

A SPATIO-TEMPORAL STUDY OF LAND USE LAND COVER CHANGE DETECTION IN PUNE CITY USING GIS AND REMOTE SENSING TECHNIQUES

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Abstract

Global population is increasing at a rapid rate in past some decades. Rapid increase in population creates pressure on resources. Land is one of resources which is also showing impact. Land is important resource only 29 % of the earth surface is covered with land among this 29% some of the land is covered with snow, desert, forest, mountains which is not useful for human activities or for human residence. Land is used for various purposes population increase can affect the land use land cover of an area. This global population increase also has major impact such as urbanization. Urbanization is a global phenomenon which affect land use land cover of an area. Urbanization is population shift from rural to urban residence. Due to the development of I'T parks and automobile industry people are migrating towards Pune city which leads to haphazard & unplanned development of Pune city to its outskirts areas. However, this leads to change in the land use land cover of Pune city. It will have impact on the natural vegetation cover as well as on the agricultural area. The present study is mainly focuses on the changing land use land cover pattern of Pune city. The main objective of this study is to assess land use land cover change of Pune city over three decades (2001-2021) and its impact on vegetation cover. The spatio-temporal study of land use land cover (LULC) is carried out for three decades 2001 to 2021 using remotely sensed multi temporal LANDSAT and LISS III Resourcesat-1 satellite data and analyzes this data by using modern technology like Remote Sensing (RS) and Geographical Information System (GIS). By analyzing this data, it has been found that amount of built-up area has increased dramatically whereas the area under agricultural as well as natural vegetation cover has been decreased. Uncontrolled urbanization and land use land cover change raises many environmental issues like loss of agricultural land, loss of animal habitat, loss of natural

vegetation cover. So that monitoring of urbanization is play very important role for planned development of cities which will help to protect environment.

Key words: Urbanization, LULC Change, GIS, RS

Introduction

Global population is increasing at a rapid rate in past some decades. Rapid increase in population creates pressure on resources. Land is one of resources which is also showing impact. Land is an important resource. Only 29 % of the earth surface is covered with land among this 29% some of the land is covered with snow, desert, forests, mountains which is not useful for human activities or for human residence. Land is used for various purposes population increase can affect the land use land cover of an area. This global population increase has major impact such as urbanization. Urbanization is a global phenomenon. Urbanization is population shift from rural to urban residence. Urbanization involves economic, demographic, social, cultural, technological and environmental processes which results in the increasing concentration of population in cities and towns. This rapid growth of urbanization leads to complex change in land use land cover. Land cover refers to the land cover by vegetation, waterbody, barren land, agriculture, fallow land and built-up area. Land use refer to use of land for various purposes like wild-life habitat, recreation, agriculture and other. Pune city is the cultural capital of Maharashtra. It is a second largest city of Maharashtra. It is famous for educational, research and development institutions. Due to the development of I'T parks and automobile industry people are migrating towards Pune city which leads to haphazard & unplanned development of Pune city to its outskirts areas. However, this leads to change in the land use land cover of Pune city. There are various studies carried out on the land use land cover change on different aspects like, Mohan Manju et. al. (2011) evaluates the land use land cover changes and urban expansion in megacity Delhi during 1997 to 2008. The results indicate that expansion of city towards peripheral region in which mostly rural areas are converted into urban areas. Built-up area has been increased by 16.86 percent and forest area increased by 0.5 percent. Waterbodies, agriculture land, sandy regions are reduced. Desai C. G. et. al. (2009) studies the land use land cover changes in Pune Metropolis during 1992 to 2008 by using RS and GIS technology. Padigala Bhaskar (2012) evaluate the changing green spaces in Indian cities a case study on Pune city for the years 1999 and 2009 results showed that cities

built-up area has been increased whereas barren and fallow land area was decrease. Mundhe N. N. et. al. (2014) analyses impact of urbanization on land use land cover in Pune city by using Geo-spatial techniques over four decades (1973 to 2011). The result shows that from 1973 to 2011 built area has been increased by 43.43 percent and the areas under vegetation, water bodies agriculture, fallow land decreased. Patra Suman et. al. (2018) studied the spatiotemporal characteristics of urban growth in which they basically focus on the impact of urbanization on land use land cover changes and its probable implications on local climate and groundwater level during 1975 to 2015 in Howrah Municipal Corporation (HMC) of West Bengal. The result shows that HMC has experienced rapid change in LULC particularly in case of built-up area. Reviewing the above-mentioned literature, it is observed that there is impact of urbanization on land use land cover change and continuously LULC is changing for that continuous monitoring of it is very essential for sustainable development of urban land. The present study is mainly focuses on the changing land use land cover pattern of Pune city. The main objective of this study is to quantify the spatio-temporal changes in LULC over Pune city since 2001 to 2021 at decadal time intervals (for the year of 2001, 2011 and 2021).

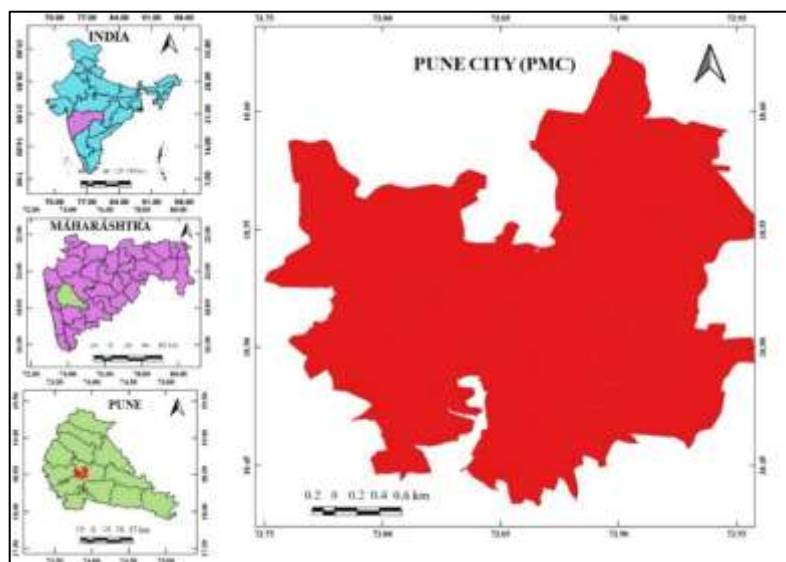
Study Area

Pune is a cultural capital of Maharashtra. Pune city is the eighth highly populated metropolitan city of India and second largest city in the state of Maharashtra. Its covering a total area of about 331.26 Sq. Km. It lies between latitudes 18°25' N and 18°37' N and 73°44' E and 73° 57' E longitudes. It is situated on Deccan Plateau and elevation is about 560 m above mean sea level. Mula and Mutha are the two major rivers flowing through the city. Pune is situated on the banks of these two rivers which is basically supporting the growth of the urban population.

The average maximum temperature of city is about 38°C March to May city is experiencing hottest climate while the average minimum temperature of the city is about 22°C which is from June to September. According to 2011 census total population of Pune City is 5.7 million with a density of over 603 persons per Sq. Km. The central part of PMC is densely populated than the marginal regions. City surrounded from western and southern direction by hills. At the southern boundary Sinhagad-Katraj-Dive Ghat ranges are the boundary of the city. The highest urban area

is Sinhagad fort while highest point surrounded by city is Vetar hills. Two more rivers Pavana and Indrayani are at the outskirts of the city.

Fig. 1.- Study Area Map



Data and Methodology

To fulfill the research objective of this research uses data on remote sensing for the Pune City for different time span (March 2001, March 2011, March 2021) collected from LANDSAT 7 (2001), LISS III Resourcesat-1 (2011) and LANDSAT 8 (2021) all having 30 m resolution. The vector map of PMC was used for clipping and sub setting the satellite images. This data is collected from LANSAT dataset of the United States Geological Survey Earth Explorer (URL: <http://edcns17.cr.usgs.gov>) and the National Remote Sensing Centre (URL: <http://bhuvan.nrsc.gov.in>). The digital remote sensing data was processed and geo referenced in ArcGIS 10.3 software. Land Use Land Cover (LULC) map were prepared by using supervised classification – maximum likelihood supervised classification. To check the accuracy of images Confusion Error Matrix were used.

Results and Discussions

Land Use Land Cover Change From 2001-2011

Land use land cover change has been studied for 2001 and 2011. To see the changes two satellite images are procured. The satellite imagery soft data LANDSAT 7 (March, 2001) has been

procured from United States Geological Survey Earth Explorer and LISS III (March, 2011) from National Remote Sensing Center (Bhuban). The images have been classified in five classes. Land use Land Cover layer represents the digital image of the city classified in five classes, namely: Agriculture, Barren Land, Settlement, Vegetation and Waterbody. Image accuracy assessment is done by using Confusion Error Matrix and it shows 88.33 percent accuracy in 2001 LULC classification and 92.45 percent accuracy in 2011 LULC classification. The area under change was measured in Sq. Km. and it represented in tabular form to get clear idea of land use land cover change. The result shows that in between 2001 and 2011 the major change was detected in barren land use category, waterbody and agriculture category. The drastic change is seen in case of barren land in 2001 barren land was 23.55 percent and it decrease by 14.48 percent in 2011 and becomes 9.07 percent. It showing great decline in one decade. This is mainly due to the increase in settlement or built-up area. In 2001 the area under barren land was converted into built-up area or settlement therefore in 2011 barren land area decline and that area is occupied by settlements. In case of waterbody same trend is detected in 2001 waterbody was 2.6% which decrease by 1.51 percent and becomes 1.09 percent in 2011. In case of agriculture cover it was 3.85% in 2001 and it reduced to 1.15% in 2011. It also decreased by 2.7 percent.

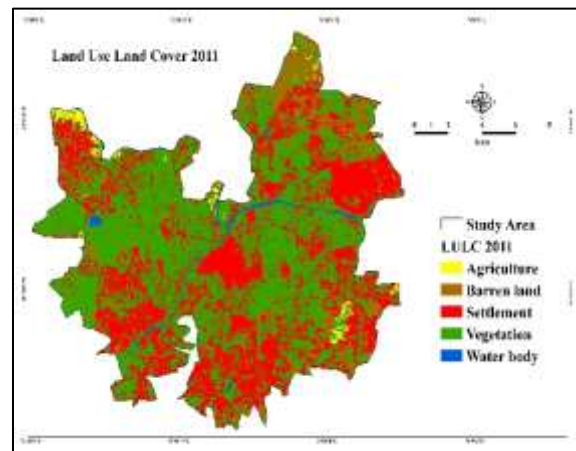
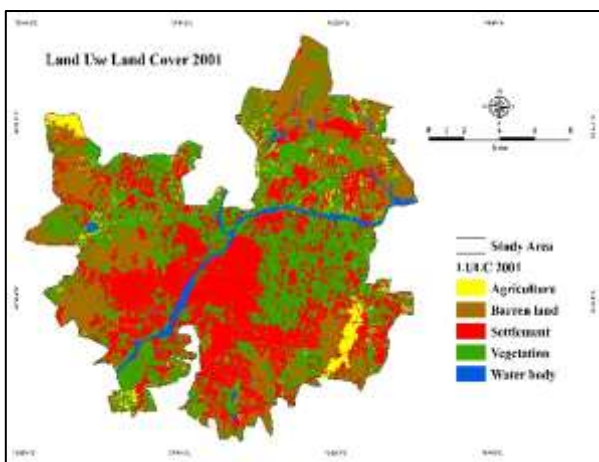


Fig. 2 – LANDSAT 7 satellite image of PMC of year 2001

Fig. 3 LISS III satellite image of PMC of year 2011

These three classes showing decline while settlement and vegetation cover has been increased in one decade of time span.

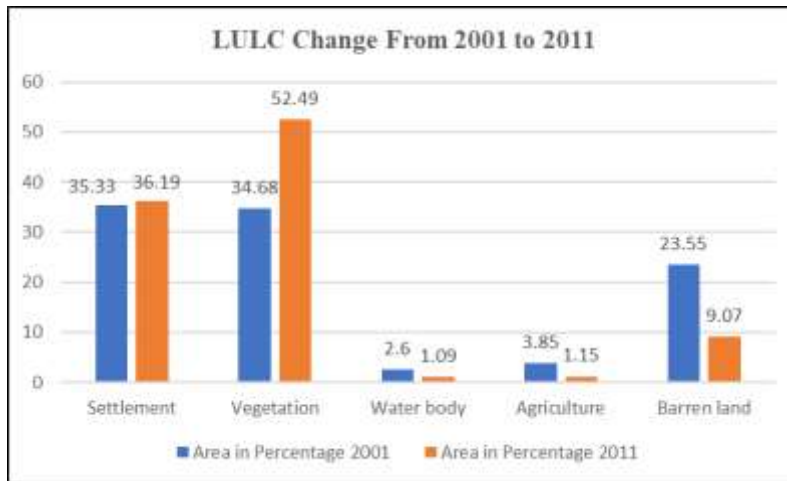


Fig. 4 – Comparison between Land Use Land Cover distribution 2001 and 2011

The total settlement area of Pune City during 2001 was 35.56 percent which becomes 36.19 percent in 2011 this indicates increase in urbanization in Pune city. Whereas, vegetation was 34.68 percent during 2001 and it becomes 52.49 percent in 2011. This is mainly due to the plantation.

The following table showing change in land use land cover in square kilometer from 2001 to 2021.

| Sr. No. | Class | Area in Sq. Km | Area in Sq. Km | Area in Sq. Km |
|---------|-------------|----------------|----------------|----------------|
| | | 2001 | 2011 | 2021 |
| 1 | Settlement | 91.27 | 93.49 | 139.92 |
| 2 | Vegetation | 89.57 | 135.59 | 76.36 |
| 3 | Waterbody | 6.70 | 2.83 | 2.39 |
| 4 | Agriculture | 9.93 | 2.97 | 1.13 |
| 5 | Barren land | 60.82 | 23.43 | 38.51 |

Land Use Land Cover Change From 2011-2021

The land use land cover (LULC) changes from 2011 to 2021 was studied from LISS III and Landsat 8 images. The confusion error matrix shows 92.45 percent and 93.90 percent accuracy in

2011 and 2021 LULC supervised maximum likelihood classification respectively. The change was detected in vegetation, waterbody and agriculture category and significant change in settlement and barren land. Land use statistics shown in below table. The major changes were observed in settlement and vegetation category. In 2011 settlement was 36.19 percent in 2011 and in 2021 it becomes 54.17 percent it means settlement cover has been increased by 17.98 percent. Barren land also increased by 5.84 percent in 2021 compare to 2011. Barren land in 2011 was 9.07 percent it becomes 14.91 percent in 2021. This is mainly due to the decrease in vegetation cover. The land which was covered with vegetation in 2011 that land reduced vegetation cover in 2021 due to human activities and considered in barren category in 2021. Along with these changes' vegetation, waterbody and agriculture were decreased by 22.93, 0.38 and 0.71 percent respectively.

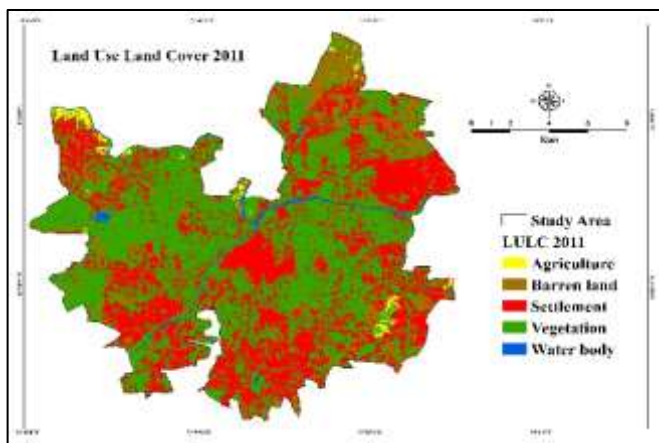


Fig. 6.-LISS III satellite image of PMC of year 2011

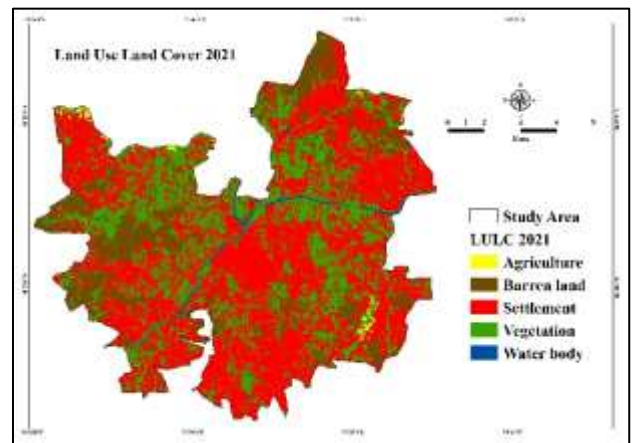


Fig. 6.-LANDSAT 8 satellite image of PMC of year 2021

Vegetation cover was 52.49 percent in 2011 it changed to 29.56 percent in 2021. Waterbody cover was 1.09 percent it becomes 0.93 percent in 2021 and in case of agriculture it was 1.15 percent and it becomes 0.44 percent in 2021.

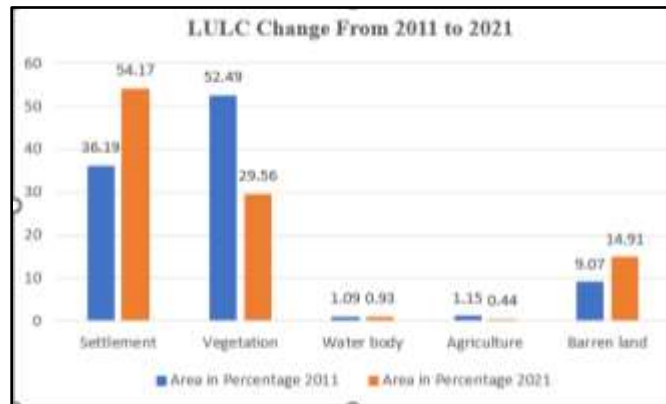


Fig. 7 – Comparison between land use land cover distribution in 2011 and 2021

Conclusion

The present study uses GIS and RS techniques with supervised maximum likelihood classification approach which effectively helped in understanding LULC change from 2001 to 2021 in these three decades. The analysis revealed that most of the region of Pune City area which was previously covered with barren land, agricultural land and vegetation in 2001 was brought under urban land use. Most of the area close to the water body and road are converted in residence or these areas come under construction. In 2001 and 2011 vegetation cover has been increase due to the plantation in the hilly areas. While barren land decreased due to the conversion of barren land into other uses. Similarly barren land in 2021 has increased compared to 2011 and in same years vegetation cover has been decrease this is due to the area under vegetation was considered barren due to absence of vegetation in 2021 image. This happen may be due to the deforestation and new constructions. The present study effectively demonstrated the land use land cover change which will be helpful for the local administrative bodies, regional planners, decision makers, stakeholders for planning purposes.

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