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A Geographical Analysis of Land Use/Land Cover Dynamics in Lolab Watershed of Kashmir Valley, Western Himalayas Using Remote Sensing and GIS

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Abstract

This study is an attempt to analyze and highlight the present state of land use/land cover in Lolab watershed of Kashmir valley in western Himalayan environment. Land use/land cover determines the structure, functions and dynamics of most landscapes. The rampant changes in land use/land cover at regional watershed scale have wider ramifications on the environment. The land use/land cover is under tremendous anthropogenic pressure. Rapid and extensive modifications of land use/land cover due to accelerated human activities especially in fragile mountainous ecosystems like Kashmir valley have wider environmental ramifications. Watershed is an ideal spatial management unit for analyzing land dynamics and for initiation of holistic integrated conservation strategies. The present study carries out the land use/land cover change detection studies were from the year 2002 to 2014. A total of seven categories were delineated and during the study period, the forests showed a decrease from 45.31 percent in 2002 to 44.61 in 2014 i.e., 0.7 percent decrease while as horticulture showed an increase from 8.05 percent in 2002 to 9.91 percent in 2014, thus registering an increase of 1.86 percent. Agriculture has decreased to 1.04 percent during the study period. The overall, scenario presented by the study reveals that the land use/land cover change is quite visible throughout the study area.

Keywords: Land use/land cover; Watershed; Kashmir; Change detection

Introduction

Land is an important natural resource available to man and is the interface for most human activity which is greatly impacted by humans [1]. Land is the basic natural resource of mankind. Humans have always played with their environment in one way or the other and particularly the land. However today, the intensity and rate of change threatens to exceed the present adaptive capacities of many individual societies, particularly in the fragile and finite areas like high altitude zones. Human-induced activities stand out as a large force for causing land use/land cover changes [1]. Intensification of food production is a key activity in the development of modern society.

Land cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features of the land, including those created solely by human activities e.g., settlements [2]. The term land cover referred to the kind and state of vegetation, such as forests and grass cover and includes other things such as human structures, soil type, biodiversity, surface and ground water [3]. Changes in land cover do not necessarily imply degradation of land. However, many shifting land use patterns driven by a variety of social causes, result in land cover change that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere [4].

Land-use refers to the way in which land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities [2]. Land use has been defined by natural scientists in terms of syndromes of human activities such as agriculture, forestry and the built up spaces that alter land surface processes including biogeochemistry, hydrology and biodiversity [5]. Observations of changes in land use are best studied by combination of natural and human methods to decipher the impacts of change on environment. As a result, scientific investigation of the causes and consequences of land use/land cover changes require an interdisciplinary approach integrating natural and social scientific methods which has emerged as the new discipline of land-change science [5].

Land Use (LU) and Land Cover (LC) are two fundamentals describing the terrestrial environment in connection with both natural processes and anthropogenic activities [6-8]. The integrated term Land Use Land Cover (LULC) includes both categories of LU and LC and analysis of changes is of prime importance to understand many social, economical and environmental problems [9]. In recent years, LULC change analysis has emerged as an important research question, because LULC change has been identified as a key factor which stands responsible for environmental modification worldwide [10]. Though it is possible to monitor LULC changes by involving traditional surveys and inventories, but Satellite Remote Sensing (SRS) apart from being advantageous in terms of cost and time saving for regional scale also provides large scale data on LULC changes with information about their geographic distribution [11]. Geographic Information Systems (GIS) and Remote Sensing (RS) have proved to be useful tools for assessing the spatiotemporal dynamics of LULC [12-15]. Information about change is necessary for updating LULC maps and the management of natural resources. It is very important to have continual, historical and precise information on LULC changes of the earth's surface for any

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kind of sustainable development program in which LULC serves as one of the major input criteria [16,17].

Over the past two hundred years human have been dominant drivers of landscape transformations [18]. During the past 50 years, humans have changed these landscapes to meet the growing demand for food, fodder, timber, fiber and fuel more rapidly and extensively than any comparable period of time (Millennium Ecosystem Assessment, 2005). Changes in land use/land cover have occurred to such an extent that it has significantly affected the functioning of biosphere, being one of the most important cause of biodiversity loss as well as climatic change.

Land use/land cover change in mountainous areas has wider ramifications. The ecosystem is fragile and it is more susceptible to the negative impacts of this change. Deforestation, bad agricultural practices, unplanned growth of settlements and developmental activities have wide ranging effects in mountainous regions. Kashmir valley is known for its beauty throughout the world. This valley has snow clad mountains, mesmerizing landscapes, cascading rivers and streams etc., but this vale has been experiencing environmental deterioration since last several decades. The lush green forests which dotted the landscapes have started dwindling because of the unprecedented anthropogenic impact. The land use/land cover pattern has changed over the period of time. The forest cover has decreased not only in extent but also in terms of density [19-21]. This land has been brought under agriculture, settlement and horticulture uses. Globally, remote sensing and GIS technologies are being applied to carry out change detection studies for land use/land cover analysis especially in mountainous regions, where there are other constraints besides accessibility [22-25].

Objectives

(1) To analyze the Spatio-temporal change in the land use/land cover of Lolab watershed from 2002-2014.

(2) To examine the factors responsible for this change.

Study Area

The Lolab watershed of the Kashmir valley with an area of about 28,162 hectares has been taken up as the study area. The watershed lies between 34°41' to 34°24' N Latitude and 74°09' to 74°23' E Longitude. It has been divided into 43 micro-watersheds in accordance to the guidelines of the Watershed Atlas of India (WAI) (Figure 1).

The watershed can be divided into three distinct physiographic units i.e., the Mountains, the Karewas and the Flood plains. The Lolab Valley is the most fascinating and picturesque of the Himalayan Valleys in Kashmir. The Lolab river has its source in the Nandmarg, the Kimsar and the Bagalsar heights, north of the Wular Lake. The main stream of the Lolab has a length of about 30 km and flows in a westerly direction. One of its lateral tributaries is the Kalaruch nala which originates below the peak of Nalgat 3645 meters and joins the Lolab below Khumarial. A little before its junction with the Kahmil, the Lolab kol receives the Haheom kol which flows from the north [26,27].

Materials and Methods

The methodology adopted for this study is based upon interpretation of IRS-1C LISS III (FCC) having a resolution of 23.5 mts using standard visual/digital interpretation techniques. The data were Georefrenced and as such matched to a standard SOI toposheet of 1:50000 scale. The source material was collected from published and unpublished records of various state government departments, especially Directorate of Economics and Statistics, J & K Forest Department, Directorate of Ecology, Environment and Remote Sensing, Soil Conservation Department etc.

The study incorporates a two tier methodology. First, a base map on 1:50000 scale was prepared with mapping units from AIS and LUS prioritization map of the year 1974-75, generated from Aerial Photographs on the same scale. Different mapping units for each land use/land cover category were delineated. Secondly, digital interpretation of IRS-1C LISS III (FCC) of the year 2014 was carried out. A legend compatible with the 1974-75 data was prepared. This was followed by selection of sample strips with observation points for ground truthing. All the mapping units were given due representation during the selection process. The field exercise was carried out and the legend was finalized, which was followed by final plotting of the mapping units. The maps served as inputs to GIS and subsequent analysis for change detection, which was performed in GIS environment.

Land use/land cover status of 2002 and 2014 in Lolab watershed

The analysis of land use/land cover of the study area for the year 2002 and 2014 were done in order to detect the changes that had taken place in the various categories.

In 2002 (Figure 2), the total area under Agriculture which is the most fundamental form of human activity in Kashmir valley was 9865.14 hectares which accounts for about 35.03 percent of the total area of the Lolab watershed in 2002. Horticulture are the lands that are

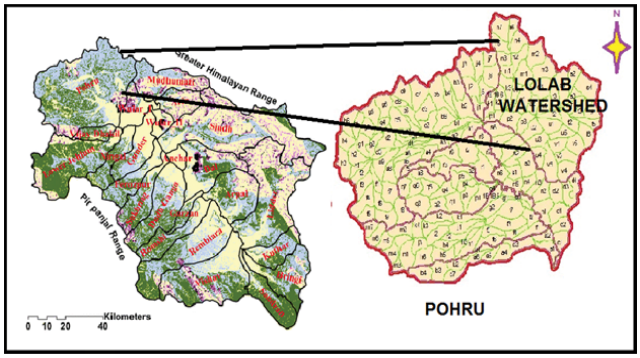

Figure 1: Study Area – Location.

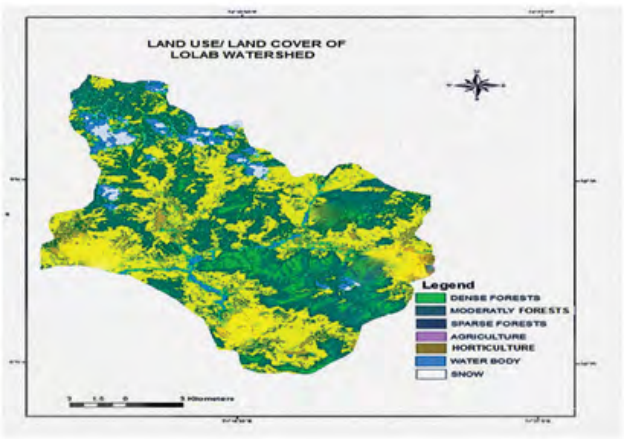

Figure 2: LU/LC analysis (2002).

primarily devoted to the use of growing horticultural crops like apples, walnuts etc., the area under horticulture was 2267.04 hectares which is 8.05 percent of the study area. The forests in the Lolab watershed have a total area of 12760.18 hectares (45.31 percent) and have been categorized into three categories which include dense forest, moderate forest and sparse forest and their area is 2886.60 ha (10.25 percent), 2275.48 hectares (8.08 percent) and 7598.10 hectares (26.98 percent), respectively. Snow covered area comprised of 1044.81 hectares (3.71 percent) and the water bodies mainly in the form of rivers comprised of 2224.79 hectares (7.90 percent) (Table 1).

Land use/land cover status of year 2014 (Figure 2) reveals that there has been a discernible change in some of the categories. As far as agriculture is concerned, it recorded total area of 9573.5 hectares (33.99 percent) which means a small decrease in this category. Horticulture has shown a gradual increase of around 2 percent during the study period with an area of 2791.03 hectares (9.91 percent). The total area under forests has decreased to 12680.02 (45.02 percent) and the same applies to its sub categories except moderate category forests which have shown a slight increase of 0.76 percent in its area (Figure 3). The respective area under dense forests, moderate forests and sparse forests during 2014 is 2693.27 hectares (9.56 percent), 2490.94 hectares (8.84 percent) and 7495.81 hectares (26.6 percent). Both the snow covered and water bodies have shrinked during the study period as Snow covered area has decreased to 1008.64 ha (3.58 percent) and water bodies have decreased to 2108.78 ha (7.48 percent) (Table 2).

S. No	Class	Year 2002 (Ha)	Percentage
1	Agriculture	9865.14	35.03
2	Horticulture	2267.04	8.05
3	Dense Forests	2886.60	10.25
4	Moderate Forests	2275.48	8.08
5	Sparse Forests	7598.10	26.98
6	Water Body	2224.79	7.90
7	Snow Covered	1044.81	3.71
TOTAL		28162 ha	100%

Source: IRS 1D LISS III (2002)

Table 1: Land use/ Land cover of the study area (2002).

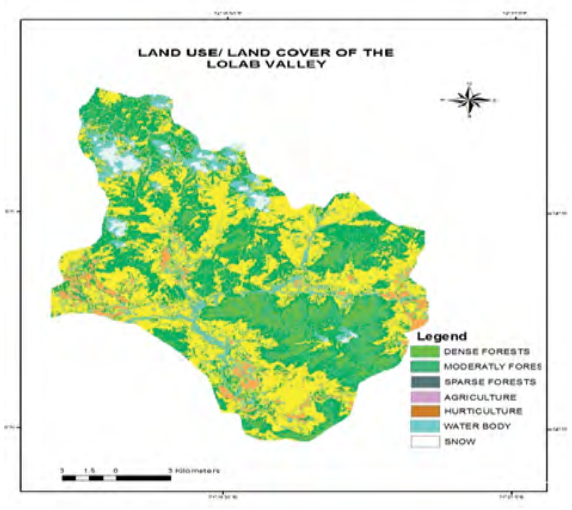

Figure 3: LU/LC Analysis (2014).

S. No	Class	Year 2014	Percentage
1	Agriculture	9573.5	33.99
2	Horticulture	2791.03	9.91
3	Dense Forests	2693.27	9.56
4	Moderate Forests	2490.94	8.84
5	Sparse Forests	7495.81	26.61
6	Water Body	2108.78	7.48
7	Snow Covered	1008.64	3.51
TOTAL		28162 Ha	100%

Source: IRS P6 LISS III (2014)

Table 2: Land use/Land cover status of Lolab Watershed(2014).

Change detection analysis

The perusal of table reveals that there has been a considerable change in the land use/land cover status of Lolab watershed from 2002 to 2014. The area which has been lost under one land use/land cover category has converted to other land use/land cover category thereby showing an increase in the respective category (Table 3).

- The Dense forest which is the dominant land cover class in the study area has shown a remarkable change as it has decreased from 2886.60 ha (10.25 percent) in 2002 to 2693.27 ha (9.56 percent) in 2014. This means forest cover has decreased by 291.64 ha (-1.04 percent) during a period of 12 years.
- Horticulture land which covered an area of 2267.04 ha (8.04 percent) in 2002 has reached to 2791.03 (9.91 percent) in 2014. It means Horticultural land has increased by 523.99 ha (1.80 percent) from 2002-2014.
- The total area and percent area under Moderate forest was 2275.48 ha which accounts for about 8.08 percent of total area in 2002, and in 2014, it was 2490.94 ha which accounts for 8.84 percent of the total area. This means that area under Moderate forest has also increased by 215.46 ha (0.76 percent) from 2002 to 2014.
- Agricultural land has reduced in area from 9865.14 ha (35.03 percent) to 9573.50 ha (33.99 percent) in 2014. The total decrease in the area under Agriculture has been 291.64 ha which shows a decrease of -1.04 percent.
- The area under sparse forest has decreased from 7598.10 ha in 2002 to 7495.81 ha in 2014. A total area of 102.29 ha has been decreased to sparse forest which accounts a change of -0.37 percent.
- Area under water bodies has shown a considerable decline. The area under water bodies has declined from 2224.79 ha which accounts for about 7.90 percent in 2002 to 2108.78 ha which accounts near about 7.48 percent in 2014. This means that the total area of 116.01 ha has been decreased from water bodies and has recorded a total decrease of 0.42 percent.
- The snow covered land has shown a net decrease of 36.17 ha from 2002-2014. The total area under snow cover in 2002 was 1044.81 ha that constitutes 3.71 percent of the land area of the study area. The same land cover class occupies only 1008.64 ha in 2014 which accounts for only 3.51 percent of the total area. This shows a net decrease of 0.2 percent from 2002 to 2014 (Figures 4 and 5).

Results and Discussion

Factors responsible for land use/land cover change in Lolab watershed

The land use/land cover alteration are generally caused by

S. No	Class	Year (2002)	Percentage	Year (2014)	Percentage	Change in hectares	Change in percentage
1	Agriculture	9865.14	35.03	9573.5	33.99	-291.64	-1.04
2	Horticulture	2267.04	8.05	2791.03	9.91	523.99	1.86
3	Dense Forests	2886.6	10.25	2693.27	9.56	-193.33	-0.69
4	Moderate Forests	2275.48	8.08	2490.94	8.84	215.46	0.76
5	Sparse Forests	7598.1	26.98	7495.81	26.61	-102.29	-0.37
6	Water body	2224.79	7.90	2108.78	7.48	-116.01	-0.42
7	Snow covered	1044.81	3.71	1008.64	3.51	-36.17	-0.2
Total		28162 ha	100	28162 ha	100		

Source: IRS 1D LISS III (2002) & IRS P6 LISS III (2014)

Table 3: Comparative Analysis of LU/LC OF 2002 and 2014.

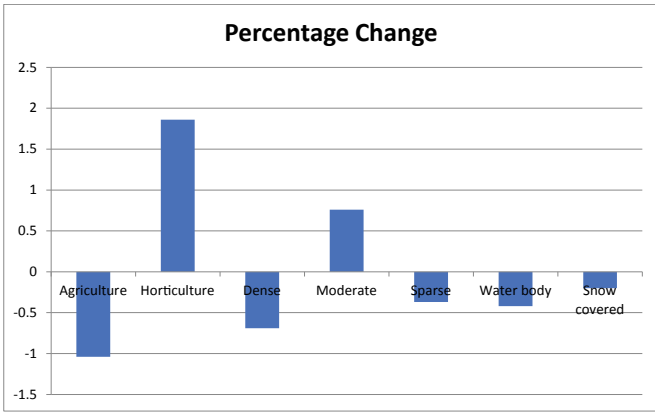

Figure 4: Percentage Change in different LU/LC Classes.

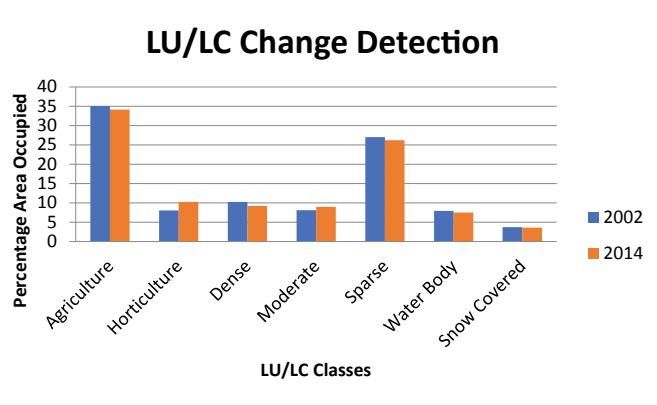

Figure 5: Percentage Area Occupied in 2002 and 2014.

mismanagement of agricultural, urban and forest land which leads to severe environmental problems. It has been a combination of climatic and economic factors in the study area (Lolab watershed) which has been responsible for the land use land cover change to take place.

- Forest cover has decreased from 2002-2014. The main cause of deforestation in the area is the increased need of timber, firewood, increase in population and conversion of forestland for some other purposes. From output maps it is easily inferred that forest land has been converted into horticultural land. Deforestation, agricultural expansion and increased built up land are putting tremendous pressure on the forest resources of the study area. Wood is the important source of energy for the rural people. Increasing demand for fuel wood and timber results in the acceleration in the process of deforestation. There are host of factors responsible for forest degradation in the area like population and livestock growth and the resultant expansion of agricultural area on forest area. These rates of deforestation in Lolab watershed are alarming as they may lead to serious ecological crises. The deforestation also accelerates the process of soil erosion, a problem which has assumed alarming dimensions in Kashmir valley.

- Agriculture being dominant activity in whole of the Kashmir valley has got maximum area under it. The area under agriculture has decreased from 2002 to 2014. This is because of the conversion of agriculture land for residential and commercial purposes are going on unabated in Lolab watershed. More and more residential houses and business establishments are coming up on paddy land along Lolab area. "Several commercial establishments, residential colonies, private educational institutions, motor garages, workshops, petrol pumps and other structures have come up on the agriculture land, particularly the paddy fields along these roads," and the district administration had failed to take any concrete measure to stop the practice.

- The area under Horticulture has increased from 2002 to 2014 due to economic benefit to the people. Although the district is considered deficient in natural irrigation, about 90 per cent of the population depends in one way or other on agriculture for their livelihood. Walnuts are the major horticulture produce in the district. People are more dependent on Horticulture than any other sector of economic activity.

- The area under water bodies' gas also shown a decreasing trend over the period of time. The factors responsible for it are the human activities and the population pressure. Increased upstream erosion and sediment load has decreased the channel size of streams and other water bodies.

- Overall, the scenario presented by the study reveals that the land use/land cover change is quite visible throughout the study area. The area decreased under one land use/land cover category has increased under other land use/land cover category (Figures 6-9).

Conclusion

To sum up, the land use/land cover of Lolab watershed has undergone drastic change during 2002-2014 as a consequence of natural increase in population and demand for settlements. The productive agricultural land is being transformed in settlement area due to increasing demand of population. The area under forest is decreasing mainly due to demand of wood for housing and furniture. The study suggested that the settlement area should not be allowed to increase at the expense of prime agricultural land and land use policy

Figure 6: Conversion of Agriculture to Horticulture land.

Figure 7: Forest wood utilization in the study area.

Figure 8: Deforestation in the forest areas of the study area.

Figure 9: Degraded lands in Sogam forests of Lolab watershed.

should be strictly followed. Remote sensing and GIS can be potential tools for monitoring the further degradation of natural resources of the watershed and for aiding land use policy options. However, nothing can be achieved unless and until we check the population growth.

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