

Analysis of Land Use/Land Cover Mapping for Sustainable Land Resources Development of Hisar District, Haryana, India



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Abstract Natural resources on the earth are being continuously stressed to meet the demands of increasing population. The increasing population requires enhanced production of food, energy, and water. To ensure reasonable civic amenities for quality life, there is need for the development of more infrastructure, more areas under habitation, and enhanced per capita expenditure. Land resources, being finite, need to be prudently used to meet the ever-increasing demand. This requires the study of land use/land cover (LU/LC) and its monitoring to understand the changing dynamics and optimal utilization of the resources. Geoinformation technologies are helpful to a great extent for not only creation of baseline information but also to monitor such changes. The present study has been carried out for Hisar district of Haryana state, India, over a period of 10 years to understand the change in the land use/land cover pattern. The district has a total geographical area of 4174.52 sq. km. Digital image processing with selected ground truth has been carried out for generating the information from satellite data. IRS/LANDSAT data have been used for the purpose. This information has been analyzed in the light of various land resources constraints by taking collateral information on soil types, groundwater quality, and depth along with geomorphological constraints. This information has been used for suggesting land resources development plan for the region which will ensure optimum and prudent use of land resources.

Keywords Land use/land cover · Hisar · India · Land resources and sustainable development

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1 Introduction

Land use refers to human use of an area of the earth. Generally, the land is divided into sections, such as forest land, agricultural land, fallow land, pasture etc., informing the economic activity that takes place on the land. Land use and changes in it have a very important impact on the environment and ecology of an area (Anderson 1971; Arya et al. 1999; Chaudhary and Kumar 2017; Chaudhary et al. 2008). Among the issues related to natural resource conservation are the points related to land use conservation: soil erosion and conservation, soil quality enhancement, water quality and availability, vegetation protection, wildlife habitat, etc. Land use and land cover have different significance in their own ways and is the basis for Natural Resources Census. Land use is defined as a land which is used by different human activities like farms, industry, etc., or how land is utilized; land cover is slightly different (Xiubin 1996; Turner et al. 1994; Falcucci et al. 2007). Land cover is that land on which physical material is present at the surface of earth, like trees, bare land, etc. Land classification refers to different land types based on similar character. Land can be classified based on physical determinants such as soil profile, soil texture, and many different conditions, as well the purpose for which it is being used. Land Cover Classification considers biophysical individuality. Land Use Classification considers the serviceable use of land associated with human activities (Anderson et al. 1976).

Remote sensing application technology provides reliable information on natural resources and proper data acquisition system, both quantitative and qualitative. It is useful for planners and natural resources persons. This technology proved to be a boon to land use planners. Land comprises all elements of the physical environment to the extent that these influence potential for land use. The growing pressure of population coupled with increasing multiple requirements – environmental, social, and land use problems – have necessitated the optimum utilization of land of an area. Information on existing land use is essential for planning optimal utilization of land (Chaudhary 2003; Clevers et al. 1999; Dhawan 2017; Gupta and Roy 2012; Hooda et al. 1992; Hussin and Shaker 1995). Land use is a dynamic phenomenon and controlled by several factors such as climate, geomorphology, soils, water availability, socioeconomic and cultural factors, etc. The physical results of past human activity, such as vegetation clearance, etc., are included within the concept of land use changes. Unfavorable consequences from past use, such as eroded soils, degraded vegetation, and salt-affected soils, must also be included.

Land and soil are precious natural resources and are nature's gift to the human-kind. The prosperity of a country depends on the richness of these resources. In a country like India, where the population pressure on land is high, rational utilization of the land resources assumes great importance for the optimal and sustained production with minimum hazards. Essentially, this will mean proper utilization of land and soil. These resources, however, have been most recklessly used by humans in the past to extract more and more from them. This has caused rapid deterioration and degradation of lands. Land is the basic and most important resource in Haryana,

as it is true for nearly all other states of the country (Kumar 2017; Kushwaha and Oesten 1995; Ram and Singh 1995; Rani 2017; Toleti 1995).

The land resources are limited, as the total geographical area is fixed. Land is, therefore, scarce in supply. It is irreplaceable and not reproducible. While the land is finite, the population dependent on land and its needs are infinite (Narumalani et al. 2004; Reid et al. 2000; Kuemmerle et al. 2006). These have been increasing with time. Per capita availability of the resources, therefore, has been declining. One of the prime requisites for better land use is information on existing land use and the distribution of settlement, forest, agricultural land, barren land, etc., and they are important to determine land use policy, planning of transportation, and communication services, etc. The present land use is the result of different causes which are related to landforms, soil conditions, irrigation facilities, marketing, communication and transport, and socioeconomic conditions (Yang and Liu 2005; Yonas et al. 2013; Meyfroidt and Lambin 2008).

Remote sensing technology implies observation of an object from a distance, without being in actual contact with it. Remote sensing of the earth or any other planetary body involves collection of information like topography, natural resources, and natural phenomena such as volcanic eruptions, forest fires, floods, droughts, etc., with the help of sensors like cameras, scanners, radiometers on board platforms like airplanes, rockets, balloons, etc. The study reveals the land use/land cover changes from 1988–1989 to 1999–2000.

2 Materials and Methods

2.1 Study Area

The study area which comprises of Hisar district extends from $28^{\circ}53'45''$ to $29^{\circ}49'15''$ N latitudes and $75^{\circ}13'15''$ to $76^{\circ}18'15''$ E longitudes, and covers an area of 4174 sq. km. The district is bordered by Fatehabad district and Rajasthan state in the west, Rohtak district in the east, Bhiwani district in the south, and Jind district in the north. The location map of the study area is shown in Fig. 1. The southwest monsoon season lasts from the interim week of June to the middle of September. The weather here is almost dry from October month to the following June. Occasionally, light disturbances occur with lightning due to western disturbances. Only 75–80% annual rainfall is received in the four rainy months of June to September. Here also the average annual rainfall is 450 mm and 133.4 mm in July, 116.2 mm in August, 54.5 mm from September, and 49.8 mm average annual rainfall since June. The average rainfall season is 354 mm. The maximum rainfall ever measured was 793.6 mm in 1976. The minimum rainfall was recorded in the year 2000, which is 145.2 mm. Here, 10–15% of the total rainfall is in the winter season due to southern disturbances. The maximum days of the rainy season are in the months of July and August and the minimum days are in November and December. The lands in the district are Aeolian plains, older alluvial plains, and Chautang flood plains, which further have sand dunes, plains, old channels, and

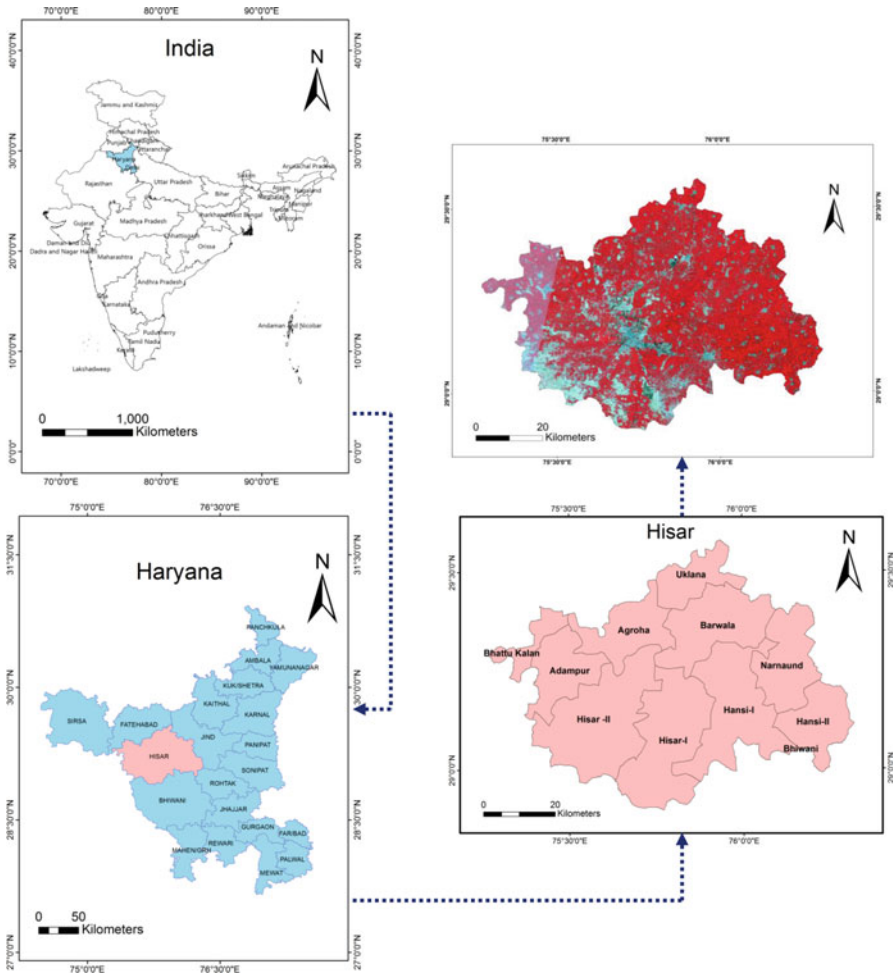


Fig. 1 Location map of Hisar district, Haryana

basin as subunits. Aeolian activities are dominant in west and southwest parts of district, having presence of sand dunes, sandy plains, and interdunal areas. As a part of the Indo-Gangetic alluvial plain, the study area owes its genesis contemporaneously with the uplift of the Himalayas. This sag has since been filled up by sediments derived from the rivers and channels of northern Himalayas and southern Aravalli hills from Pleistocene to recent times (Rani 2017).

2.2 Data Used

The study area is covered by Survey of India Toposheet Nos.: H43P-7, 8, 10–12, 14–16 H43Q-03, 04, 08, H43V-09, 13 on 1:50,000 scales. These were used for the

preparation of digital base map, demarcation of district boundary, and other collateral information. Landsat TM+ data of October 1999, February 2000, October 2014, and February 2015 (A, B, C, and D in Fig. 3) are used to prepare LU/LC maps of study area. In the preparation of LU/LC map of area, ancillary data in the form of topographic maps and other published relevant material were used as reference information.

Landsat TM and ETM+ images were selected as the remotely sensed data for this study. The Landsat's temporal resolution is 16 days and its spatial resolution is 30 m, meaning that images for a specific path and row are available every 16 days. Landsat being sun-synchronous, it generates day images only (Rani et al. 2018; Kumar et al. 2014, 2018a, b; Mandal et al. 2014; Yadav et al. 2014). These images are available for download upon request from United States Geological Survey (USGS)-specified websites such as earthexplorer.usgs.gov and glovis.usgs.gov. For acquiring Landsat TM and ETM+ data from its historical data archives, earthexplorer.usgs.gov was chosen. USGS offers open access to Level 1C product to users; L1C is a radiometrically and geometrically corrected. The correction algorithms used the spacecraft model and sensor, using images generated by in-flight computers during data acquisition events. Operational Land Imager (OLI) on board Landsat TM and ETM+ makes available the opportunity to estimate SSC in Gaula River. Orthorectified and terrain-corrected level-1 data that overpass on 28 October 2017 was acquired from USGS Earth Explorer site to synchronize with collected ground truth data from three sites. Data was provided in Geo TIFF format with UTM projection and WGS84 datum.

Landsat TM and ETM+ satellite has two main sensors. There are the Landsat TM and ETM+ using nine spectral bands in different wavelengths of visible thermal infrared sensor (TIRS). OLI which collects and captures visible bands, near-infrared and shortwave light to observe a 185 km (115 mile) wide swath of the earth in 15–30 m resolution covering wide areas of earth's landscape while providing sufficient resolution to distinguish feature like urban centers, farms, forests, etc., corresponding image was selected by inputting Path and Row numbers of 194 and 56 respectively. This TILE covers the entire length of the Gaula River basin. After selecting the desired date and type of product an order was placed for processed L1C product. It is to be noted that the best monsoon seen month of October was considered for the present study.

2.2.1 Georeferencing of Satellite Images

Satellite data of both the years were loaded through EXPORT/IMPORT function of ERDAS/IMAGINE as generic binary file or directly in GEOMATICA. From the original data sets Area of Interest (AOI) was extracted and subsequently mosaicking of images was performed. Raw satellite images do not orient with respect to ground. In order to correct them, ground coordinates of any coordinate system has to be assigned (Bisht et al. 2014; Kumar et al. 2012, 2013; Rani et al. 2011; Sharma et al. 2011). Image rectification/georeferencing includes assigning map coordinates to image data. Georeferencing/rectification may be carried out by two techniques.

In forest technique, it is image-to-image registration, and this process involves assigning coordinates of already geo-rectified image to raw image; and second technique is assigning coordinates to known points in raw image collected from ground by means of GPS. For this study, Landsat ETM+ satellite data, which are freely available, were downloaded from website (GLCF data product). These satellite images are already geo-referenced and used to geo-reference IRS 1D LISS III satellite images of the study area using image-to-image georectification process in ERDAS Imagine (Murthy et al. 2017; Kumar et al. 2016; Pandey et al. 2015).

A flowchart of the methodology used and satellite images are given in Fig. 2. Scanning, georeferencing, and mosaicking of the toposheets were carried out for using these as reference sources for georeferencing of different digital satellite data of 1999–2000 and 2014–2015 after that supervised and unsupervised classification was carried out. Also, various LU/LC categories were identified on the basis of standard image interpretation keys like tone, texture, shape, size, pattern, and association, etc. The built-up area gave doubtful signature in the supervised/unsupervised classification, and hence on-screen digitization was also carried out for removing the doubt in built-up land (Fig. 3).

3 Result and Discussion

For various land resource studies, regional planning and management, land use/land cover mapping is very important. In case of land degradation status mapping and monitoring, the land use/land cover study is proved to be very much helpful. In this study, land use/land cover mapping was carried out to achieve the ultimate objective of this research. The detailed methodology to generate land use/land cover map has been discussed.

3.1 Land Use/Land Cover

The LU/LC map was generated using supervised classification approach using two seasons satellite imageries, and five broad land categories were identified. These land categories are as follows:

- Built-up (Built-up Compact, Built-up, Sparse Vegetated/Open Area, Rural, Industrial Area, Ash/Cooling, Pond/Effluent and other Waste)
- Agricultural Land (Kharif, Rabi, Cropped in Two Seasons, Cropped in More than Two Seasons, Fallow Land, Agriculture, Plantation)
- Forest (Open, Deciduous, Open Tree, Clad Area)
- Grass/Grazing Land (Alpine/ Sub-Alpine)
- Wastelands (Salt-Affected Land, Open Scrub Land, Desertic Sandy Area)
- Wetlands (Manmade, i.e., Water-logged, Saltpans, Inland, etc.)
- Water Bodies (Canal/Drain Permanent and Seasonal Lake/Ponds)

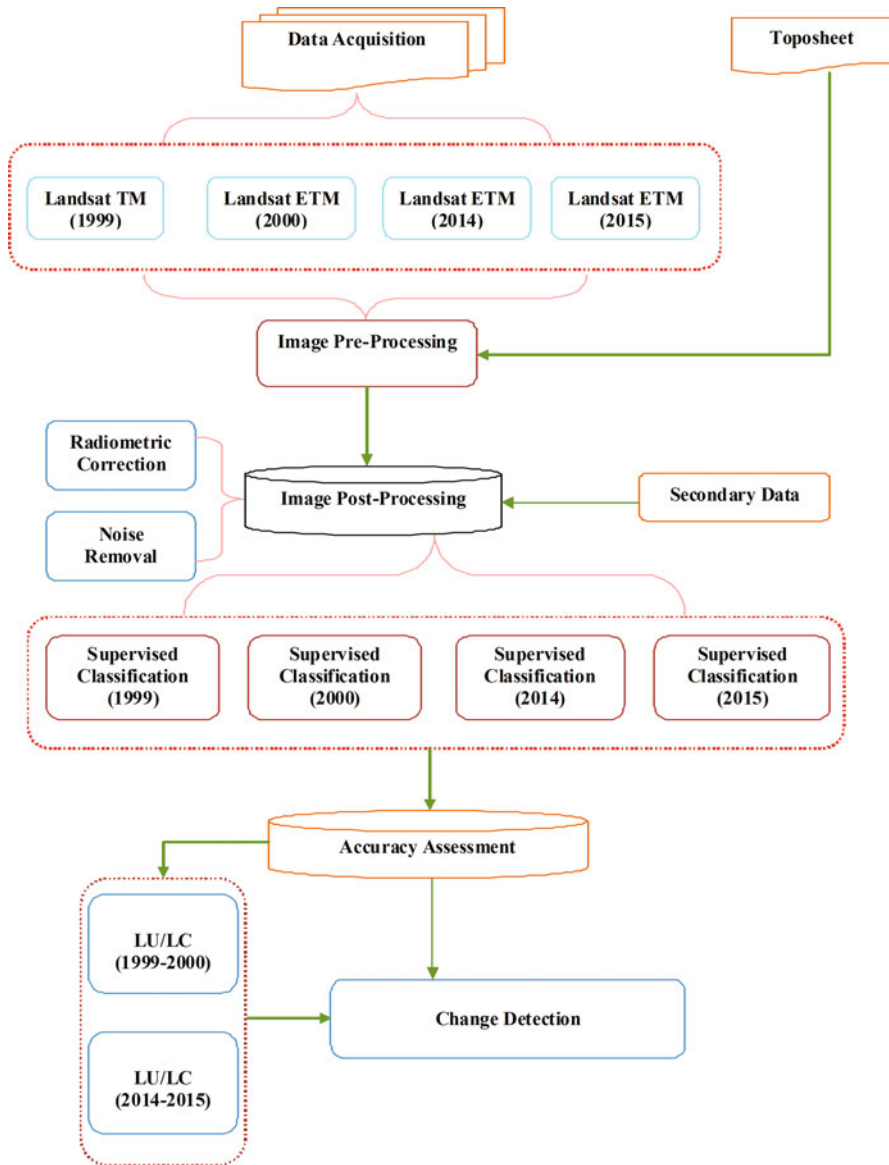


Fig. 2 Flowchart of methodology

The classes interpreted were subsequently verified in the field by conducting an extensive field survey. Area statistics for different land use/land cover categories was generated and are given in Tables 1 and 2. Characteristics and spatial distribution of each of the land class have been discussed in the following sections. In present study, the district divides in to 7 major categories and 21 subcategories according to world standards (Natural Resources Information System (NRIS)), as follows.

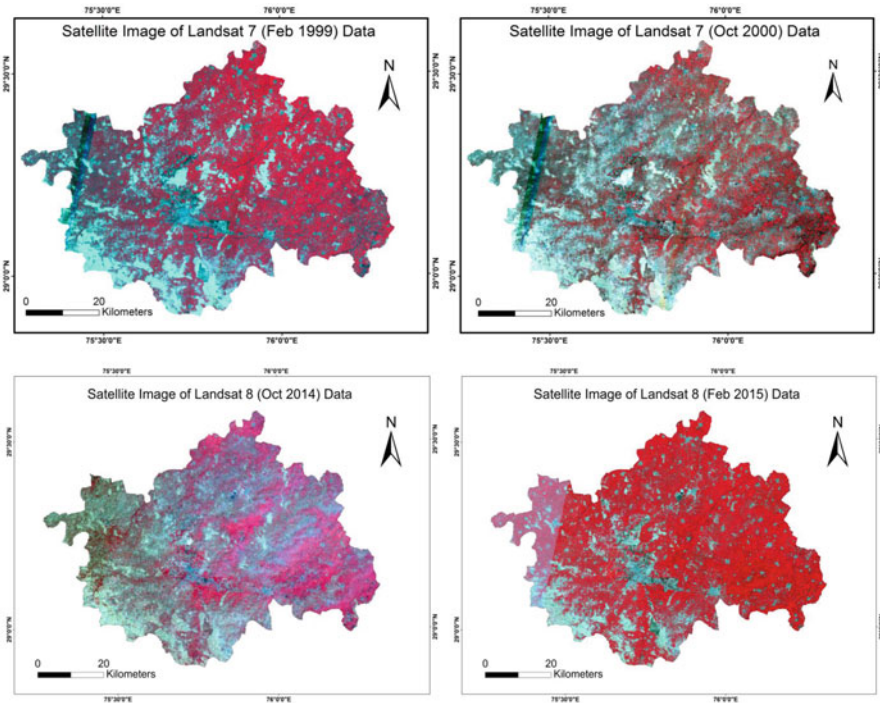


Fig. 3 Satellite images (a-October 1999, b-February 2000, c-October 2014, and d-February 2015)

3.1.1 Built-Up Land

It is characterized by intensive land use where the site has been altered by human actions. Level-II classifications under Built-up land category are Built-up Compact, Built-up Sparse, Vegetated/Open Area, Rural, Industrial Area, Ash/Cooling Pond, and other Waste. Total area under this category is 127.5 sq. km in year 1999–2000, and it increased by 28.40 sq. km in year 2014–2015.

3.1.2 Agricultural Land

The land which is used for farming and production of food and crops. In this category, land covered under Kharif, Rabi, Cropped in 2 Seasons and Cropped in More than 2 Seasons, Fallow Land, and Agriculture Plantation. Area covered under this category is 3829.68 sq. km in year 1999–2000, which decreased by 8.37 sq. km in year 2014–2015.

Table 1 Showing area statistics of different land use/land cover classes of Hisar district for year 1999–2000

Area of land use/land cover categories in year 1999–2000		
Category	Subcategory (level-III)	Area (sq. km)
Built-up	Built-up compact	21.08
	Built-up sparse	5.59
	Vegetated/open area	6.64
	Rural	57.05
	Industrial area	36.57
	Ash/cooling, pond/effluent, and other wastes	0.59
Agricultural land	Kharif	187.85
	Rabi	189.95
	Cropped in 2 seasons	3284.75
	Cropped in more than 2 seasons	0.37
	Fallow land	162.75
	Agriculture plantation	3.79
Forest	Open deciduous (dry/moist/thorn)	5.49
	Open tree clad area	23.46
Grass/grazing land	Alpine/sub-Alpine	134.73
Wastelands	Salt-affected land	0.58
	Open scrub land	18.07
	Desertic sandy area	5.46
Wetlands	Manmade (water logged, salt pans, etc.), inland	0.64
Water bodies	Canal/drain	13.83
	Permanent and seasonal lakes/ponds	15.27
	Total area	4174.52

Table 2 Showing area statistics of different land use/land cover classes of Hisar district for year 2014–15

Category	Area in 1999–2000	Area in 2014–2015	Change in area
Built-up	127.52	155.93	28.40
Agricultural land	3829.68	3821.31	–8.37
Forest	28.92	39.43	10.51
Grass/grazing land	134.73	113.02	–21.71
Wasteland	24.11	15.23	–8.88
Wetland	0.66	0.40	–0.25
Water bodies	28.89	29.20	0.31
Total area	4174.52	4174.52	0.00

3.1.3 Forest Land

Forest land use is a function of the social and economic purposes for which land is managed, while forest land cover is a human definition of the biological cover observed on the land (Watson et al. 2000). In this category, land covered under

Open Deciduous (Dry/Moist/Thorn), Open Tree Clad Area. Area covered under this category is 28.92 sq. km in year 1999–2000, which increased by 10.51 sq. km in year 2014–2015.

3.1.4 Grass/Grazing Land

Land covered by grass/crops and suitable for grazing by animals is known as Grass/Grazing Land. Alpine/Sub-Alpine are type of grasslands present in study area. Area covered under this category is 134.73 sq. km in year 1999–2000, which decreased by 21.71 sq. km in year 2014–2015.

3.1.5 Wasteland

Wasteland is a barren or uncultivated land which may be barren due to flood or any other natural activities. In this category, land covered include Salt-Affected Land, Open Scrub Land, Desertic Sandy Area, etc. Area covered under this category is 24.11 sq. km in year 1999–2000, which decreased by 8.88 sq. km in year 2014–2015. The various wasteland categories identified in the study area are scrubland, land without scrub, sand (desertic and riverine) stony land, and gully or ravine land.

3.1.6 Wetland

Wetlands are areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. In this category, land covered under manmade (waterlogged, salt pans, etc.) and inland. Area covered under this category is 0.66 sq. km in year 1999–2000, which decreased by 0.25 sq. km in year 2014–2015.

3.1.7 Water Bodies

It is an area which is covered water and by flow of water. In this category, land covered under Canal/Drain and Permanent and Seasonal Lake/Ponds. Area covered under this category is 28.89 sq. km in year 1999–2000 (Table 3), which increased by 0.31 sq. km in year 2014–2015. Ephemeral rivers/streams are major contributors in this category of land. Tank or ponds are associated with settlement areas, whereas other natural water bodies exist in east of Aravalli hills.

Land use/land cover map of study area for year 1999–2000 and 2014–15 is shown in figures 4 and 5. Land use/land cover map of Hisar district prepared using online digitization technique of satellite imageries Landsat 7 and Landsat 8 for year 1999–2000 and 2014–15. Area covered under different categories shown in Tables 1 and 2. Change in area is also in Table 3 (Figs. 4 and 5).

Table 3 Change in area of LU/LC under different category from 1999–2000 to 2014–2015

Category	Area in 1999–2000	Area in 2014–2015	Change in area
Built-up	127.52	155.93	28.40
Agricultural land	3829.68	3821.31	-8.37
Forest	28.92	39.43	10.51
Grass/grazing land	134.73	113.02	-21.71
Wasteland	24.11	15.23	-8.88
Wetland	0.66	0.40	-0.25
Water bodies	28.89	29.20	0.31
Total area	4174.52	4174.52	0.00

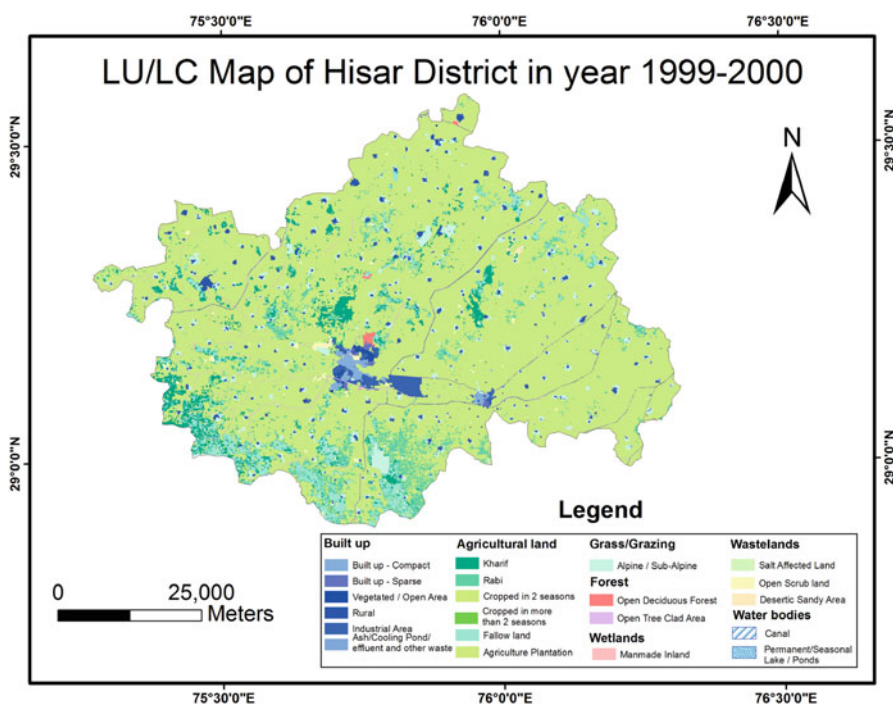


Fig. 4 Land use/land cover map of Hisar district for year 1999–2000

4 Conclusions

The study indicates maximum increase of 28.40 sq. km under built-up land over last 15 years. This is due to the conversion of agriculture land and grass land to built-up land due to increasing pressure of population and migration of the people from other states to the area. There is negligible increase in the area under water body, which is not commensurate with the population increase in these 15 years as the area is

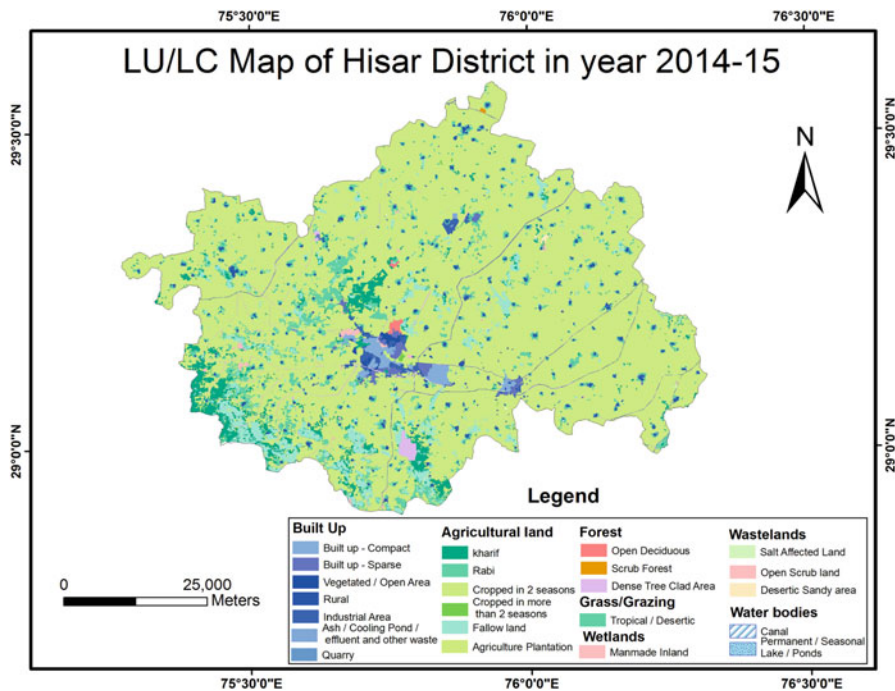


Fig. 5 Land use/land cover map of Hisar district for year 2014–15

predominantly deserts and groundwater conditions including quality and availability are not so good. Hence there is a need of some water harvesting planning in the district. Grass/ grazing land is increasingly being converted into forest land which is a healthy sign. There is remarkable reduction in the area under wastelands which has been converted to built-up and forests. The study demonstrates the subtle role of geospatial technology in LU/LC mapping and monitoring for the use of planners/ decisions makers.

Acknowledgements The authors are thankful to University Grant Commission, New Delhi, for the funding provided under Major Research Project wide reference F. No. 41-883/ 2012 (SR).

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