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RESEARCH ARTICLE

Land use / land cover changes using GIS and remote sensing for Lahul and Spiti district of Himachal Pradesh, India

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Abstract

A major factor in sustainable development and humanitarian response to global change in land use and land cover change. In global environmental change, land use and land cover play an important role and contributes significantly to earth-atmosphere interactions and the loss of biodiversity. The distribution of land cover in the region is closely linked to climatic conditions. For a wide variety of applications, such as landslide and erosion management, land planning, Disaster management, etc., mapping of land use and land cover change is important. In this study, land use and land cover mapping carried out using GIS and remote sensing in Lahul – Spiti District of Himachal Pradesh. Landsat 7 and 8 data of the years 2005, 2010, 2015 and 2019 have been used for land use and land cover mapping. The maps for LULC produced using supervised classification techniques using the maximum likelihood classification (MLC) algorithm. Supervised classification methods have been used for delineating five major classes: snow/glacier, barren/rocky surface, forest, agriculture/grass, and water. LULC maps have been prepared using ArcGIS 10.8. Forest cover reduced from 4.34% in 2005 to 1.58% in 2019. Same way Snow/Glacier has increased from 27.31 percent to nearly 39.15 percent in the year 2019. Agriculture practice has decreased from 13.06 % to 6.92% in the year 2019. The slope area that represents the barren land in the study area is reduced from 55.22% to 52.29% in 2019. The area under water also reduced by 0.06% in 2005 to 0.04% in 2019.

Keywords: Landuse/Landcover (LULC); GIS; remote sensing; supervised classification; Himachal Pradesh

Introduction

Land use and land cover information are important for a range of planning and management activities. Due to their significant impact on how land will be used in the future, current land use trends are a key factor in determining how land development, management, and planning activities should be carried out. Any of the natural resources in a given locality are directly or indirectly connected to the surface cover.

Vegetation is a very sensitive aspect of vegetation as a key factor in land cover for the Climate Change Ecosystem. The growing season and the total quantity of vegetation, called the dynamics of vegetation, are also greatly influenced by climate change. Due to human impacts, HP's environment is undergoing a rapid transition. Owing to environmental changes, changes in land use and land cover are very rapid, and there is a need

for an archive of past and current land use and land cover information in Himachal Pradesh. The availability of land use and land cover information helps decision-makers to establish short and long-term strategies for the conservation, sustainable use, and growth of natural resources. HP is the main factor in sustainable land use management and development.

The two fundamental principles for understanding the natural world and its use by humans are land cover and land use. Landcover refers to land's physical state; an assemblage of components of biotics and antibiotics; Climate and geo-physical climate reflections. It denotes the natural existence of various areas of land, such as forests, grasslands, deserts, etc. The concept of land use extends to multiple uses of land by humankind. Land use refers to the use of land by humans for various purposes and activities, which may include settlements or construction areas, agricultural land, etc. Land, pasture, transport, and other activities related to infrastructure. Some aspects of increasing developmental trends and environmental dimensions in a region are represented by land cover/land use and its transition. It determines where and what kind of growth affects the use of land. It determines where and what kind of growth affects the production of Land use. The relationship between climate factors, environmental changes, and disaster vulnerability of the region is expressed in these changes. Information on land-use/land cover is instrumental in recognizing the positive and negative aspects of change, regulating haphazard development and environmental degradation. The research aims to study temporal changes in LULC for the years 2005, 2010, 2015 and 2019 using ArcGIS 10.8.

Study area

The study area taken for this study is the Lahul – Spiti District located in the north-western Indian Himalayan state of Himachal Pradesh (Figure 1). The District occupies location from 31°44′57′′N to 32°59′57′′N latitude and 76°46′29′′E to 78°41′34′′E longitude with a geographical area of 13,835 km^2. Area wise, it is the largest district of Himachal Pradesh state compare to another district. Lahul – Spiti separated in the east from the Tibet region of china that forms an international border. Jammu and Kashmir district mountain Ladakh lies in the north and Chamba district to its southwest and west. Towards, southeast and south it makes boundary with Kullu and Kinnaur districts of the state. The mountains adorn it is surrounding with various ice-capped glaciers and therefore the entire region includes a rugged parcel of land. The great Himalayan vary keeps it for the most part isolated from the remainder of the country the neighbouring territories for almost half a year.

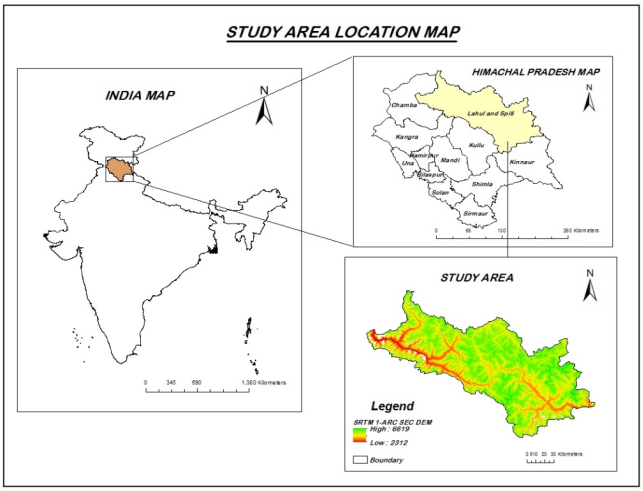

Fig. 1. Study area

Material and Datasets

Satellite data : The Remote Sensing datasets used for this study are high-resolution satellite imagery and Digital Elevation Model (DEM). To carry out the analysis of land cover/use from 2005 to 2019, Landsat 7 and Landsat 8 data were used in the research. By comparing all available datasets for this study, images with a maximum 10% cloud cover and least snow cover from October to November were selected for this study. A total of 12 Landsat images were downloaded from the USGS Website (https://earthexplorer.usgs.gov). The months for which Landsat images were used are October (11 scenes) and November 1 Scene). Following are the details of the dataset along with their specifications.

Datasets specification and details

Table 1. The specifications and details of various dataset used in the study are summarized

Sl. No	Data	Sensor	Swath (km)	Spectral Resolution (μm)	Spatial Resolution (m)	Temporal Resolution (days)	Radiometric Resolution
1	Landsat 7	EMT+	185	Blue:0.450 – 0.515	30 × 30	16	8 bit
				Green:0.525 – 0.605	30 × 30		
				Red:0.630 – 0.690	30 × 30		
				NIR:0.750 – 0.900	30 × 30		
				NIR:1.55 – 1.75	30 × 30		
				Thermal:10.40 – 12.50	60 × 60		
				MIR:2.08 – 2.35	30 × 30		
				PAN:0.52 – 0.90	15 × 15		
2	Landsat 8	OLI TIRS	185	Visible:0.433 – 0.453	30 × 30	16	12 bit
				Blue:0.450 – 0.515	30 × 30		
				Green:0.525 – 0.600	30 × 30		
				Red:0.630 – 0.680	30 × 30		
				NIR:0.845 – 0.885	30 × 30		
				SWIR 1: 1.56 – 1.66	30 × 30		
				SWIR 2: 2.1 – 2.3	30 × 30		
				PAN:0.52 – 0.90	15 × 15		
				Cirrus1.36 - 1.39	30 × 30		
				TIRS 1: 0.3 – 11.3	100 × 100		
				TIRS 2: 11.5 – 12.5	100 × 100		

For 2005 (Landsat 7)

Table 2. Summarizes the details of LANDSAT 7 data

Data	Path	Row	Date of acquisition
Landsat 7	147	37	2005-10-29
Landsat 7	147	38	2005-10-29
Landsat 7	146	38	2005-10-22

For 2010 (Landsat 7)

Table 3. Summarizes the detailsof LANDSAT 7 data

Data	Path	Row	Date of acquisition
Landsat 7	147	38	2010-10-11
Landsat 7	147	37	2010-10-11
Landsat 7	146	38	2010-11-05

For 2015 (Landsat 8)

Table 4. Summarizes the details of LANDSAT 8 data

Data	Path	Row	Date of acquisition
Landsat 8	147	38	2015-10-17
Landsat 8	147	37	2015-10-17
Landsat 8	146	38	2015-10-10

For 2019 (Landsat 8)

Table 5. Summarizes the details of LANDSAT 8 data

Data	Path	Row	Date of acquisition
Landsat 8	147	38	2019-10-28
Landsat 8	147	37	2019-10-12
Landsat 8	146	38	2019-10-21

Methodology

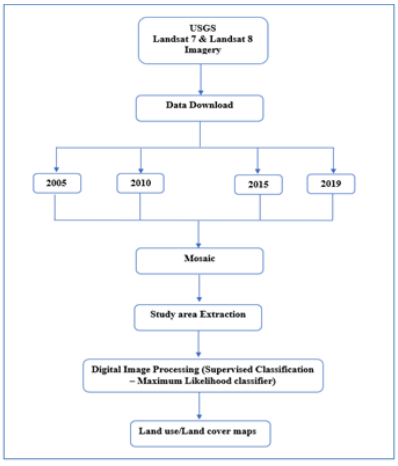

Fig. 2. Methodology flow chart

Objective

Land use change detection in the study area.

Result and Discussion

Land use and land cover (lulc)

The maps for LULC of Lahul – Spiti District were produced using supervised classification techniques on Landsat satellite imagery for 2005, 2010, 2015 and 2019(Figure 3&4). The classification process started with the identification of training sets representing different land-use classes. These training sets were used for supervised classification using a maximum likelihood classification (MLC) algorithm. The maximum likelihood classification is the most accurate and reliable classifier (Richards and Jia, 1999; Foody et al., 1992; Saha et al. 2005) the pixels in the unknown class are assigned to a specific land-use class of which it has the greatest likelihood of membership. In this analysis, five major classes of land use/land cover are identified: snow/glacier, barren/rocky surface, forest, agriculture/grass, and water. The area of each class can be estimated using the Field Calculator tool in ArcGIS. Graphs for various land use classes in the area were produced in MS Excel. (Figure 5)

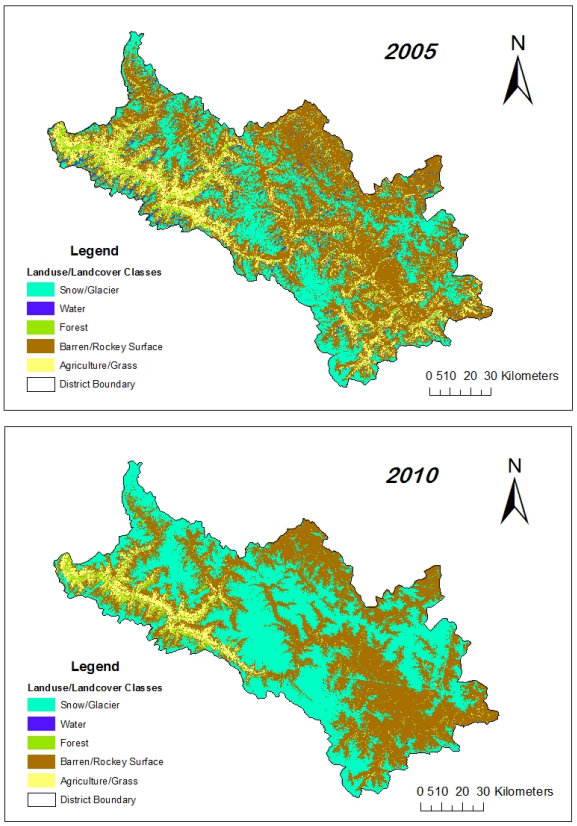

Fig. 3. Landuse/ Land cover map (2005 & 2010)

Table 6. Landuse/Land cover change (2005 - 2019)

	Land use/Land cover Class	Area (Percent)				Percent Change (05 - 19)
		2005	2010	2015	2019	
1.	Snow/Glacier	27.313	45.491	37.145	39.155	43.357
2.	Barren/Rocky Surface	55.219	47.188	53.762	52.286	-5.312
3.	Forest	4.343	2.528	1.137	1.587	-63.458
4.	Water	0.061	0.062	0.057	0.047	-22.951
5.	Agriculture/ Grass	13.064	4.731	7.899	6.925	-46.992
		100.00	100.00	100.00	100.00	

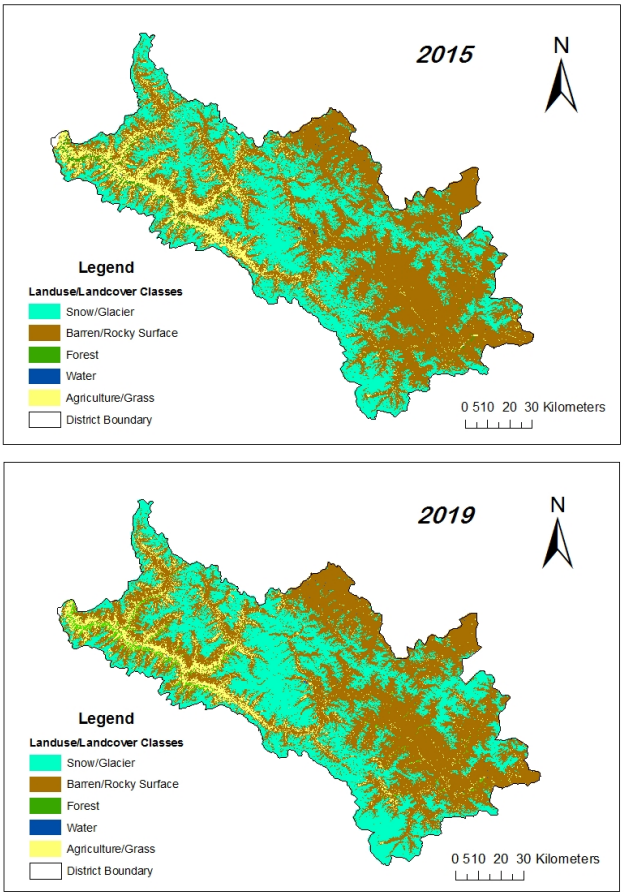

Fig. 4. Landuse/ Land cover Map (2015 & 2019)

The Landsat satellite imagery for the 20-year duration (2005, 2010, 2015, and 2019) was categorized and contrasted for land use and land cover analysis in the following study. The results obtained were illustrated in the study of satellite imagery (Figs. 3, 4). In Table 6, total area coverage of different classes of land use was given. A short description of the outcomes was discussed in the corresponding paragraph.

The Lahul- Spiti district is mainly covered by Barren/Rocky Surface (more than 50%). In the last 20 years,

snow cover is constantly increasing resulting in a decrease in Barren/Rocky Surface. The snow cover increased by 44 percent while barren surfaces reduced by about 6 percent during 2005-2019 (table 7). The forest cover in the area shows a large change and has reduced by about 64 percent. The area under Agriculture/Grass shows a considerable reduction (47%) during 2005-2019. The area under water also reduced by 23 percent. The distribution of land use/land cover is shown in table 6. The whole area sloppy mountains and agriculture is practiced on sloppy lands. The total area coverage for the different years is given in Table 6 and Fig. 5 shows the graph of the temporal differences between the year of each LULC characteristic (2005 to 2019).

Conclusion

The study shows the need for satellite imagery to measure temporal changes in a region that is highly difficult to quantify by conventional methods. The study showed that there were significant changes in land use in forests, agriculture, and snow. Land use and land cover change mapping will provide insight into the implementation of natural resource management plans and environmental concerns. An efficient method for planning land, water, and other natural resource management is remote sensing and GIS. The study will therefore help to better understand the growth dynamics of different groups of land use and allow decision-makers to establish effective management strategies for economic and sustainable development.

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