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LAND USE AND LAND COVER CHANGE DETECTION MAPPING OF MULA RIVER BASIN USING GEOSPATIAL TECHNOLOGY

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ABSTRACT

Understanding the patterns of land-use and land-cover (LULC) change is important for efficient environmental management, including effective water management practice. Based on remote sensing (RS) and geographic information system (GIS) techniques, the study is an attempt to monitor the changes in LULC patterns of Mula watershed of Ahmednagar district for the periods 2008 and 2018. Images from Landsat-7 Enhanced Thematic Mapper (ETM+) were used to extract land cover maps. LULC maps of the basin are prepared using the method of unsupervised classification using isodata clustering method. The study area was classified into four categories on the basis of field study, geographical conditions, and remote sensing data. Four major LULC classes viz; vegetations/agriculture land, barren land/fallow land, built-up area/settlement, and water bodies have been identified and indicate that major land use in the watershed is agricultural land and barren land. Results shows, Barren land/fallow land and built-up area/settlement have increased by 3% (65 km^2) and 6% (177 km^2) while agriculture land/vegetation have decreased by 9% (—242 km^2) respectively from 2008 to 2016. During this study period builtup area has showed an increasing trend by 6%, while water bodies remain constant as 3% area. The comparison of LU/LC in 2008 and 2018 derived from satellite imagery interpretation indicates that there is a significant increase in built-up area, and fallow lands. It is also noted that substantial amount of agriculture land, dense vegetation area vanished during the period of study which may be due to increase in settlement of the study area.

Keywords: Land Use Land Cover, Geographic Information System, Thematic Mapper, Remote Sensing, Unsupervised Classification, Etc.

I. INTRODUCTION

In this section highlight the importance of In the global environment change Land use/land cover (LULC) changes are major issues. For monitoring environmental changes and managing natural resources Land-use and land-cover (LULC) change has become a fundamental and essential component in current strategies. There is great potential in the satellite data which can be used to generate valuable information about land use and land cover (Yuan et al., 2005). The satellite remote sensing data with their repetitive nature have proved to be quite important in mapping land use/ land cover patterns and changes with respect to time. Quantification of such land use and cover changes is possible through GIS techniques. These studies have helped in understanding the dynamics of human activities in space and time. Land use refers to human activities. In the modification of the global environment humans have taken an increasingly large role during the past millennium. Various LULC mapping and change detection techniques have been developed and applied all over the world over the last few decades. With increasing numbers and developing technologies, man has emerged as the biosphere's major, most powerful, and universal instrument of environmental change. It is observed globally that land covers are replaced by various land use classes (Geist and Lambin, 2001). LULC changes on the earth surface are divided into land use and land cover (Barnsley et al., 2001). These are two concepts and they are often used interchangeably (Dimyati et al., 1996). The process of identifying differences in the state of a feature or phenomenon by observing it at different times is nothing but change detection. For planning and sustainable management of natural resources it is important to investigate LULC and their impacts (Lambin et al., 2000). Spatial distribution of land use/land cover information and changes in it is desirable for any local, regional, and national planning, management, and monitoring programmes. This information not only improves understanding of land utilisation issues, but it also plays an important role in the development of any region. The conventional approach of identifying land use land cover changes are costly, low in accuracy and present a picture of only small area (Jaiswal et al., 1999). Because of its ability to provide synoptic viewing and repetitive coverage, remote sensing provides useful information on land use/land cover dynamics (Sharma et al., 1989).

Land-use/cover is largely determined by the ecological condi- tions, altitudes, geological structure and slope along with techno- logical, socio-economic and institutional set-up, which also influences the land-use pattern (Rai et al., 1994). Population growth, industrialization, and urbanisation have all had a rapid impact on the LULC (Voogt and Oke, 2003). Though changes in land cover by land use do not necessarily imply degradation of the land how- ever, LULC change is one of the most significant drivers of global changes (Lambin, 1999) and this affects many parts of geo- environmental and natural ecosystems such as biodiversity, water, radiation budget (Pauleit et al., 2005; Lambin and Meyfroidt 2011.). Climate, bio-geochemical cycles, energy fluxes and livelihoods of people get affected by changes in conditions and land covers (Salazar et al., 2015; Tolessa et al., 2017; Gashaw et al., 2018; Niquisse et al., 2017).

Jenson (1986) proposed that detecting changes in land use/land cover necessitates the use of at least two period data sets. Using current and archived remotely sensed data, a practical approach to studying changes in land use/land cover that may be caused by natural/human activities can be accomplished (Luong, 1993). it is now possible to prepare up-to-date and accurate land use/land cover maps in less time, at lower cost and with better accuracy with the availability of multi-sensor satellite data at very high spatial, spectral and temporal resolutions.

In the present study Multi-temporal satellite images of Landsat-7 Enhanced Thematic Mapper (ETM+) having resolution 30 m has been used to map the changing pattern of LULC of Mula basin from 2008 to 2018. Land-use/cover within the pondered watershed is to a great extent decided by the environmental conditions, altitudes, topographical structure and incline. Apart from the above factors, technological, socio-economic and institutional set-up is also expected to influence the LULC pattern (Rai et al., 1994).

The main objective of the present study is to prepare LULC maps for the Mula basin and to assess the changes in various LULC classes using digital remote sensing techniques. The results of such investigations not only reveal the nature of the changes that have occurred, but are also very useful for future planning.

II. METHODOLOGY

Data required:

1. LANDSAT 7 ETM+ images of two year 2008 and 2018 download from USGS, www.earthexplorer.com.

2. ArcGIS software for image classification.

Study area:

The area under the study, Mula basin, lies entirely in the Ahmednagar district of Maharashtra State having area about 2919.55 sq.km. Mula river, which is seasonal in nature originate in Sahyadri ranges and is the tributaries of the mighty Bhima River. Mula dam is one of the important dam constructed on river Mula in Ahmednagar district. Estimating and mapping LULC change for this area will prove to be valuable for environmental management. To achieve this goal, remote sensing data from satellite has been used to map land use changes in the Mula river basin during the 10 year period from 2008 to 2018.

Climatic Condition of Study Area

Climatically, the region falls under the semi-arid and sub-tropical zone with average annual rainfall of 566.5 mm. The distribution of rain is uneven, coupled with frequent droughts. The rainy days vary from 15 to 45 in different years. The annual mean maximum and minimum temperature range between 33 to 43 ^{0}C and 10.10 to 22.9 ^{0}C, respectively. The annual mean pan evaporation ranges from 3.7 to 12.4 mm day. The annual mean wind speed ranges from 3.2 to 13.09 km hr^{-1}. The annual mean maximum and minimum relative humidity range from 59 to 90 per cent and 21 to 61 per cent, respectively.

Data source and method of analysis

Landsat imagery was used to determine LULC change, while dates were selected based on data quality, data availability and the dry season (Table1). Land use is one of the most important factors affecting watershed runoff, evapotranspiration and surface erosion. Four Landsat imageries were acquired for the years 2008 and 2018 from the USGS Earth Explorer (https:// earthexplorer.usgs.gov) using address and place for Mula river basin in Ahmednagar District. The land use map/satellite images of the study area were obtained from USGS Earth explorer (https://earthexplorer.usgs.gov), Landsat 7 ETM+ image with the cloud cover less than 10%, spatial resolution of 30 m × 30 m, acquisition date (06-11-2008 and 18-11-2018). The datasets were

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downloaded considering the time period between 2008 and 2018 having a cloud cover less than 10% to avoid the classification error. If the cloud cover is less than 10% in the Additional Criteria option, click the Results option to get the desired satellite imagery. Click the result icon in the previous step to see the satellite image. Click the metadata record icon to verify that the land cloud cover is zero. Finally, click Level 1 Geo TIFF Data Product to start the download. This is because the accuracy of satellite imagery depends on its MB. Finally, save the zipped data in your working directory for further analysis.

This data was used to generate the LULC map that was entered into the GIS. The software package Arc GIS 10.4 was employed at various stages of analysis. All the images have the same spatial resolution (30 m), and sensed using same satellite but at different years. The images captured in same years were mosaicked and after mosaicking the Landsat scenes by date, the resulting two images were clipped to the study area. The satellite images were classified based using Google Earth linkage with ArcGIS 10.4 software. This was done to represent the land use according to the specific land cover types such as cultivated, vegetation, settlement, water bodies etc,.

Table 1: Satellite data used for the LULC change classification

Satellite	Sensor	Spatial resolution	Number of bands and Wavelength(micrometers)	Acquisition date
Landsat 7 Enhanced Thematic Mapper plus	ETM+	30m	8 Band 1: 0.45-0.52 (Blue) Band 2: 0.52-0.60(Green) Band 3: 0.63-0.69(Red) Band 4: 0.77-0.90(NIR) Band 5: 1.55-1.75(SWIR 1) Band 6: 10.40-12.50(Thermal) Band 7: 2.09-2.35(SWIR 2) Band 8: 0.52-0.90(PAN)	06/11/2008 06/11/2008 18/11/2018 18/11/2018

Land use/land covers classification

The objectives of land use land cover is, to understand the general procedures of land cover classification from satellite images, to conduct land cover classification from the Landsat 7 ETM+ using unsupervised classification.

Image pre-processing:

Pre-processing satellite imagery before detecting changes is essential and has the unique purpose of creating a more direct link between the data and the biophysical phenomenon. The methodology chosen for this study considered a variety of image preprocessing operations, including geometric correction, atmospheric correction, image enhancement and interpretation. The downloaded satellite imagery were pre-processed before the classification was processed. The images downloaded have been layer staked and mosaicked. The downloaded images had a large area, while the actual area being studied can only cover a small portion of the image. To save on disk space and processing time, new images representing the basin were produced, using extraction by mask method in ArcGIS.

Image classification:

There are basically two image classification methods used for land cover classification. Unsupervised classification is an image classification method that performs a land cover classification type from satellite imagery data when the user does not know how many land cover types exist in the field. Other type of classification is: Supervised classification; a method of classifying land cover types using pattern polygons (ground truth points) from known land cover types.

For this study; unsupervised type of classification was used. The family of classifiers involves algorithms that examine unknown pixels in an image and aggregate them into a number of classes based on the natural groupings or clusters present in the image values. The basic assumption is that the values within a particular coverage type must be close to each other in the measurement space. On the other hand, different classes of data need to be separated relatively well.

The classification algorithm is designed to automatically say dense regions within the n-dimensional hyper spectral data cloud. This algorithm is based on the well-known observation that spectra from large and diverse land covers tend to gather around the mean spectrum. This is the basis of the unsupervised cluster analysis classification package. The pixel density around the central spectrum depends on the spectral variation of the land cover and the area range of the land cover.

Table 2: Land use land cover (LULC) change classification scheme

Sr. No.	Class	Discription
1.	Settlement area/Builtup area	Land covered by concrete, including low-, medium, and high-density road networks; residential, industrial, and commercial buildings; educational institutes; transportation; open-roof concrete structures; other human-made structures; and solid waste landfills. Residential, commercial, industry, transportation, roads, mixed urban.
2.	Water Body	This class of land cover describes the areas covered with water either along the river bed or man- made earth dam's band ponds. Eg. River, open water, lakes, ponds and reservoirs.
3.	Agriculture land/ Vegetation	Areas characterized by a high density of grasses, herbs, and crops, including parks and regularly tilled, planted croplands. Describes areas for crop cultivation and the scattered rural settlements. Describes area covered with grass that is used for grazing and that remains covered by grass for a considerable period of the year.
4.	Barren land/Fallow land	Areas with or without sparse vegetation that are likely to change or be converted to other users in the future. This category includes land without crops, land with barren rock, and sand areas along rivers/stream beaches

Method

The supplied image is first extracted from its compressed format for the bands 5, 4, 3, and 2 of NIR, Red, Green and Blue and saved. A composite of Bands 4, 3, 2 (true colour) was performed in ArcGIS and saved as TIFF/GEOTIFF. Then the area of interest was extracted using spatial analyst tool extraction by mask using given shapefile of area. First, an unsupervised classification was performed on the Image using the ISODATA clustering method to classify the image into the desired classes of which 5 different classes were effectively identified.

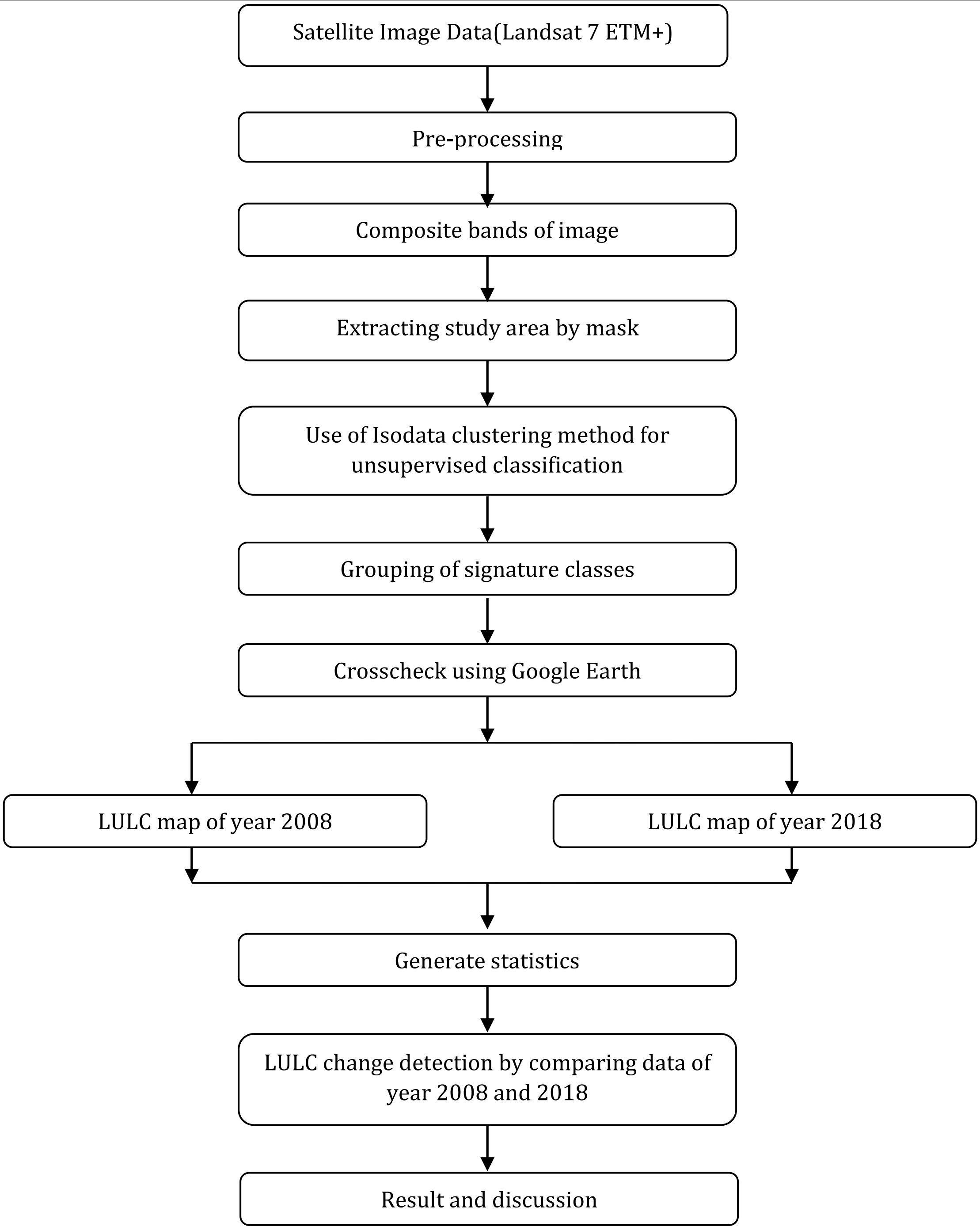

Figure 1: Flowchart of Methodology for land use land covers change detection

III. RESULTS AND DISCUSSION

The present study was carried out on Mula river basin in Ahmednagar district for management of land and water resources.

LULC pattern of 2008

The LULC map layout generated from the Landsat ETM+ data set is displayed in Figure 3. The land categories for the year 2008, and their statistics are listed in Table 4. According to the results, the largest category was agriculture land (1251 km^2, 43% of the total area), followed by barren land/fallow land (1167 km2, 40% of the total area). The remaining land use categories were builtup area/settlements (412 km2, 14% of the total area) and water bodies (89 km2, 3% of the total area).

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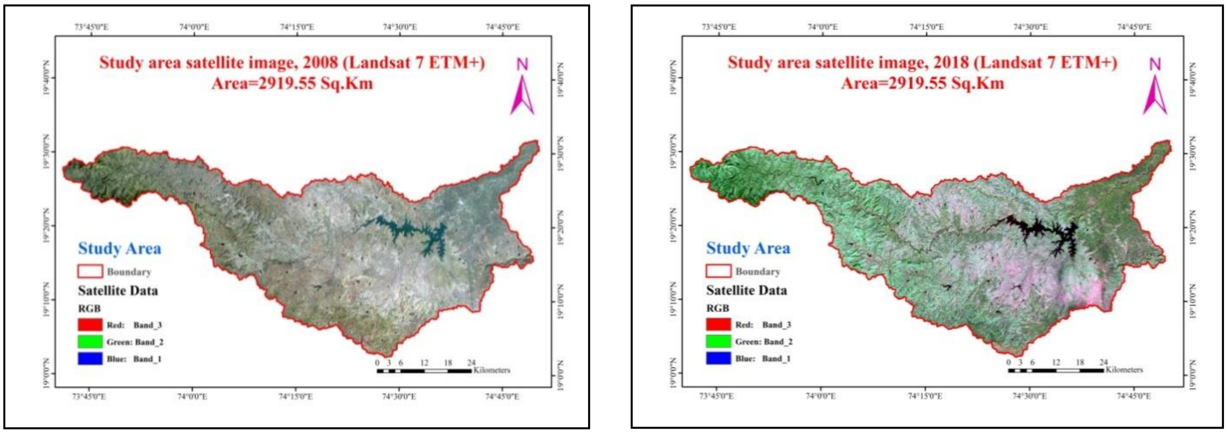
LULC pattern of 2018

The classified image for 2018 (Figure 4) was produced using the Landsat 7 data set. According to the 2018 results, the land area mainly comprised barren land/ fallow land (1232 km2, 43% of the total land), followed by vegetation/agriculture land (1008 km2, 34% of the total area). The land-use categories were builtup area/settlement (589 km2, 20% of the total area) and water bodies (89 km2, 3% of the total area). Table 4 shows the land use categories and their statistics for 2018. From 2008 to 2018, the LULC patterns changed considerably.



(a) (b)

Figure 2: Satellite image Natural colour a) 2008 b)2018

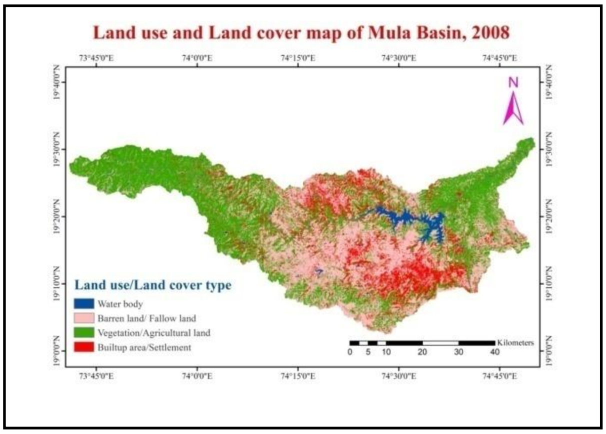


Figure 3: LULC map of Mula Basin, 2008

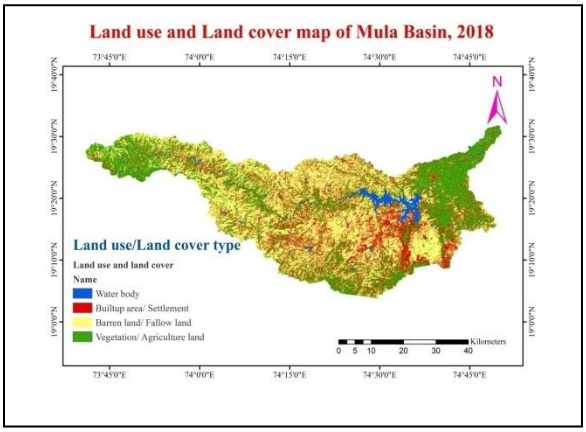


Figure 4: LULC map of Mula Basin, 2018

Table 3: Change in Land use and Land cover types from 2008-2018

Land use land cover type	2008		2018		Change in area	
	Area in Sq.km.	%	Area in Sq. km.	%	Sq.km	%
Vegetation/Agricultural land	1251.115199	43%	1008.78592	34%	-242.33	-9%
Barren land/ Fallow land	1167.018475	40%	1232.221264	43%	65.2028	3%
Builtup area/Settlement	411.7061005	14%	589.1842434	20%	177.478	6%
Water Body	89.44214751	3%	89.09049365	3%	-0.3517	0%
Total	2919.551922	100%	2919.551922	100%		

Change detection from 2008 to 2018

The area under the LULC classes and its changes from 2008 to 2018 are presented in Table 4. Positive and negative changes were observed over 10 years in the area under the LULC categories. The barren land/fallow land and builtup area/settlement categories exhibited a increase in their area, whereas the vegetation/agricultural land exhibited an decrease in their area. As presented in Table 4, the most substantial changes in area were observed for the built-up/settlement categories, followed by the barren land/fallow land categories. There is negative change observed in agriculture land/vegetation category. It is changed into builtup area/settlement and some changed into fallow land.

The following graph shows the change in land use land cover over the period of 2008 and 2018.

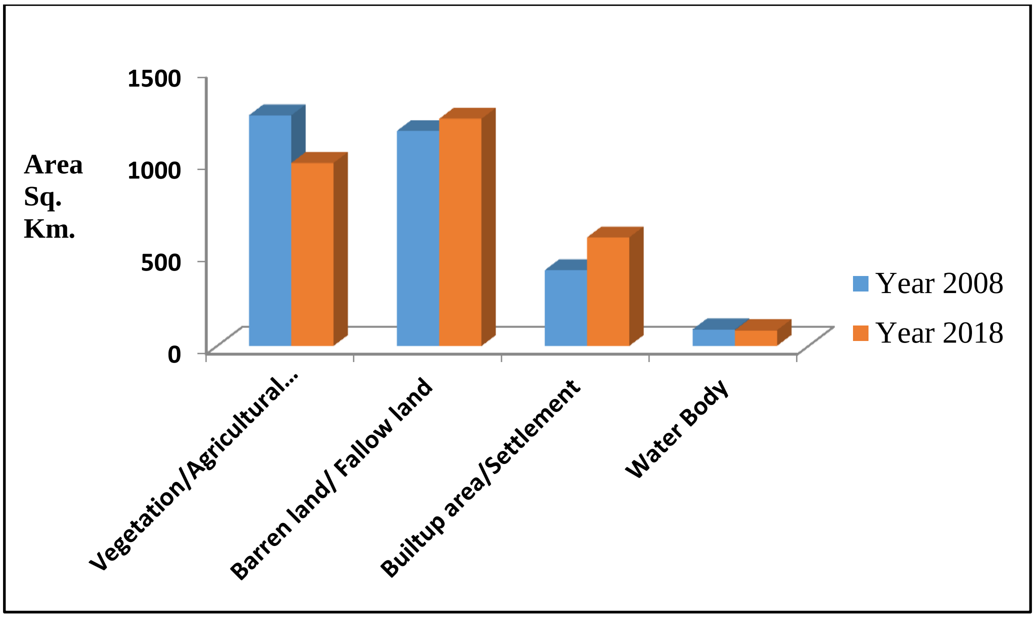


Figure 5: Graphical representation of LULC change detection.

IV. CONCLUSION

The present study demonstrates the application of Remote sensing and Geographic Information Technology technique to access the change in LULC by using satellite image of year 2008 and 2018.In this research, remote sensing and GIS were integrated for quantifying and understanding the LULC changes in Mula river basin in Ahmednagar district over 10 years from 2008 to 2018. The technique used in this study is simple and inexpensive. The extent of land-use changes in Mula river basin was determined using multi-temporal satellite imagery. Significant changes in the LULC were observed in the study area between 2008 and 2018. In the present study built-up area/settlement area is drastically changed. It increases 6 % in the year 2018. During these 10 years, the area under built-up land and settlement increased considerably, whereas the area under agriculture land drastically decreased. Vegetation/agriculture land in the study area has been decreased 9% in year 2018, due to the encroachment of built-up area. Water bodies remain constant during this period of study. Causes of changes in LULC in the study area include decreased agricultural activity and increased accumulation activity. LULC changes may not have a significant environmental impact on the study area. However, LULC changes should be carefully monitored from the perspective of future environmental sustainability.

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