Monitoring Land Use Land Cover Change for Dehradun District of Uttarakhand from 2009-2019

Apeksha Agarwal1, Krishna Kumar Soni2, MSS Rawat1

1Department of Geography, HNB Garhwal (A Central) University, Srinagar Garhwal, Uttarakhand- 264174, India
2Department of Geography, Gujarat University, Ahmedabad-380009, Gujarat, India

Correspondence should be addressed to Apeksha Agarwal, apeksha.ag@gmail.com

Publication Date: 6 September 2019

DOI: https://doi.org/10.23953/cloud.ijarsg.431

Abstract Land cover indicates the physical land type on the earth's surface in the form of waterbodies, vegetation etc. whereas land use refers to the human adjustments with the land. Human has been modifying the land as a resource to fulfill their own needs since time immemorial but recently changes in land use land cover is unprecedented at local, regional as well as at the world level. These changes builds an enormous pressure on the surrounding environment and leading to climate change and loss of biodiversity. Thus, an attempt has been made to detect changes in land use land cover classes in Dehradun district of Uttarakhand state. The study has been carried out for 10 years (2009-2019) through remote sensing approach using satellite imageries of LANDSAT-5 “TM” for March 2009 and LANDSAT-8 “OLI” & “TIRS” sensor for April 2019. Methodology based on supervised classification has been applied using maximum likelihood in QGIS. The current analysis resulted that the district Dehradun has experienced land use land cover changes rapidly, as the area occupied by vegetation was about 46 percent during 2009 has decreased to 28 percent in 2019. About 27.54 percent area covered by vegetation gets turned into agriculture, 4.60 percent area into urban/ built-up and 6 percent into barren land. Agriculture and Urban/ Built-up area has increased immensely. Other land use land cover classes such as waterbody and barren land has also undergone changes. Monitoring and mediating the consequences of LULC classes has therefore become a major priority of researchers and policymakers around the world.

Keywords Change detection; Dehradun district; Land conversion matrix; Land use land cover

1. Introduction

Human relies on land as a resource for the fulfillment of there own needs thus land is an important natural resource from the developmental point of view. Basically land use and land cover are completely different terminologies but sometimes used interchangeably (Dimyati et al., 1996). Land cover indicates the physical land type on the earth's surface in the form of waterbodies, vegetation etc. whereas land use refers to the human adjustments with the land. The land use land cover pattern of a region is an outcome of natural and socio-economic factors prevailing and their utilization by man over the time and space. Industrialization and other factors has recently encouraged the concentration of maximum populations in the urban areas (urbanization) and due to which giving way to depopulation
of their rural counterparts, along with the intensification of agriculture and abandonment of the marginal lands.

Thus, land use land cover change detection is very essential for better understanding of the landscape dynamics during a given period of time (Kiefer Lillesand, 1987; Zhang, 2011) and to assess additions as well as the losses. Land use land cover change is an accelerating process worldwide which are mainly driven by the anthropogenic activities, which in turn changes the ecosystem (Ruiz-Luna and Berlanga-Robles, 2003; Turner and Ruscher, 2004).

The need of digital classification of land use land cover is necessary for the extraction of accurate results and thus lead to better understanding of relationships among human and various natural phenomenon and finally helps in decision making processes (Jokar Arsanjani et al., 2013; Pontius and Malanson, 2005).

Use of Geospatial technology has become important in the field of land use land cover mapping of a region as it gives a detailed information about the land features in very less time with better accuracy (Selcuk et al., 2003). Introduction of satellite imageries with very high resolution and advancement in GIS technology has given way for more consistent monitoring of changes in land use land cover classes over the earth.

Through this study an attempt has been made to map the status of land use land cover of Dehradun district of Uttarakhand for two time periods i.e. 2009 and 2019 and also to detect the changes that has been taken place during the last ten years using geospatial techniques.

2. Materials and Methods

2.1. Study Area

Dehradun district is one the 13 districts of the state Uttarakhand, also the capital of the state lies in the same district. As of 2011 Census, it is the second most populous District, encompassing an area of 3074.40 sq. km., extending in between 29°57’ 56.44” North to 31°1’ 127.13” North Latitudes and 77°38’ 19.57” East to 78°14’ 24.53” East Longitudes (Figure 1). It has an area of 3088 sq. km. with the population size of 1696694. The district comprises of 7 tehsils, 6 developmental blocks and 767 villages. Few places of national importance are present in the district such as Forest Research Institute, Indian Military Academy, Lal Bahadur Shastri National Academy of Administration and Survey of India. Temperate climate is found in most of the places in the district with the elevation of 288 m to 3096 m.

2.2. Database and Methodology

A research methodology is the theme of any research work; it defines the way through which conclusion for the problem can be taken out. Generally, it includes the very first step to the end result (Figure 2). Collection of data for the present work is of secondary in nature. Toposheet from Survey of India, Remote Sensing Satellite Imageries acquired from US Geological Survey has been used.

The base map of the district has been prepared with the help of SOI Toposheet and freely available maps of the concerned area. The base map of the district has been digitized and proper attribute data has been inputted in the QGIS environment.

High resolution remote sensing satellite data of LANDSAT-5 with 7 spectral bands of March 31, 2009 and LANDSAT-8 with 9 spectral bands of April 28, 2019 has been used for identification, classification and change detection of land use land cover classes for the period from 2009 to 2019.
The main tools used for processing, analysis and interpretation are QGIS (Free Source Software) and MS-Excel.

![Study area: Dehradun district](image)

**Figure 1:** Study area: Dehradun district

**Figure 2:** Methodology chart

### 2.2.1. Land Use Land Cover Classification

A number of methods has already been invented for land use land cover classifications, which are known as unsupervised and supervised classification. Land use classification can be carried out based on the relative spectral similarity among the pixels may be either by an unsupervised method in group cases, or by a supervised method based on similarity of cases of predefined classes that have been characterized spectrally. In the present study supervised method of classification with maximum likelihood algorithm has been applied in QGIS so as to get the higher accuracy in classification.
Majorly five land use land cover classes have been identified: Urban/Built-up, Agriculture, Barren, Vegetation and Waterbody.

2.2.2. Change Detection of Land Use Land Cover and its Analysis

To find out changes in land use land cover classes, post-classification detection method has been applied. Change information has been extracted by comparing pixels of the same class and thus the interpretation of the change has been done.

Classified image pairs of two years i.e. 2009 and 2019 and compared using cross-tabulation in order to determine qualitative and quantitative aspects of the changes for the period of 10 years from 2009 to 2019. A change matrix or land conversion matrix has been produced using QGIS software. All the tabulations related to the gains and losses among the land use land cover classes between 2009 and 2019 has been done using MS-Excel.

3. Results and Discussion

The final results obtained through the analysis of multi-temporal satellite imageries are diagrammatically illustrated in Figure 3 (a) (b), 4 (a) (b) and data has been shown in Table 1 and 2. Figure 3 (a) (b) and 4 (a) (b) depicts land use land cover classification for the year 2009 and 2019. Table 1 and 2 shows changes in different land use land cover classes over the span of 10 years. A brief account of these results is discussed in the successive paragraphs.

![Figure 3 (a): Land Use Land Cover, 2009 (based on Landsat Satellite Imagery)](image)

3.1. Land Use Land Cover Classification 2009-2019

The spatial distribution pattern of five land use land cover classes in Dehradun district for the year 2009 has been shown in Figure 3 (a) while Figure 4 (a) depicts for the year 2019. Figure 3 (b) reveals that in 2009 out of the total area 46.56 percent (1431.71 km$^2$) was under vegetation which is highest among all. 22.88 percent (703.60 km$^2$) was under agriculture, 12.53 percent (385.40 km$^2$) under urban/built-up, 11.54 percent (353.89 km$^2$) under barren land and 6.49 percent (199.81 km$^2$) was under waterbody. During 2019 as illustrated in Figure 4 (b), the area under different five land use land cover categories was found about 28.49 percent (876.15 km$^2$) under vegetation, 36.92 percent (1135.19 km$^2$) under agriculture land, 18.39 percent (564.65 km$^2$) under urban/built-up, 13.43 percent (413.11 km$^2$) under barren land and only 2.77 percent (85.27%) was under waterbody.
Figure 3 (b): Area under five land use land cover classes, 2009

Figure 4 (a): Land use land cover, 2019 (based on Landsat Satellite Imagery)
3.2. Land Use Land Cover Changes 2009-2019

Table 1 and 2 data reveals that various changes of +ve and −ve nature has occurred in five land use land cover classes pattern in Dehradun district during last one decade i.e 2009 to 2019. Out of all the five land use land cover classes, the area covered by class agriculture has immensely increased from 703.60 km² to 1135.19 km² from 2009 to 2019 accounting for 14.04 percent of the area. The area under urban/ built up reach from 385.40 km² to 564.65 km² from 2009 to 2019 which leads to 5.86 percent of the area. The Barren land class has also been slightly increased from 353.89 km² in 2009 to 413.11 km² in 2019 contributing for 1.89 percent of area. The two classes of land use land cover have shown negative values in the study region. Vegetation has immensely decreased from 1431.71 km² to 876.15 km² from 2009 to 2019 accounting for 18.07 percent of area. Also there is a slight decrease in the length of waterbodies from 199.81 km² to 85.27 km² from 2009 to 2019 accounting for 3.72 percent of area (Table 1).

Table 1: Change in area (sq. km.) among land use land cover classes from 2009-2019

| Class           | 2009 Area (sq. km.) | 2019 Area (sq. km.) | Change (2009-2019) |
|-----------------|---------------------|---------------------|--------------------|
| Urban/ Built up | 385.40              | 564.65              | 179.25             |
| Agriculture     | 703.60              | 1135.19             | 431.59             |
| Vegetation      | 1431.71             | 876.15              | -555.56            |
| Waterbody       | 199.81              | 85.27               | -114.54            |
| Barren          | 353.89              | 413.11              | 59.22              |
| Total           | 3074.40             | 3074.40             | 0.00               |

Source: Calculated by Authors

Table 2: Land conversion matrix (in %) for five land use land cover classes from 2009-2019

| LULC Classes (2009-2019) | Urban/ Built-up | Agriculture | Vegetation | Waterbody | Barren |
|--------------------------|-----------------|-------------|------------|-----------|--------|
| Urban/ Built up          | 74              | 21.85       | 4.60       | 0.71      | 2.29   |
| Agriculture              | 8               | 51.49       | 27.54      | 14.52     | 18.42  |
| Vegetation               | 0.71            | 9.95        | 62         | 34.04     | 35.04  |
| Waterbody                | 0               | 0.04        | 0          | 42.88     | 0.89   |
| Barren                   | 17              | 16.67       | 6.00       | 8.04      | 43.36  |
| Class total              | 100             | 100         | 100        | 100       | 100    |

Source: Calculated by Authors
To understand how different land use land cover classes has changed into other uses over 10 years, a land conversion matrix (Table 2) has been prepared based on the percentage which in turn explains that:

- Vegetation covered area of about 27.54 percent has turned into agriculture, 4.60 percent area under urban/built up and 6 percent area under barren land;
- Agriculture area of about 21.85 percent has turned into urban/built up, 16.67 percent into barren land and 9.95 percent area into vegetation;
- Barren land area of about 35.04 percent has turned into vegetation, 18.42 percent into agriculture, 2.29 percent area into urban/built up;
- Under urban/built up class, 17 percent of the area has been turned into barren land and 8 percent of area into agriculture;
- About 34.04 percent area of waterbody has been turned into vegetation, 14.52 percent into agriculture, 8.04 percent into barren land and 0.71 percent into urban/built up.

4. Conclusion

The work has been carried out for Dehradun district in the state of Uttarakhand advocates that multi-temporal land use land cover classifications derived from high resolution satellite data provides suitable data to assess past as well as present changes in land use land cover classes.

The changes in land use land cover classes has been rapid. Urbanization has found to be among the major drivers of change, as the statistics of the change shows a drastic increase in the urban/built-up area from 12.53 percent in 2009 to 18.39 percent in 2019. Also agriculture area has increased from 22.88 percent to 36.92 percent and barren land area from 11.54 percent to 13.43 percent. Vegetation cover in the study area has immensely reduced from 46.56 percent in 2009 to 28.49 percent in 2019. Thus the results shows that there is a drastic increase of urban/built-up area and agriculture area whereas reduction in green cover and waterbody area within the concerned district. As the rapid growth of the cities in Dehradun district as expected to progress, it can be expected that further urbanization will probably impact the overall vegetation cover in the.

The present work itself explains that how important is the applicability of Geospatial Technology, it helps to analyze the lengthy temporal as well as spatial datasets with faster results in a more accurate manner which is in another way not at all possible with the use of conventional mapping techniques.

Acknowledgement

This paper constitutes a part of mini project done during DST-NRDMS sponsored Summer Training Programme. Moreover, we acknowledge the supply of LANDSAT data by the US Geological Survey.

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