%. In 2004, fallow land was 20.16% shown and land use for fallow land appeared in 2006 was just 17.11%.

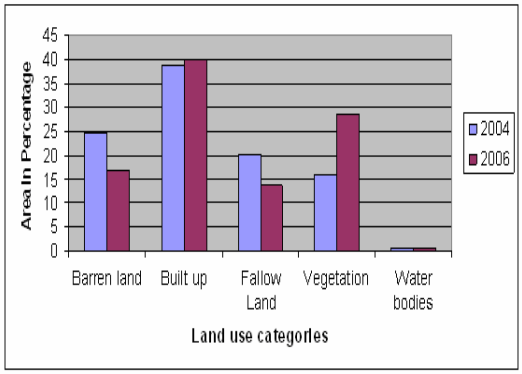

Fig 6- Comparison between Land use distributions – 2004 and 2006

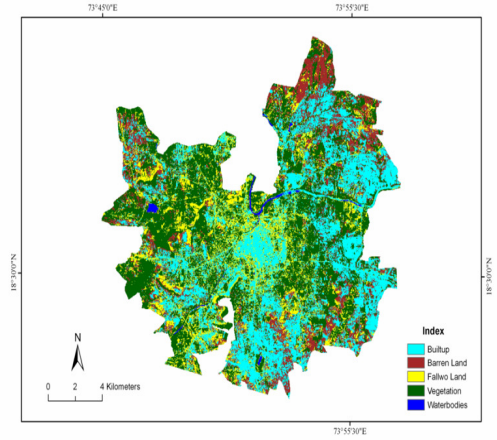

Fig 7- LISS III image of PMC of year 2006

Table 3- Land use changes from 2004-2006

Sr. No	Year	Barren Land	Built up	Fallow Land	Vegetation	Water Bodies	Total
1	2004	24.76	38.80	20.16	15.72	0.55	100.00
2	2006	17.11	39.89	13.67	28.74	0.59	100.00

Land Use Change From 2006-2008

The land use changes / land cover changes were studied from LISS III images. The change was detected in the barren land use and Fallow land category and significant change in vegetation and built up land use. Land use statistics are shown in the below table.

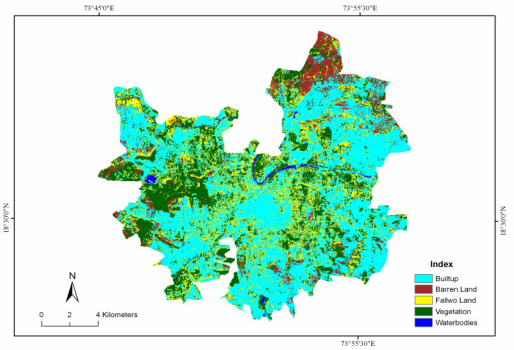

Fig 8-LISS III satellite image of PMC of year 2008

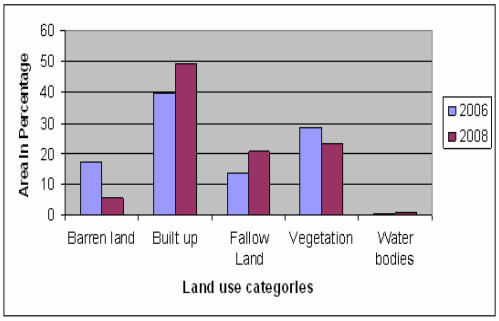

Fig 9-Comparison between Land use distributions – 2006 and 2008

Table 4- Land use changes from 2006-2008

Sr. No	Year	Barren Land	Built up	Fallow Land	Vegetation	Water Bodies	Total
1	2006	17.11	39.89	13.67	28.74	0.59	100.00
2	2008	5.73	49.15	20.82	23.52	0.78	100.00

There is major difference in the barren land use statistics between these two years. Built up land also used bit more in 2008 as compared to in 2006. Along with these changes vegetation and Fallow land also got change.

The analysis revealed that almost 70-80% of open/vacant/cultivable land was brought under urban land use. Most of the vacant lands close to the roads are converted for residential purpose or are under construction. In between some vacant lands are occupied with brick kilns, marble stockyards and stone quarries. The open lands located inside the city, were mostly converted into big shopping complexes/malls or hotels. The open areas, close to the outskirts of the city, are mostly turned into big townships, new colonies, Institutions and apartment complexes. The land use indirectly reflects the land values, as the prices in the fringe areas are much lower than the areas near the central areas of the city. Presently the land values are increasing along the urban fringe areas due to great demand.

Conclusion

The present study demonstrated the efficiency of Remote Sensing and Geographic Information System as a tool in the study of land use /land cover changes. Particularly in the absence of required data from the local authorities, it gives a fairly a good understanding of land use/land cover changes for a period of two decades, which in turn will be very helpful for local administrative bodies, decision makers, regional planners and stakeholders. Thus, this technology has the capability to provide the necessary input and intelligence for preparation of base maps, formulation of Planning proposals and act as a monitoring tool during the implementation phase.

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