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Change Detection in Land Use and Land Cover Using Remote Sensing Data and GIS in Renuka Forest Division

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Abstract:

Land use and land cover change have been among the most important perceptible changes taking place around us. Although perceptible, the magnitude, variety and the spatial variability of the changes taking place has made the quantification and assessment of land use and land cover changes a challenge to geographers. Furthermore, since most of the land use and land cover changes are directly influenced by human activities. The Remote Sensing and Geographic Information System has proved to be very important in assessing and analyzing land use and land cover changes. Satellite-based Remote Sensing, by virtue of its ability to provide synoptic information of land use and land cover at a particular time and location, has revolutionized the study of land use and land cover change. The temporal information on land use and land cover helps identify the areas of change in a region. The use of Geoinformatics has enabled us to assign spatial connotations to land use land cover changes, namely, population pressure, climate, terrain, etc. which drive these changes. This has helped geographers to quantify these tools and to predict various scenarios. This article gives an overview of the current trends in land use and land cover changes of Renuka forest division in Sirmour district.

Key words: Land use; Land cover; Remote sensing; Geographic information system; Geoinformatics.

Introduction

Human beings have been altering the face of the earth for the last few centuries but with the introduction of machines, the land cover of the earth has changed drastically in the last three centuries. The debate about the relationship between human population dynamics and the availability of natural resources dates back to more than 200 years when Malthus (1798) put forward his argument that population growth would eventually outstrip the production capacity of the land. It was only in the second half of the 20th century when the probability of the Malthusian projection seemed to be a reality, that sincere efforts to study the human population–environment relation were undertaken. The scientific study and analysis of land use and land cover change involves a quantitative estimation of land use and land cover at a particular location and time. In this regard, remote sensing plays a major role in giving a synoptic view of the spatial extent of land use and land cover at a particular point of time. The Human use of land resources gives rise to land use which varies with the purpose it serves, whether it be food production, provision of shelter, recreation, extraction and processing of materials, and the biophysical characteristics of the land itself. In the developing countries, due to population pressure and in a bid to extract the maximum output from the available sources, the impact of degradation can be worse than in other countries and adversely affect the land cover of the region.

Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil and/or artificial structures (Ellis 2007). Land use, on the other hand, has a more complicated aspect as it involves social sciences and management principles and is defined as the social and economic purposes and contexts for and within which lands are managed. Although land use and land cover are frequently used together, there is a very clear difference between the two.

While land cover signifies the spatial distribution of the different land cover classes on the earth's surface, and can be directly estimated qualitatively as well as quantitatively by remote sensing, land use and its changes require the integration of natural and social scientific methods to determine which human activities are occurring in different parts of the landscape, even when the land cover appears to be same (Lambin et al. 2001).

Land use and land cover change are perhaps the most prominent form of global environmental change since they occur at spatial and temporal scales immediately relevant to our daily existence (CCSP 2003). Technically, land use and land cover change mean quantitative changes in areal extent (increase or decrease) of a given type of land use and land cover respectively. Land use and land cover change are a manifestation of forces both anthropogenic and environmental – climate driven factors (Liu et al. 2009). The changes in land use in various spatial and temporal domains are the material expressions, and also indicate environmental and human dynamics and their interactions mediated by land availability (Lambin et al. 2003). Spatial data on land use and land cover in a region is a prerequisite to determining the qualitative and quantitative changes in land use and land cover. Advances in remote sensing over the past few decades now enable repeated observations of the earth's surface (NAP 2008). With the increase in sensor capability in terms of spatial resolution, spectral variability and temporal frequency, the minute changes on the earth's surface can be estimated fairly accurately.

Land use and land cover changes, apart from changing the physical dimension of the spatial extent of the land use and land cover classes, also influence many of the secondary processes which lead to the eventual degradation of the ecosystems of the earth (Dregne and Chow 1992). First and foremost, the impact of land use and land cover changes is the

reduction of vegetation cover. The loss of a vegetation cover, in turn, leads to many other deleterious effects on the environment, namely, loss of biodiversity, climate change, pollution of other natural ecosystems with a reduction in their quality, changes in hydrological regimes, and the list continues (Niyogi et al. 2009). The secondary impact of land use and land cover changes initiates a cascade of effects on the environment and this works in a loop to further influence land use and land cover changes.

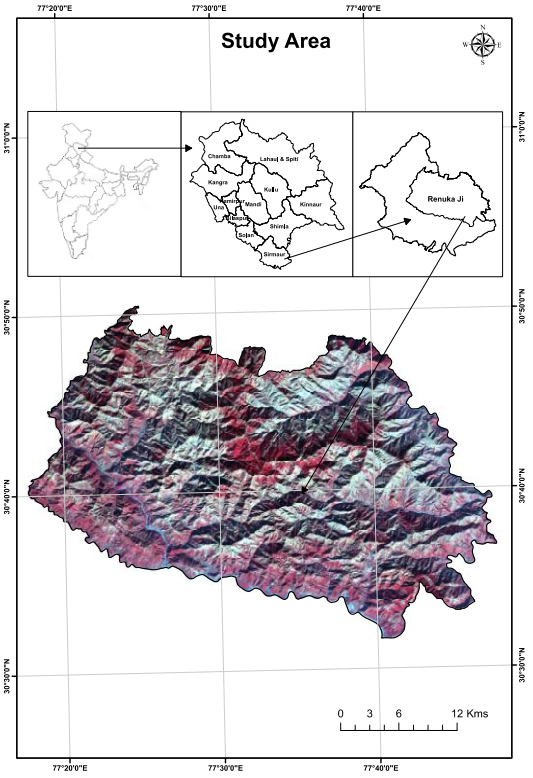

Fig.1.1

Study Area

The study area, (Fig. 1.1) Renuka Forest Division situated in Sirmour district. It lies between 77º17´34´´ and 77º47´38´´ east longitudes and 30º31´11´´ and 30º52´16´´north latitudes. It is bounded on the North by Chopal and Rajgarh Forest Divisions,

on the East by Chakrata Forest Division of Uttarakhand, on the South by Nahan Forest Division and on the West by Paonta Sahib Forest Division. The geographical area of the division is 987 sq. km. and forest area of 273.65 sq. km. There are five forest ranges in Renuka division namely Renuka, Sangrah, Nohra, Shillai and Kafota. The entire tract is mountainous and varies in elevation from 620 M msl to 3647 M msl. The slopes are generally steep to precipitous with deep khalas and springs. The entire region of Renuka Forest Division falls within the catchments of Giri, Sainj and Tons rivers. The Jalal Khad and Nait ka Khala are two important khalas, which drains into Giri at Sieun and Khairi respectively.

Methodology

In the present study, for assessing the temporal changes in the land use and land cover, the Lansat TM, landsat ETM+ and Indian Remote Sensing Satellites (IRS) Resource Sat's imageries were used. Digital image processing software Erdas imagine 9.3 and ArcGIS 9.3 were used for the processing, analysis and integration of spatial data to reach the objectives of the study. The final maps which represent the land use and land cover change during 1972, 1989, 2001 and 2010 (both area and percentage) were also generated.

Land use and land cover changes

For the land-use classification, Landsat TM, Landsat ETM+ and Resource Sat images were used. Supervised classification was used to prepare land use map because it has higher accuracy over unsupervised classification. The result shows that forest is major land use, which is followed by agricultural land, open land/grass land/shrub and other water. The land use status of different dated images is given below.

Image classification- 1972

For the classification of 1972 image, Landsat TM satellite image was used. The land use land cover status is given in the table 2.1 and the map showing land use land cover is given in the figure 1.2.

According to Lansat image, forest occupies 61.8 percent of total land and became the major land use land cover of the study area. Agriculture consists of 18.03 percent, open land/grass land/shrub land consists of 19.25 percent, and water consists of 0.91 percent. The land use land cover status is given in table below and land use land cover map is shown in figure 2.1.

Table: 2.1 Land use/ land cover pattern of Renuka division 1972

Land Use Land Cover 1972		
	Status	
LULC	Area in Sqkm.	% age
Forest	610	61.80
Agriculture	178	18.03
Open Land/Grass Land/Shrub Land	190	19.25
Water Body	9	0.91
Total Area in Sqkm.	987	100.00

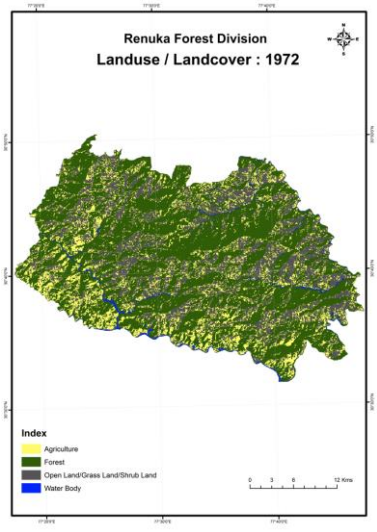

Fig. 1.2

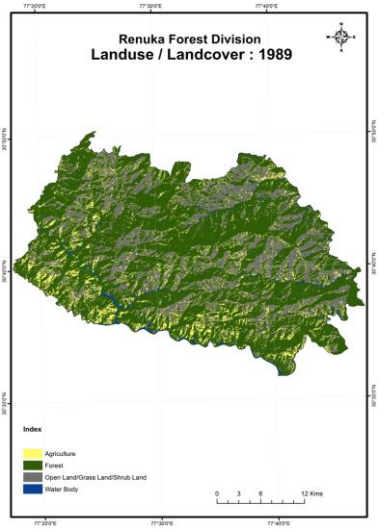

Fig. 1.3

Image classification – 1989

For the classification of 1989 image, Landsat TM satellite image was used. The land use land cover status is given in the table 2.2 and the map showing land use land cover is given in the figure 1.3.

Forest still remains the major land use land cover consisting of 64.3 percent of total land. Agriculture has decreased in area occupying 11.7 percent while; open land/grass land/shrub Land has increased to 23.3 percent. Similarly, water area has also decreased to 0.81 percent.

Table: 2.2 Land use/ land cover pattern of Renuka division 1989

Land Use Land Cover 1989		
	Status	
LULC	Area in Sqkm.	% age
Forest	634	64.24
Agriculture	115	11.65
Open Land/Grass Land/Shrub Land	230	23.30
Water Body	8	0.81
Total Area in Sqkm.	987	100.00

Image classification – 2001

For the classification of 2001 image, Landsat ETM+ satellite image was used. The land use land cover status is given in table 2.3 and land use land cover map is shown in figure 1.4. 2001 classification maps show that forest decreases up to 558 sq. km (56.5 percent). Agriculture has decreased in area occupying 10.3 percent while; open land/grass land/shrub Land has increased to 32.4 percent. Similarly, water area has also decreased to 0.71percent.

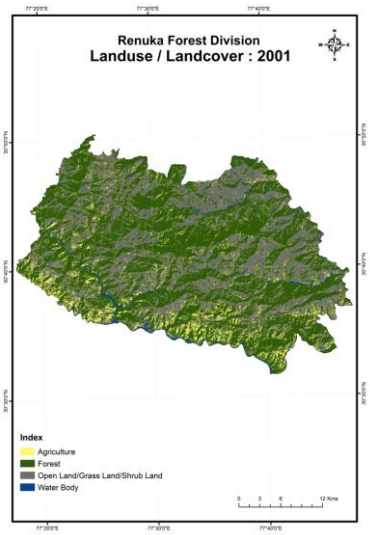

Fig. 1.4

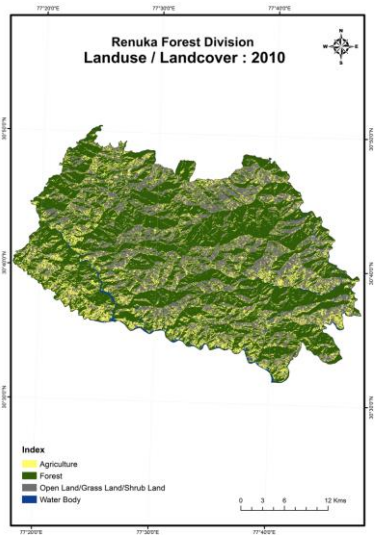

Fig. 1.5

Table: 2.3 Land use/ land cover pattern of Renuka division 2001

Land Use Land Cover 2001		
	Status	
LULC	Area in Sqkm.	% age
Forest	558	56.53
Agriculture	102	10.33
Open Land/Grass Land/Shrub Land	320	32.42
Water Body	7	0.71
Total Area in Sqkm.	987	100.00

Image classification – 2010

For the classification of 2010 image, Resource Sat-II satellite image was used. The land use land cover status is given in table 2.4 and land use land cover map is shown in figure 1.5.

According to Resource Sat image, forest decreases from 56.5 percent to 55.6 percent of the study area. Agriculture increases of 19.3 percent, while open land/grass land/shrub land decreases of 19.25 percent, and water also decreases of 0.61 percent.

Table: 2.4 Land use/ land cover pattern of Renuka division 2010

Land Use Land Cover 2010		
	Status	
LULC	Area in Sqkm.	% age
Forest	549	55.62
Agriculture	190	19.25
Open Land/Grass Land/Shrub Land	242	24.52
Water Body	6	0.61
Total Area in Sqkm.	987	100.00

Land use and land cover changes between 1972- 1989

The comparison of land cover maps of 1972 and 1989 showed the considerable changes in forest, agriculture, open land/ grass land/ shrub land (Table 2.5). However, there is a negligible or little change in forest and water body. Between 1972 and 1989, forest has increased by 2.43 percent that is due to afforestation programme carried out by forest department. However, the natural growth in tree cover has been also noticed during the field survey. Similarly, agriculture and water has decreased by 6.38 percent and 0.10 percent respectively whereas, little improvement has seen in open land/grass land/shrub land area with an increase of 4.05 percent. The graph (Fig.1.6) below, blue colour denoting for year 1972 and red colour for the year 1989.

Table: 2.5 Land Use /Land Cover Change between 1972-1989

	Land Use Land Cover 1972		Land Use Land Cover 1989		Land Use Land Cover Change	
LULC	Area in Sqkm.	%age	Area in Sqkm.	%age	Area in Sqkm.	%age
Forest	610	61.80	634	64.24	24	2.43
Agriculture	178	18.03	115	11.65	-63	-6.38
Open Land/Grass Land/Shrub Land	190	19.25	230	23.30	40	4.05
Water Body	9	0.91	8	0.81	-1	-0.10
Total Area in Sqkm.	987	100.00	987	100.00	0	0.00

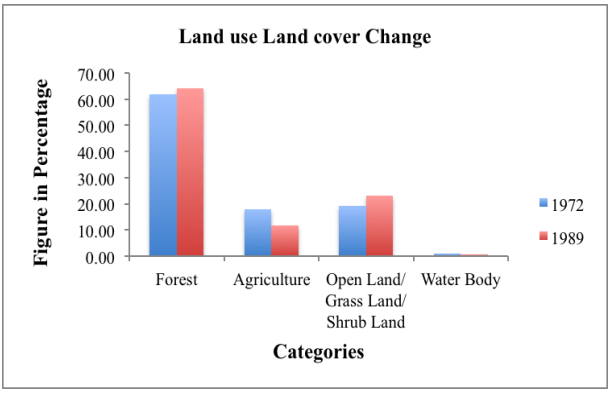

Fig. 1.6

Land use and land cover changes between 1989-2001

The result shows that forest is decreased by 7.70 percent. The bond between human and forests have been age old. This relation has remained sustainable for long but ever growing population has put enormous pressure on forest in present era. Whereas agriculture also decreased by 1.32 percent and open land/grass land/shrub land has increased by 9.12 percent. Water continued to decreased occupying the area of 0.10 percent. Table 2.6 shows the change in area between 1989 and 2001 and graph (Fig.1.7) below shows the change percent.

Table: 2.6 Land Use /Land Cover Change between 1989-2001

	Land Use Land Cover 1989		Land Use Land Cover 2001		Land Use Land Cover Change	
LULC	Area in Sqkm.	%age	Area in Sqkm.	%age	Area in Sqkm.	%age
Forest	634	64.24	558	56.53	-76	-7.70
Agriculture	115	11.65	102	10.33	-13	-1.32
Open Land/Grass Land/Shrub Land	230	23.30	320	32.42	90	9.12
Water Body	8	0.81	7	0.71	-1	-0.10
Total Area in Sqkm.	987	100.00	987	100.00	0	0.00

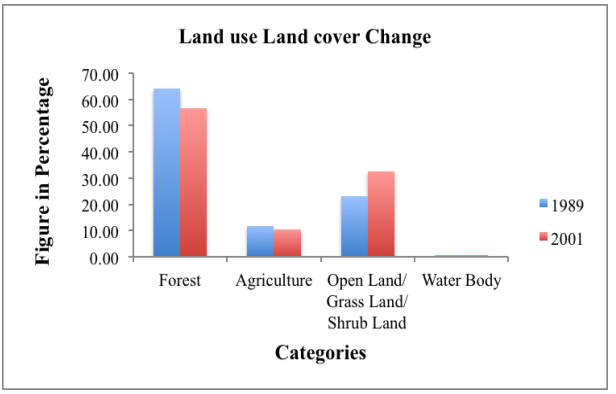

Fig. 1.7

Land use land cover changes between 2001-2010

The result shows that forest is decreased by 0.91 percent due to illegal encroachments by villagers and the forest cover in certain region has depleted at a faster rate as a result of over exploitation for meeting the daily human needs of fuel fodder and fibre. The decline in the forest cover has been the result of lopping and chopping for fuel wood and other purposes and growth of roads and other infrastructural facilities. Whereas agriculture increased by 8.92 percent because of human pressure and open land/grass land/shrub land has decreased by 7.90 percent. Water continued to decreased occupying the area of 0.10 percent. It has been observed that the land use and land cover change in the region is mainly driven by the socio-economic changes in the region. Table 2.7 shows the change in area between 2001 and 2010 and graph (Fig. 1.8) below shows the change percent.

Table: 2.7 Land Use /Land Cover Change between 2001-2010

	Land Use Land Cover 2001		Land Use Land Cover 2010		Land Use Land Cover Change	
LULC	Area in Sqkm.	%age	Area in Sqkm.	%age	Area in Sqkm.	%age
Forest	558	56.53	549	55.62	-9	-0.91
Agriculture	102	10.33	190	19.25	88	8.92

Open Land/Grass Land/Shrub Land	320	32.42	242	24.52	-78	-7.90
Water Body	7	0.71	6	0.61	-1	-0.10
Total Area in Sqkm.	987	100.00	987	100.00	0	0.00

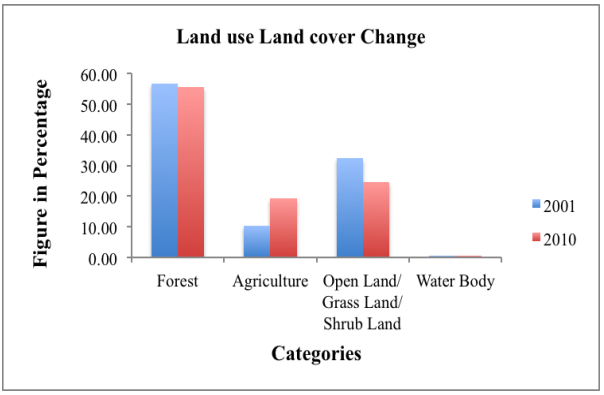

Fig. 1.8

Conclusion

Spatial land use and land cover change is a reflection of the impact of biotic drivers as well as abiotic drivers on the prevalent land use and land cover of the region. The force of the drivers as well as the changes in driver composition leads to changes in the prevalent land use and land cover of a region. GIS- based analysis of the RS derived temporal data of the land use and land cover of a region can identify the potentially vulnerable areas to change as a result of the different driving forces. A Geographic understanding of land use change processes can be achieved by analyzing a temporal database for spatial patterns, rates of change and trends. The analysis requires understanding a region's land use history involving population data, timelines of historical events and related information. Spatio- temporal analysis of past historical events aid in understanding and subsequently modeling the issues that influence the development in a region in association with topography and adequate supply of water and other natural

resources. Furthermore, the various drivers of land use and land cover change until now date have been mostly qualitative. There is a need to quantify the drivers of land use and land cover change for estimating and quantifying their consequences. Numerical modeling of land use and land cover change gives us a tool to understand and quantify the processes involved in this alteration and will enable us to take the necessary steps to arrest the various land use and land cover changes taking place.

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