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Changes in land-use/land-cover dynamics using geospatial techniques: A case study of Vishav drainage basin

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Vishav watershed belongs to the hilly areas of the Pir Panjal range in Kashmir valley. In this study area, the major natural resource is forest and plain lands that have fertile soil. Land-use/land-cover study is an important component in understanding the interactions of the human activities with the geo-environment. In this paper, an attempt is made to study the changes in land-use and land-cover (LULC) transformations of Vishav watershed over 20 years period (1990 to 2010) by using geospatial techniques such as remote sensing and Geographic Information System which play an unavoidable and indispensable role in detecting, analyzing, monitoring, managing and comparing land-use/land-cover exchanges and trends. Empirical observations revealed a change in the land-use/land-cover classes in Vishav watershed part of Jhelum basin which is situated in the Western Himalayas, Kashmir, India. Hence, information on landuse/land cover is essential for the selection, coordination and implementation of land-use and can be acclimated to meet the incrementing demands for rudimentary human needs and welfare. This information avails in monitoring the dynamics of land-use resulting out of the changing demands of incrementing population. Growing population and incrementing influence of the unplanned developmental processes are the main forces behind the major shift of forest and agricultural lands into horticulture and other categories.

Key words: Land-use/land-cover, geospatial, remote sensing, geographical information system (GIS), population, Vishav

INTRODUCTION

Land-use/land-cover refers to the way in which land has been put to use, usually with emphasis on the functional role of land for economic activities. Land-cover, however, refers to the physical attributes of the earth's surface, distributed in the form of vegetation, water, soil and other physical features of the land, including those created entirely by human activities (mines and settlements) (Lambin et al., 2003; Zubair, 2006). Land-use/land-cover change is one of the most important drivers of global changes (Lambin, 1999) and this affects many parts of geo-environmental systems. Changes in the condition and composition of land-cover affect climate, bio-geo-chemical cycles and energy fluxes and livelihoods of people (Vitousek et al., 1997). Changes are often

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nonlinear and might trigger feedbacks to the system, distress living conditions and threaten vulnerability of people (Kasperson et al., 1995). Therefore, not only assessment of land-use/land-cover change trajectories but also projections of possible future conditions under certain assumptions are an elementary task to ensure sustainable conditions (GLP, 2005; Veldkamp and Lambin, 2001).

Land-cover is defined by the characteristics of the earth's land surface which are captured in the spatial and temporal variation of surface and subsurface biotic and abiotic factors including vegetation, desert, ice, biota, soil, topography, surface water and groundwater, and mine exposures. These together with human settlement that is created as a result of human activities are also included under this framework (Lambin et al., 2003; Chrysoulakis et al., 2004). On the other hand, land-use is the proposed employment of land management strategy placed on land-cover by human agents or land managers to utilize the land-cover. It reflects human activities such as industrial zones, residential zones, agricultural zones, grazing fields, logging, and mining among many others (Chrysoulakis et al., 2004). Land-use/land-cover changes may be grouped into two broad categories such as conversion and modification. Conversion refers to the intended shift from one cover or use type to another, while modification involves maintenance of the broad cover or use type in the face of changes in its attributes (Baulies and Szejwach 1998).

The strong interest in land-use/land-cover results from their direct relationship to many of the earth's fundamental attributes and processes, including land productivity, floral and faunal diversity, and biochemical and hydrological cycles. Change is nearly inseparable from human activities and use, and the main aim is to encourage enhancement and counter forces that encourage dilapidation (Fazal and Amin 2011). Rapid demographic transition and growth in economic output per capita, and the resultant changes in land-use pattern come at the cost of the natural environment (Cohen, 1995). Demographic growth stimulates structural change through multiplier effects. Conversion of forests into other forms of land-uses has been the general trend in the mountainous areas. Such changes have been widespread in the past several decades in the Himalayan region (Singh et al., 1983). This type of conversion has been necessitated by increasing population pressure and limitation of productive agricultural land (Sharma, 2004).

Because of human activities, the extent of the land under dense forest is getting reduced. In the same way, land used for cultivation of food crops is also decreasing. But at the same time, land under sparse forest, horticulture and built up area is increasing. This is an unhealthy situation of land management. In this context, present study was undertaken to investigate the land-use/land-cover change in the Vishav watershed to understand the existing situation and accordingly plan for the future.

Objectives

The main objective of the present investigation is to analyse the nature and extent of land-use/land-cover changes in Vishav watershed since last two decades (1990 to 2010) and also to identify the main forces behind them. Moreover, a suitable plan strategy will be suggested to contravene the negative forces behind these changes. A land use policy in the area to regulate the land use/land cover dynamics in a proper and sustainable manner by the various parameters like geology, hydrology, soil character, socio-economic and demographic dynamics should be given the priority.

Significance

Water systems are valued natural resources and essential for stimulating a robust economy and a virtue of life. Human activities carried out on land surface show footprints in the water systems, for more preponderant or for worse. Integrated watershed management is a paramount framework to integrate natural resources in a sustainable way and this includes land-use/land-cover evaluation as a consequential part of culling and maintaining cost-efficacious water supply with minimal impact on the environment. Comprehensive understanding of land use land cover (LULC) change process and its implicative insinuation for environmental condition and ecosystem functioning is essential to identify the accommodations provided by the ecosystem. Remotely sensed data along with Geographic Information Systems (GIS) increase the capability to analyze the human impact on the environment in quantitative and qualitative form. The main goal of this study is to engender the LULC multi-temporal information to quantify and analyze the LULC change and its likely impacts. In contrast to terminus of pipe solutions (treating the symptoms), our focus will be on reducing or eliminating problems at the source. This is by and large done through implementation of a watershed action plan that describes what is to be done to secure safe and secure water systems supply and healthy aquatic systems.

Study area

The Vishav drainage basin covering an area of 1083.48 km^2 (10 % of the Jhelum drainage basin) occupies the southeastern division of the Kashmir valley and is positioned between (33^0 39′ to 33^0 65′ N) latitude and (74^0 35′ to 75^0 11′ E) longitudes with its major part (80%) in the Kulgam and Shopian districts of Jammu and Kashmir, India (Figure 1). The Vishav watershed is a

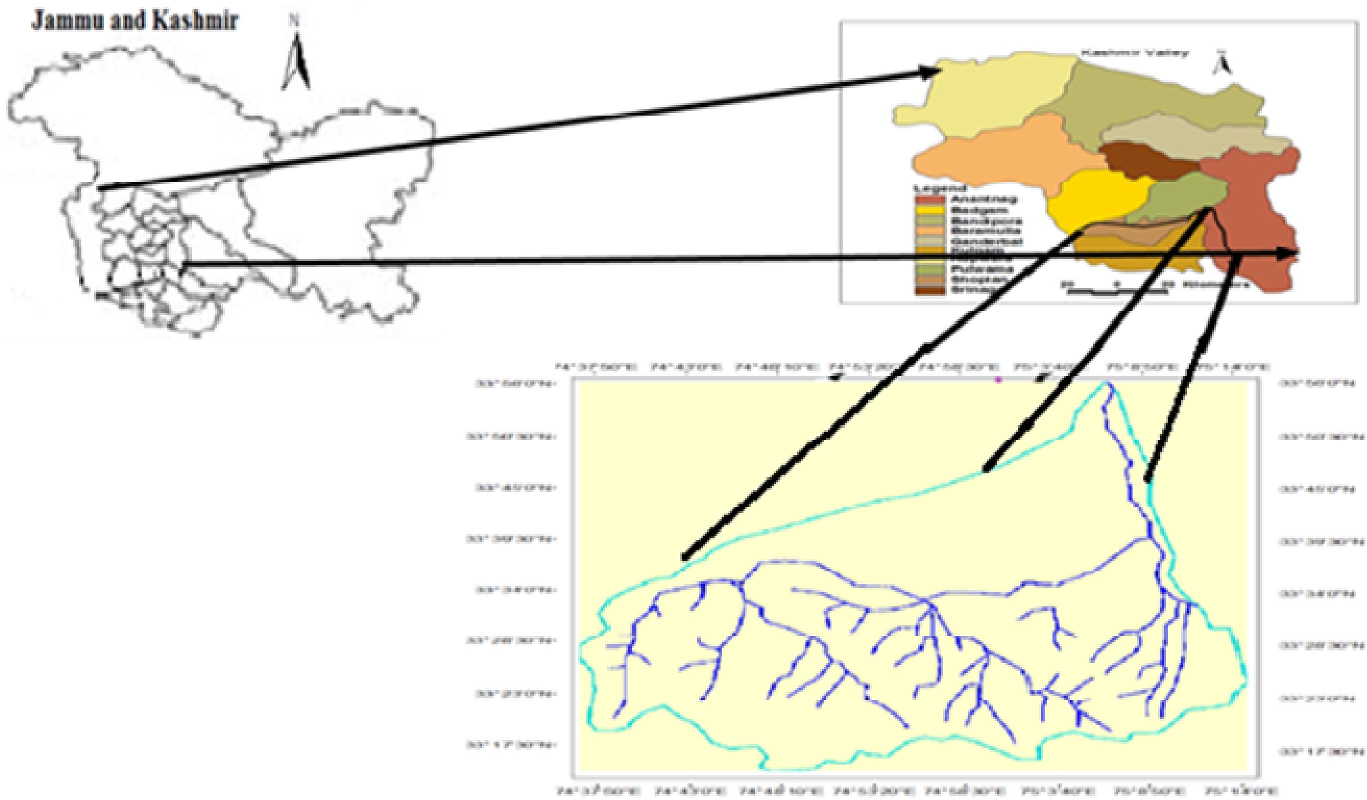


Figure 1. Location map of the study area.

significant left bank permanent tributary of the Jhelum stream. Having its origin from Kounsarnag (3,840 m. from a.s.l.) which lies on the gentler northern countenance of the Pir Panjal range of Kashmir Himalayas, Vishav watershed appears to stem from a glacier fed stream near the base of Kounsarnag called Teri, which afterward joins the underground stream assumed to start off from Kounsarnag 2 km downstream at Mahinag, falling steeply north-northeast to arrive at the main strike valley till it amalgamate with Jhelum at Niayun (Raza et al., 1978).

Vishav watershed is one of the perennial left bank tributary of River Jhelum. After originating from Kounsarnag lake at an altitude of 3,840 m.a.s.l and running in the direction of south-west to north-northeast, the stream drains the entire northern face of the Pir Panjal between Sundartop Peak (3,879 m) in the southeast and Budil Pir Pass (4,264 m) in the northwest. On its downward movement, the Vishav receives glacial meltwater from two other headwater streams. One of its headwater streams namely Chitti Nadi rises in the vicinity of Budil Pir Pass (4, 264 m). Another headwater stream namely Zajl Nar being a major one rises in the Gulalmarg and Zajimarg area and washes the Pir Panjal slopes from Dadi Gali (3,810m) in the east to Brahma Sakal Peak (4,706 m) in the west, draining the most important grassland area of Kongawatan. From the base of Kounsarnag Lake (3840 m.a.s.l), Vishav watershed stems from a glacier fed stream near the base of Kounsarnag called Teri, which later joins the underground stream which is believed to originate from Kounsarnag 2 km downstream at Mahinag, dropping steeply north-northeast to reach the main strike valley.

Gathering momentum, the stream runs towards Aharbal (tourist spot) between steeply mountain areas, over a boulder stream bed, emerging into the pleasant upland serenity of the Aharbal. Vishav watershed forms a famous cataract at Aharbal (18m high) after passing torrentially through a deep gorge. After the union of the three headwater streams, Vishav takes an easterly direction. Near Damhal Hanzpur, Vishav receives a lateral tributary called Kandai Kol from Sundartop peak. The united stream occupies a wide sandy bed and gets bifurcated into a number of channels among which Reshinagar water channel, Sunaman Kol, the Kawal Kol and the Mau Kol are important. The Sunaman Kol and the Mau Kol reunite and merge with the Rembiara near Nyaiyun (Figure 1).

MATERIALS AND METHODS

Detection and analysis

Land-use/land-cover classification was carried out; following

Table 1. Information used for landuse/land cover analysis of Vishav stream basin

Data/Software	Details
IRS-IC-P6 LISS III	23.5 m (resolution) Date: September to October, 2010
Landsat TM 5	28 m Date: September to October, 1900
SOI toposheets	Toposheet Nos.:43 K/10, 43 K/12, 43 K/14, 43 K/15, 43 O/1, 43 O/2 and 43 O/3 on 1:50,000 scale

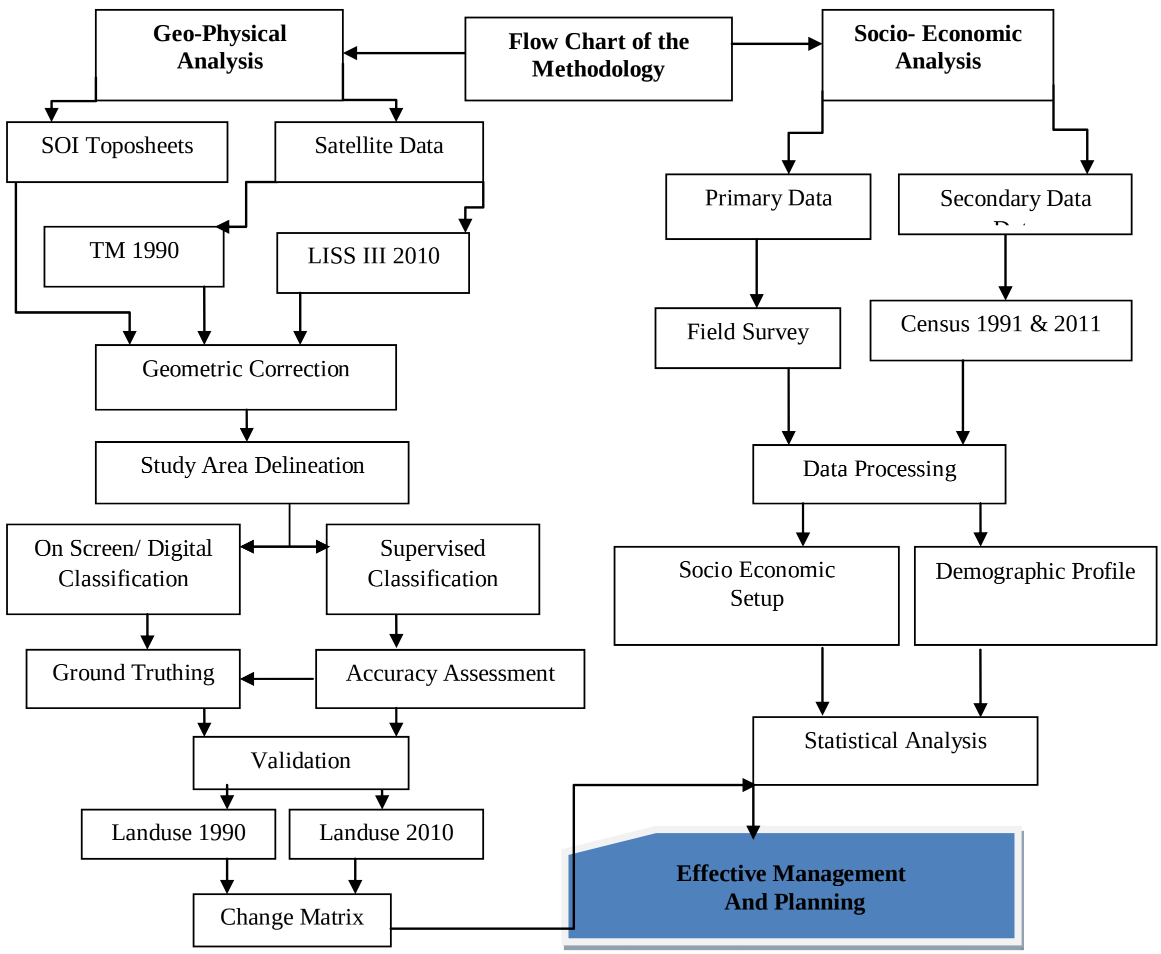


Figure 2. Methodological flowchart

supervised classification method with maximum likelihood algorithm was applied using ERDAS Imagine 9.0 Software. A base map was prepared from the Survey of India (SOI) topographic sheets, that is, 43 K/10, 43 K/12, 43 K/14, 43 K/15, 43 O/1, 43 O/2 and 43 O/3 on 1:50,000 scale with the use of ArcGIS 9.0 software by assigned UTM, WGS 1984, 43N zone projection system. Land-use/ land-cover map of the study area for two time periods that is; 1990 and 2010 were generated from Landsat TM 5, 1990 and IRS-1C P6 LISS III, 2010 satellite data respectively (Table 1. The method-logical framework for the present study is very comprehensive and integrative. The satellite images of the study area were registered and rectified with reference to already geo-referenced 1:50,000 scale topographic maps of the same area. Further, a subset was derived for the area of interest from the geo-referenced SOI topographic maps. Comprehensive field work for ground truthing was carried out after selection of appropriate training sets for finalization of the LULC maps (Figure 2).

Change detection and analysis

For determination of LULC change, a post-classification method was employed. A change matrix was produced with the help of ERDAS Imagine 9.0 Software (Weng, 2001). Quantitative data of

Table 2. Land-use/Land-cover change in Vishav watershed, 1990 to 2010

Landuse/land-cover category	Area in sq. km (1990)	Percentage of the total area (1990)	Area in sq. km (2010)	Percentage of the total area (2010)	Change in area Sq. Km (%)
Dense Forest	177.12	16.66	129.09	12.14	-48.04(-4.52)
Sparse Forest	147.88	13.91	175.71	16.53	27.83 (2.62)
Agricultural Land	289.59	27.24	250.59	23.58	-39.00 (-3.67)
Horticulture	166.38	15.65	196.55	18.49	30.17 (2.84)
Built-up	14.26	1.34	15.92	1.50	1.66 (0.16)
Water body	34.00	3.20	32.59	3.07	-1.42 (-0.13)
Snow/Glacier	133.31	12.54	136.33	12.83	3.02 (0.28)
Wetland	2.22	0.21	2.02	0.19	-0.20 (-0.02)
Grassland	51.39	4.83	60.25	5.67	8.66 (0.83)
Wasteland	46.76	4.40	63.87	6.01	17.11 (1.61)
Total	1062.91	100	1062.91	100	

Source. Generated from Landsat TM 5, 1990 and IRS-1C P6 LISS III satellite data, 2010.

land use/land cover changes as well as gains and losses were generated based on identified category in between 1990 and 2010 respectively.

RESULTS AND DISCUSSION

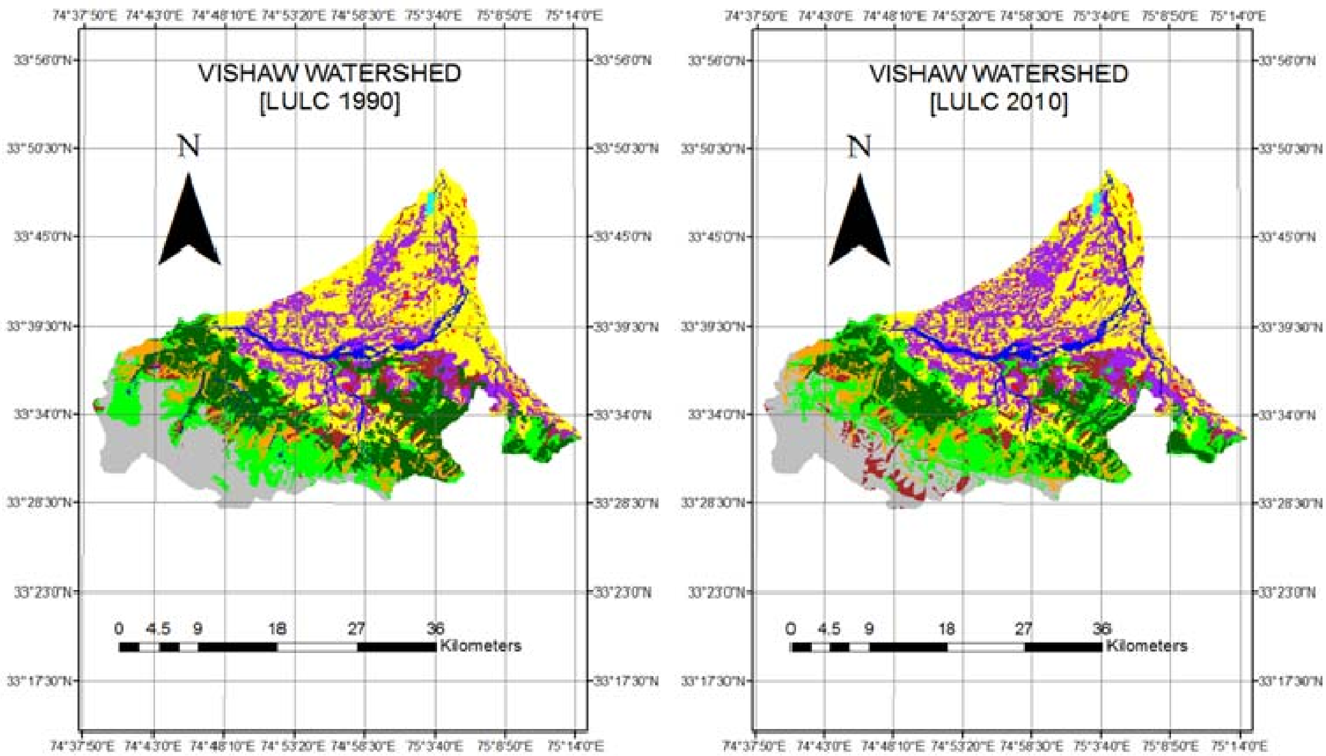
Conversion of forests to other forms of land management has been the general trend in mountainous areas. Such changes have been widespread in the past several decades in the Himalayan region (Rai et al., 1994; Singh et al., 1983). This type of conversion has been necessitated by increasing population pressure and limitation of productive agricultural land (Rai and Sharma, 1998). The same trend has been observed in the Vishav watershed. In the study area the population has tremendously increased (almost doubled) from 2, 10,130 (Census, 1991) to 4, 17,347 (Census, 2011). The present study was intended to analyse the nature and extent of land-use/land-cover changes in Vishav watershed since last two decades and identify the main forces behind them. The land-use/land-cover statistics of 1990 and 2010 and the change and growth in areal extent in different land-use/land-cover classes between the two times periods in the Vishav watershed are given in (Table 2 and Figure 3). The study area has been divided into the ten major land-use/land-cover classes as shown in Figure 3. Vishav watershed is a hilly area with forest cover as the main natural resource. Most of the forest lands are reserved and dense forest. But day by day, forest lands and agricultural fields are being lost to sparse forest, horticulture and built-up (settlements, road, tourists amenities) (Figure 4).

Percentage growth in Land-use/Land-cover classes from 1990 to 2010

Total percentage growth in different LULC categories in the study area is very high. Some LULC classes have registered a positive growth while others have witnessed a negative growth as shown in (Table 3 and Figure 5). Dense forest has reduced from 16.66% in 1990 to 12.14% in 2010, thus registering a growth of -27.12%. Decrease in forest cover means more and more degradation of environment. Deforestation, horticulture expansion and increasing built-up are putting tremendous pressure on the forest resources of the study area. Since wood is the most important source of energy and construction for the rural people in the area, increasing demand for fuel wood and timber has resulted in the acceleration in the deforestation process. Sparse forest cover is one of major land-cover categories in Vishav watershed and has registered a further growth of 18.82% from 1990 to 2010. The degradation of forests due to various reasons over a long period of time transforms them into scrublands. Agriculture has registered a significant decrease from 27.24% (289.59 Sq. Km) in 1990 to 23.58% (250.59 Sq. Km) in 2010, therefore, showing an absolute change of -3.67% that is, -39 Sq. Km at an annual rate of -0.18%.

Horticulture has registered a significant increase from 15.65% (166.38 Sq. Km) in 1990 to 18.49% (196.55 Sq. Km) in 2010, therefore, showing an absolute change of 2.84% that is, 30.17 Sq. Km at an annual rate of 0.014%. People are more dependent on horticulture than any other sector of economic activity as there is almost absence of diversification of economic activities. Built-up constituted 1.34% of the area in 1990 and 1.50% in 2010 thus, registering a growth of 11.63% from 1990 to 2010. Most of the built-up area has increased within the whole valley.

Water bodies have seen a substantial decrease in the area under water bodies from 1990 to 2010. A growth rate of -4.16% has occurred in this land-cover category within a period of two decades. Snow glaciers are mostly located in the south-eastern corner of the study area.



Source. Generated from Land Sat TM 5, 1990 and IRS-1C P6 LISS III satellite data, 2010.
Figure 3. Land-use/ land-cover of Vishav watershed, 1990 and 2010.

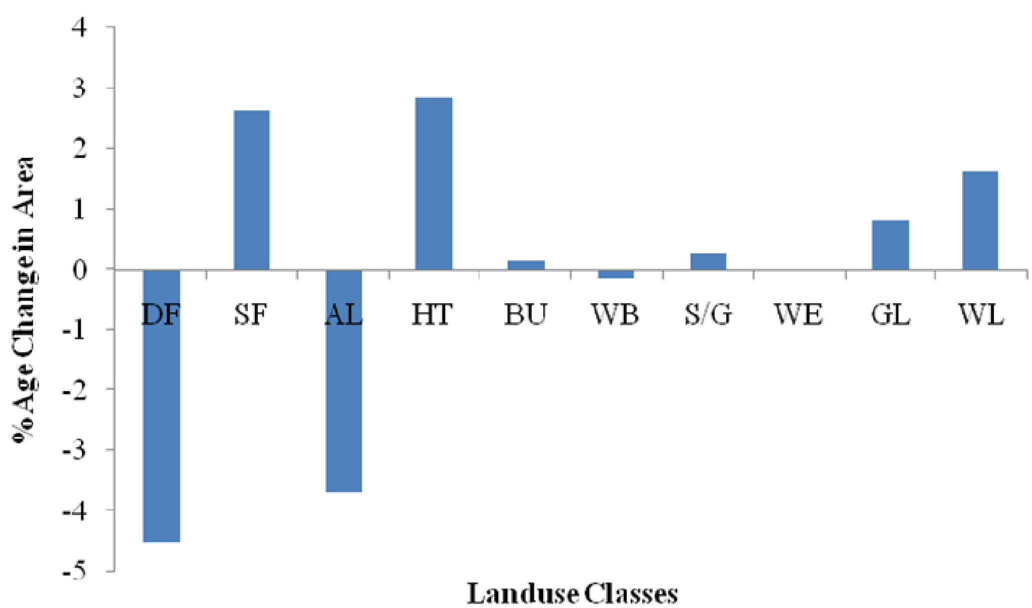


Figure 4. Land-use/Land-cover change in Vishav watershed, 1990 to 2010
(DF=Dense Forest; SF=Sparse Forest; AL=Agricultural Land; HT=Horticulture; BU=Built-up; WB=Water Body; S/G=Snow/Glacier; WE=Wetland; GL=Grassland; WL=Wasteland)

They have increased with a total growth of 2.26% from 1990 to 2010. Wetlands of the study area in 1990 comprised 0.21% and have been reduced to 0.19% of the total area, thus, registering a net change of -0.02% at an

Table 3. Total growth in different land-use/land-cover categories- 1990 to 2010.

Landuse/landcover category	Percentage of total area (1990)	Percentage of total area (2010)	Percentage of (%)total growth
Dense Forest	16.66	12.14	-27.12
Sparse Forest	13.91	16.53	18.82
Agriculture	27.24	23.58	-13.47
Horticulture	15.65	18.49	18.13
Built-up	1.34	1.50	11.63
Water body	3.20	3.07	-4.16
Snow/Glacier	12.54	12.83	2.26
Wetland	0.21	0.19	-8.87
Grassland	4.83	5.67	17.24
Wastsland	4.40	6.01	36.59
Total	100	100	158.30

Source. Generated from Landsat TM 5, 1990 and IRS 1C P6 LISS III, 2010.

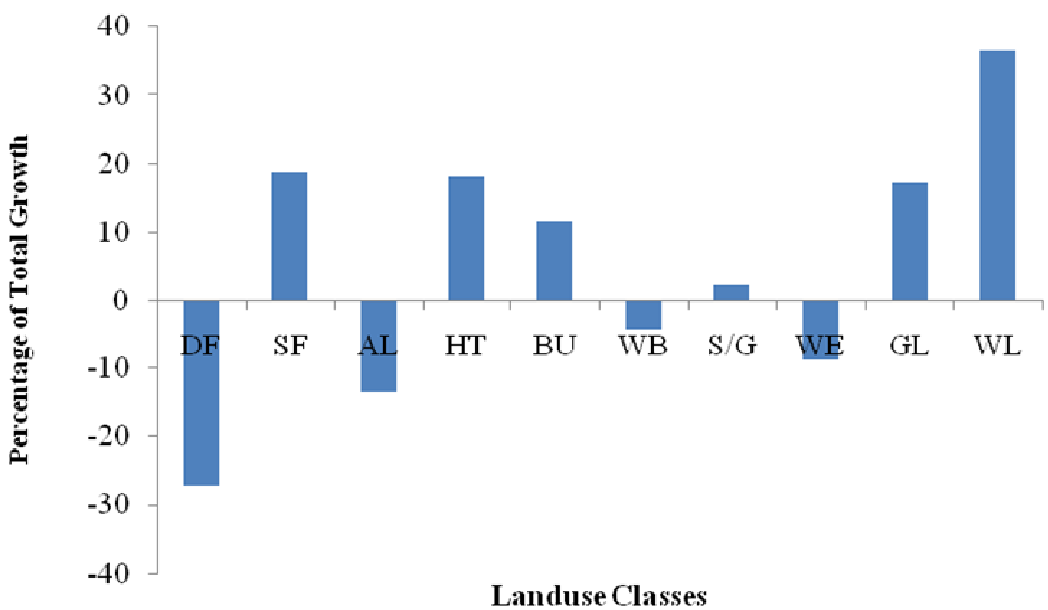


Figure 5. Growth in land-use/land-cover categories from 1990-2010
(DF=Dense Forest; SF=Sparse Forest; AL=Agricultural Land; HT=Horticulture; BU=Built-up; WB=Water Body; S/G=Snow/Glacier; WE=Wetland; GL=Grassland; WL=Wasteland)

annual rate of 0.00093%. Grassland is located in the hilly region of the study area mostly around the Kounsarnag and Aharbal areas. A total growth of 17.24% has occurred in grassland from 1990 to 2010. Wastelands have witnessed a positive growth of 36.59% from 1990 to 2010. The prolonged degradation of forests and scrub has resulted in a net increase in wasteland category within the study area.

The population density in the study area has increased over the period of time because of high population growth. The density has increased from 169 persons/km^2 projected in 1991 to 378 persons/km^2 in 2011. The population growth in the study area has increased from 44.38% in 2001 to 54.48% in 2011, which is the main driving force responsible for the change in landuse/land cover since the last two decades (see Table 4).

CONCLUSION

The study conducted in the Vishav drainage basin located in the Pir Panjal advocates that multi-temporal

Table 4. Population increase from 1991 to 2011 in Vishav watershed.

Time	Total population	Percentage of population	Area in Sq. Km	Population/ Sq. Km	Total growth
1991	180310	21.39	1062	169.78	
2001	260327	30.89	1062	245.13	44.38
2011	402141	47.72	1062	378.66	54.48

Source. Census of India, 1991-2011, (J and K, Series).

satellite data is very useful to detect the changes land use comprehensively. The study reveals that the land-use pattern and its spatial distribution are the major rudiments for the foundation of a successful land-use strategy required for the appropriate development of any area. Land-use/Land-cover studies are of immense importance and occupy a central position in the strategies for managing and monitoring land resources, and they subsequently play a strategic role in man's economical, social and cultural progress.

During the last two decades the area under horticulture land has been increased from 15.65% (166.38 Sq. Km) in 1990 to 18.49% (196.55 Sq. Km) in 2010, therefore, showing an absolute change of 2.84% while the area under dense forest cover has reduced from 16.66% in 1990 to 12.14% in 2010, thus registering a negative growth of -27.12%. The agricultural land has also decreased by -3.67% (-39 Sq. Km). Forest lands and agricultural fields lost to sparse forest cover, horticulture and built-up (settlements, road, tourists amenities) may lead to a lot of environmental and ecological problems. The forest cover referred to as green gold is decreasing at a very rapid rate in the Vishav watershed due to which we are losing our natural ecosystem and biodiversity. The study concludes that there has been a major shift of forest and agricultural lands into horticulture and other categories on account of the growing population and incrementing influence of the unplanned developmental processes. Therefore, it becomes imperative to manage the LULC dynamics and conserve the resources of the watershed through a regulated land-use planning strategy for its sustainable development. The approach adopted in this study clearly demonstrated the potential of GIS and remote sensing techniques in measuring the change pattern of land use/cover in basin area.

Since the watershed under the threat of certain problems raised due to improper management of land, the free gift of nature, the government should come forward to take effective measures to protect the lands especially under forest. Here proper LULC planning is needed; otherwise the results would be fatal for the environment of the area and the economy and health of the people in the near future.

Conflict of Interests

There is no conflict of interest between the authors or with any other organization.

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