LONG-TERM IMPACT OF TRANSHUMANT PASTORALISM ON FOREST COVER : A CASE STUDY FROM NORTHERN LIDDAR VALLEY OF KASHMIR HIMALAYA

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ABSTRACT

Transhumance involves cyclic movements from lowlands to highlands to make use of resources like high mountain pastures. This kind of phenomenal activity has been in tune with nature in Himalayas, since long it has become a problem, severity of which has been increasing in the recent past. Thus the region is presently under heavy stress on account of a large-scale exploitation for fuel wood, timber and fodder on one hand and mismanagement of forest resources and frequent fires due to transhumant activities on the other. Northern Liddar valley from Kashmir Himalayas has been selected to investigate impacts of long-term transhumant activities on land use and land cover at regional level. A detailed ground truthing has revealed that the camping sites used by transhumant pastoralists are exploited for various resources. The camping sites act as spheres of deterioration, the effects of which change the landscape at regional level. Thus, to find out the assessment of transhumance in the study area, combination of spatial and non-spatial data has been combined to carry out spatial forest change analysis.

Key Words : Transhumance, Forest resources, Land use and Land cover, Mountain pastures, Liddar valley

INTRODUCTION

Transhumant Pastoralism in Himalayas involves cyclic movements from lowlands to highlands to make use of resources like high mountain pastures.[1] Movement of people and their livestock proceeds between previously earmarked sites, which become more or less regular seasonal encampments or bases.[2] Similarly, in Kashmir Himalayas, transhumant pastoral community frequently establish seasonal cattle camps, locally called Dhoka. A temporary seasonal shed called as Kotha is constructed with specified size and dimensions and all major pastoral activities are carried around it. They are usually built near a source of water and forest, where the wood for fire and construction is readily available.[3] Owing to huge resource extraction, the seasonal cattle camps are the points from where the degradation of forests start and acts as a nucleus around which a heavy destruction can be seen. Therefore, the monitoring of these grazing sites is essential to understand its impact for long-term conservation and management of natural resources.

The Liddar valley is no way different from other places of Kashmir Himalaya, with a high proportion of forest and alpine meadows. The area has been purposively selected because of its high transhumant pastoral circulations. Many efforts have been taken to study the anthropogenic pressures on the Himalayan forests.[4,5] However, the present study has been attempted to show the cumulative effects of transhumant activities on the forest cover.

Migratory grazers with a large herd of sheep, goat, horses and buffaloes regularly spend summer months in the high altitude pastures and temperate forests.[5] Until late seventies, these grazing lands were managed scientifically and grazing was regulated. The

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movement and number of live stock were monitored at established registered grazing check posts. This regulation would ensure that carrying capacity of each pastureland does not get disturbed silviculturally. Whenever depletion of any land or any sizable forest damage was observed, restraints were exercised.

However, the scenario at present is spectacularly different. The forests of Jammu & Kashmir state are open to indiscriminate and unregulated grazing. This is among the most important cause of degradation of the forests. The present rate of deterioration and depletion of the overall production status is not only due to grazing beyond the carrying capacity but also as a result of continued misuse, in-discriminate cutting and mob grazing which has resulted into proliferation of noxious and poisonous weeds. Furthermore, the increase in population size together with the change in governance and management brought lot of irregularities. All regulations about the forest grazing faded such that the present managers are hardly aware about existence of such practices. Thus, the problems have assumed malignant dimensions. Livestock grazing by means of transhumance has influenced vegetation structure, composition and biodiversity.[6] Transhumant Livestock in remote areas utilize various grazing resources across altitudinal gradients during migrations, reduce the forest cover by means of fuel wood extraction, looping, and torch wood extraction. This leads to the formation of canopy openings.

AIMS AND OBJECTIVES

The study highlights the impact of seasonal transhumant activities on the forest cover in the region during last two decades on the basis of multi-date remote sensing satellite data.

METHODOLOGY

Study area

One of the valleys most affected in Kashmir is that of the Liddar (spelled as Lidder) located towards East of the summer capital Srinagar. Total area of this catchment is 1248 km^2; it gradually rises in elevation from South (1600 mts) to North (5400 mts). Owing to its wide altitudinal gradient and varied edapho-climatic and physiographic features, the region harbors wide array of habitats including fresh water lakes, wetlands, springs, ponds, swamps, marshes, streams, canals, flood plains, terraced tablelands, wastelands, montane slopes, rocky outcrops and permanent glaciers. The interior of the Liddar valley has concentration of high mountain ridges making its actual area far far more than the apparent area and this anomaly gives rise to the alpine and sub alpine grazing grounds.

The Northern most part of this catchment has high density of pastoral nomads observing transhumance. This part of the valley has no permanent settlements but supports large number of short distance and long distance transhumants in terms of subsistence animal husbandry. The part of the valley studied here is thus designated as Northern Liddar Valley. It has a total area of 627 km^2 and is situated between 34^0 00’ 00” N to 34^0 15’ 35” N and 75^0 06’ 00”E to 75^0 32’ 29” E as shown in **Fig. 1.** Some transhumant communities of the region include the buffalo herding *Gujjar*, goat and sheep herding Bakarwal, and local Pohal, continue a long-standing tradition of migrating up to the alpine pastures for the summer and descending to the low-lying foothills in the winter.[1,7] Although the pattern of seasonal migration is constant since centuries, the social and economic nature of the migration has changed significantly in the last few decades and very limited studies on the above aspect have been carried out. Further, its importance for ecosystem diversity and sensitive response to environmental changes makes it a place of concern. To find out the assessment of transhumance on the study area, a combination of spatial and non-spatial data have been used. Landsat TM data have been procured from Global Land Cover Facility (GLCF) from the University of Maryland*(http://glcf.umiacs .umd.edu/data / landsat)*with UTM/WGS 84 projection. The specifications of the remote sensing data are given in **Table 1**. Other ancillary datasets include ground survey observations using handheld *Garmin* GPS, Survey of India toposheets of 1:50,000 scale and Forest administration map with 1:50,000 scale.

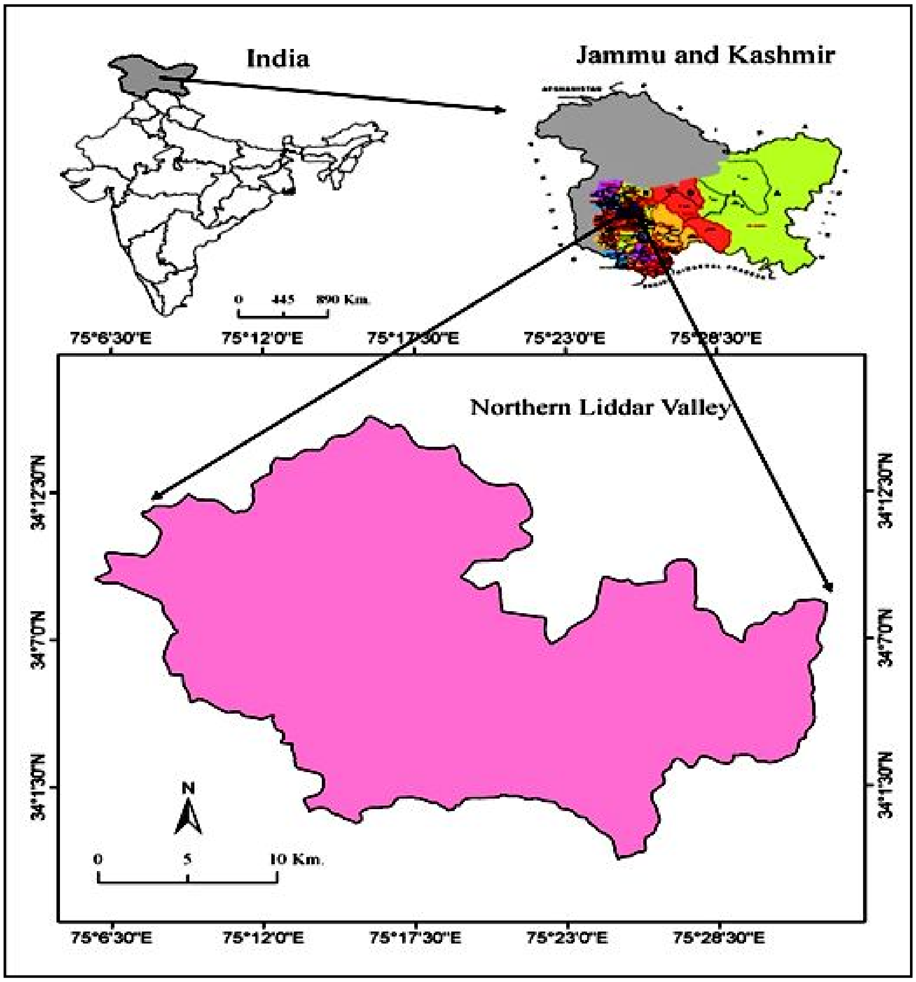


Fig. 1 : Map showing location of Northern Liddar valley

Table 1: Satellite data used for studying change analysis in Northern Liddar valley

Satellite	Path	Row	Month of pass	Cloud cover
Landsat TM	149	36	Oct, 1992	0%
Landsat TM	149	36	Oct, 2010	0%

Image processing and classification

Supervised classification was chosen to process the satellite data by visual interpretation. To accomplish this step, interpretation key has been developed to extract information from the imageries. Here training areas representative of specific classes or objects on the ground were provided. Supervised classification of the Landsat TM (2010) data was carried out initially and area was delineated into forests, meadows, alpine scrub, rock outcrops, water bodies, agriculture and snow as shown in **Table 2.**

The selection of training sites was done considering representation of all digital categories of radiance (spectral signature) and color composites.[8-10] The criterion of Maximum Likelihood was used to assist in the classification of overlapping signatures, in which pixels were assigned to the class of highest probability. Area of interest (AOI) of the same places have been taken from vegetation map of Landsat TM data of 2010 for classification of Landsat TM 1992 data. In both data sets, eight land cover classes have been delineated by classifying them as shown below in **Table 3.**

Table 2 : Image interpretation key for land cover classification

Land cover	Tone	Texture	Shape	Description
Pure forest	Dark umber	Smooth	Irregular	Dense canopy with conifers in composition
Subalpine meadows	Pink red	Smooth	Irregular	Dense grass cover with few trees interspersed
Alpine scrub	Pale red	Rough	Irregular	Sparse grass cover with Junipers as woody plants
Pyospheres	Bright red	Smooth	Irregular	Open patches with healthy vegetation of weeds
Rock out crops	Grey	Rough	Irregular	Morines, Exposed rock surfaces
Water	Blue	Smooth	Irregular, defined	Rivers, Springs, Lakes
Snow	white	Smooth	Irregular	Glaciers, Snow Caps
Agriculture	Dark	Rough	Regular	Cropland and fallows

Table 3 : Land cover classification adopted in the study

Level 1	Level 2	Level 3	Total classes
Forest	Pure forest	Pure forest	Pure forest
	Open patches	Open patches	Sub alpine meadows
Alpine lands	Meadows	Sub alpine meadows	
		Alpine scrub	Alpine scrub
		Piospheres	Piospheres
	Rock out crops	Rock out crops	Rock out crops
Water	Water	Water	Water
Snow	Snow	Snow	Snow
Agriculture	Agriculture	Agriculture	Agriculture

Reclassification and accuracy assessment

After the completion of classification, misclassified areas were observed and reclassified using small AOI or through interactive editing for improved accuracy. Maps Prepared by interpretation of satellite data were assessed for interpretation accuracy. Accuracy assessment has been determined based on simple random sampling technique wherein the number of sample points selected for ground truthing was calculated using the formula given by Snedecor and Cochran in 1967.

$$n = \frac{(p \times q)}{d^2} \quad (1)$$

Where p is the desired proportion of estimated accuracy; q is 100-p; d is the standard error (5 percent), where p, q and d are expressed in percent. At P=95 percent and d=5 percent, the number of sample points (n) to be selected, works out to be 19. For any meaningful results, the smallest number size should be at least 20.[7] Accordingly, the sample size was the selection of sample points fixed at 20. To accomplish this step, map of study area was divided into 2.5x2.5 inch grid sand. The total number of grids falling in the area was counted. This constituted the population. Out of these, 20 samples were selected by simple random sampling technique and marked on the map and their locations were noted. Thereafter, ground truth of these selected samples was collected by visiting the field. Furthermore, the assessment of the classification accuracy of the derived land cover maps from satellite data was carried as shown in **Table 4.** The overall accuracies for 1992 and 2010 were 80% and 80% with Kappa statistics of 0.7429, and 0.7479 respectively. Producer's and user's accuracy was consistently high. Therefore, accuracy is sufficient for evaluation of land use and land cover.

Table 4 : Summary of classification accuracies (%) for year 1992 and 2010

Land cover class	1992		2010	
	Producer's	User's	Producer's	User's
Agriculture	93. 82	82.35	93.75	88.24
Subalpine grasslands	66.67	100.00	100.00	75.00
Pyospheres (Degraded)	92.86	72.22	100.00	100.00
Alpine scrub	76.47	86.67	83.33	66.67
Forest	100.00	66.67	64.29	81.82
Rock outcrops	83.33	66.67	84.62	100.00
Snow	100.00	88.89	75.00	100.00
Water body	93.33	88.89	93.33	81.82

Change rate analysis

Images were analyzed to identify the magnitude and direction of change. To assess the magnitude of the changes of various classes, the compound interest formula was used.[11] It provided changes in the native land use and land cover category.

$$\text{Change rate} = \frac{[Ln(At1)-Ln(At0)]}{t1-t0} \times 100 \qquad (2)$$

Where, At_1 is area of class in current year, At_0 is area of class in base year, t_1 is current year, t_0 is base year and Ln is natural logarithm.

RESULTS AND DISCUSSION

The effects of the deforestation have been considered under this scheme by simple classification technique. The land cover maps of 1992, and 2010 were produced from Landsat TM data are shown (**Fig. 2(a)** and **Fig. 2(b))** for quick reference and the distribution of land cover is shown in **Table 5.**

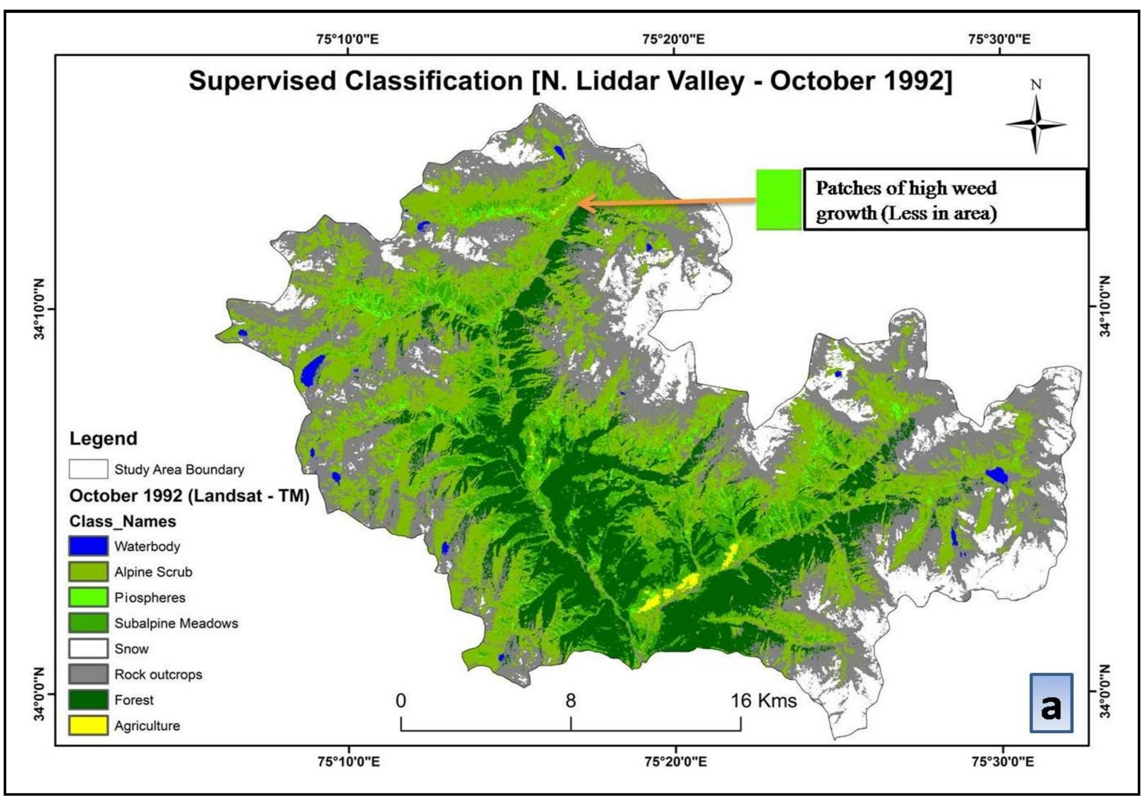


Fig. 2(a) : Classified remote sensing images of the Northern Liddar valley- Kashmir : Supervised Classification [N. Liddar Valley – October 1992]

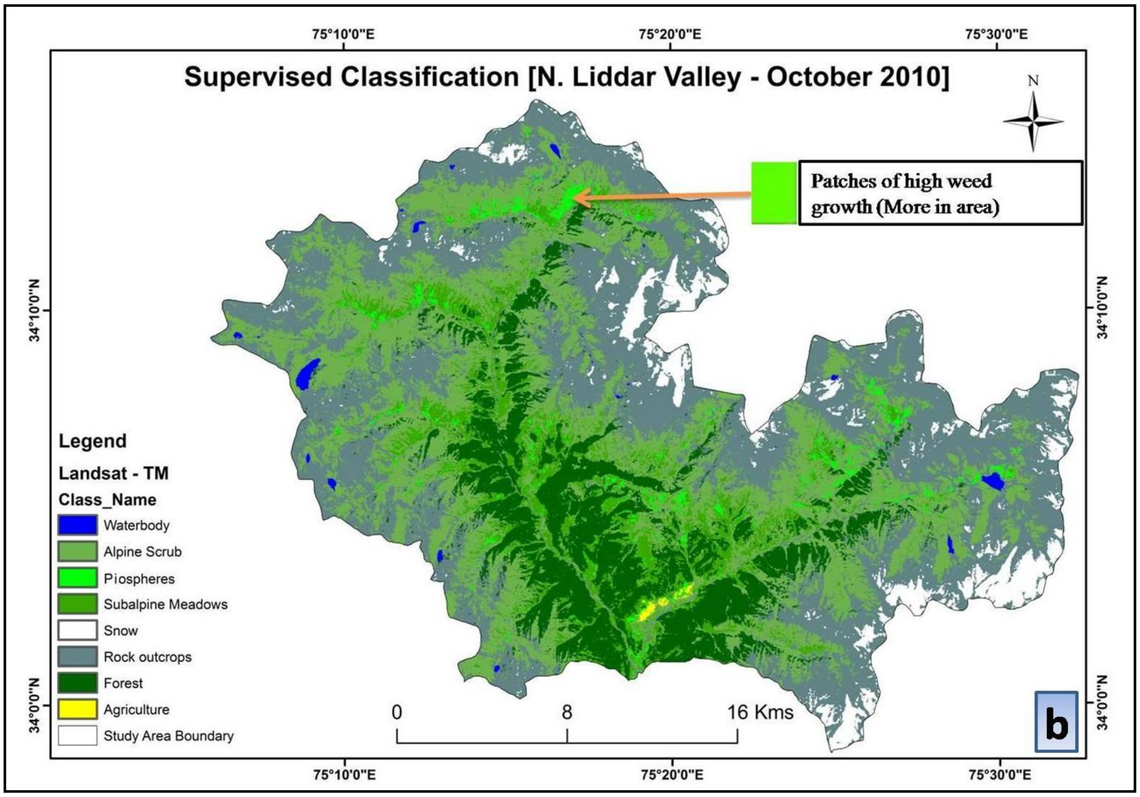


Fig. 2(b): Classified remote sensing images of the Northern Liddar valley- Kashmir : Supervised Classification [N. Liddar Valley – October 2010]

Change analysis

The significant changes in terms of forest loss and degradation of high altitude meadows have been understood by change analysis of data for two intervals of time. **Table 5** shows the land use and land cover change from 1992 to 2010. Prominent changes in land cover of the area took place from dense to open areas. In 1992, area under forest cover was about 104.42 km^2 (16.65%) out of total study area of 627.00 km^2. However, there was a gradual decrease in forest cover in two decades and it reduced to 14.34% (89.92 km^2) in 2010. The illicit damage during period of grazing is attributed largely to regular cutting and lopping of the trees by the transhumants who, stay at cattle camps along with their livestock and meet all their needs from the forests. As a result, there is an increase in size of the cattle camps **(Fig. 3(a)** and **Fig. 3(b))**. Analysis of time-series data indicates that tree cover between the adjacent camping sites was gradually lost because of anthropogenic activities and has resulted in connectivity between them. The Remote sensing analysis of the study site shows that the area of grazing land (Alpine, subalpine and Piospheres) was initially 249.33 km^2 in 1992 which accounts 39.77%, it gradually increased to 258.55 km^2 in 2010 (41. 24%). This clearly indicates that there has been a steady increase in the area of grazing land at the cost of forest cover around camping sites.

On an average, there was change in forest at the rate of 0.83 km^2/year from 1992–2010 and finally led to 2.31% loss of forest cover **(Table 5).** Among grazing lands, significant loss of area has occurred from subalpine meadows to alpine scrub with a decrease from 8.15% in 1992 to 7.33% in 2010. The increase in scrub area is expression of huge grazing pressure, which has been referred as Nibble effect. In this effect, the forests are degraded to scrub area and grasslands accommodate secondary scrub vegetation. The sudden increase in bare rocks is also attributed to limitless grazing, as it is responsible for excessive removal of vegetative cover, accelerating the process of solifluction,

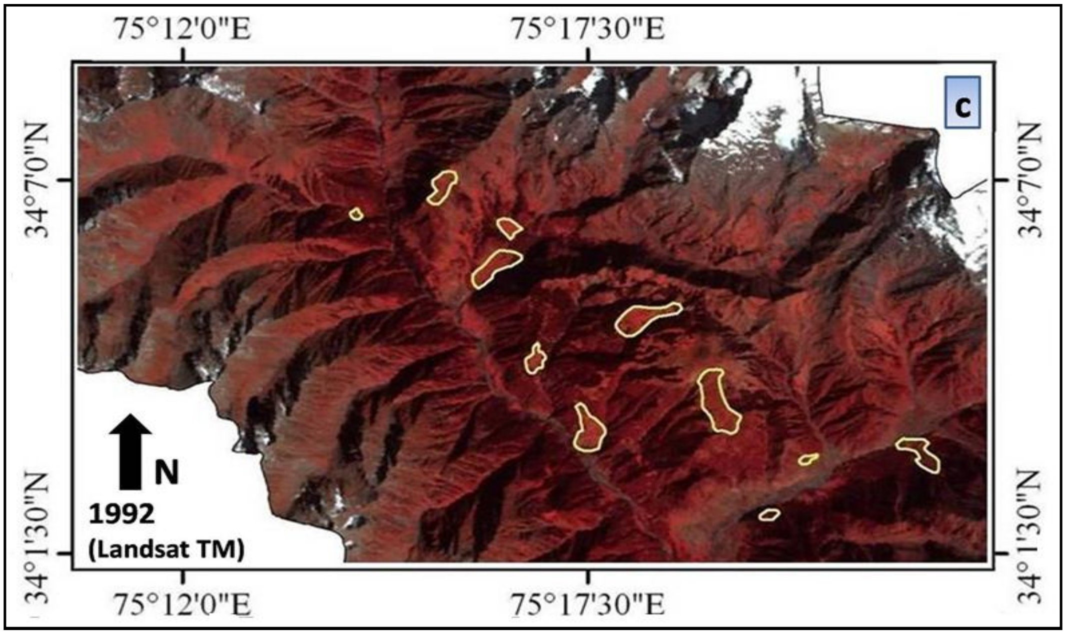


Fig. 3(a) : Images of the Northern Liddar valley showing fragmented forest patches : Image of 1992 showing small patches

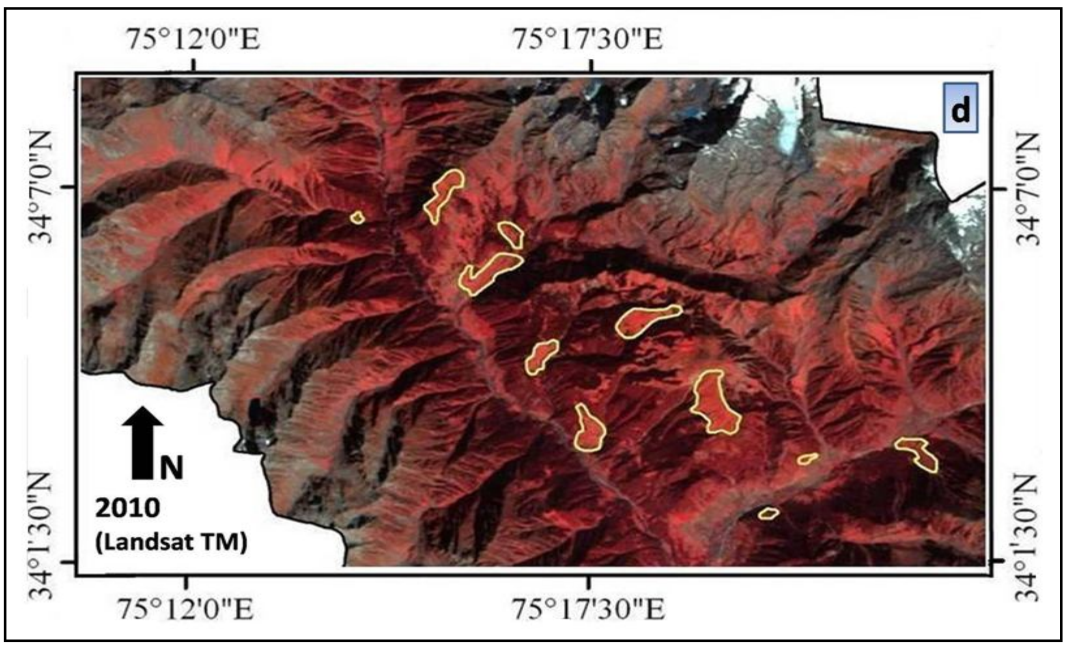


Fig. 3(b) : Images of the Northern Liddar valley showing fragmented forest : Image of 2010 showing larger and connected patches

which, thereby increases the area under rocks and stones.[12] The increase in rock outcrops is further associated with decrease in area under snow and water bodies. The issue is of glaciers is of great importance globally and the evidence of global climate change on glaciers can be witnessed from the results of the present study. Analysis further indicates drastic decrease in agriculture land from 1.47 km^2 (0.23%) to 0.87 km^2 (0.14%). Casmir and Rao documented the change of agriculture to pastoral settlements in the region; the discreteness of the settlements was however beyond the scope of available data to highlight such changes.Transhumant pastoral practices leads to propagation of *Piospheres,*

Table 5 : Distributions of land cover areas in Northern Liddar valley from 1992 to 2010

Land use class	Percent of physiographic zone		1992-2010	Remarks
	a	b	(a-b) in %	
	% age in 1992	% age in 2010		
Forest	16.65	14.34	2.31	Decrease
Subalpine grasslands	8.15	7.33	0.82	Decrease
Piospheres	2.07	2.69	-0.62	Increase
Alpine scrub	29.55	32.22	-2.67	Increase
Agriculture	0.23	0.14	0.10	Decrease
Rock outcrops	30.94	37.10	-6.16	Increase
Snow	12.00	5.67	6.33	Decrease
Water body	0.41	0.51	-0.10	Increase

which are patches where the grazing impacts radiated in a diminishing response away from the centre.[13] These are the result of the impact of a disturbance (e.g., livestock grazing) at an environmental resource patch such as water, shade, mineral licks, etc. However, here these patches are formed near the temporary settlements as holding pen for livestock. The disturbance's impact is highest at the center of a resource patch and attenuates radially with increased distance from the patch center.[14,15] These patches have a vigorous weedy growth of exotic annual plants and are usually formed by deposition of live stock excreta. The central most part of a Piosphere is called a sore spot. Identification and documentation of these patches was a challenging job and results demanded accurate classification.

Rate of change

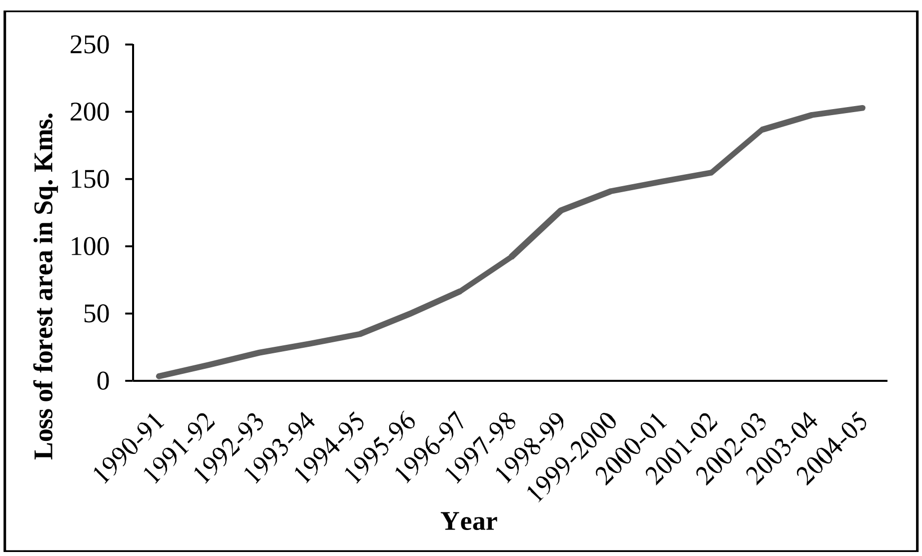
With the knowledge of changes in the forest cover, rate of deforestation was computed and shown in **Table 6.** Magnitute of deforestation shows increasing trend from 2000-2010 as compared to 1992-2000. It is because of high political instability during 1992 to 2000, which restricted the huge circulation of transhumants in the forests. Piospheres increased at an alarming rate during 1992-2010, which is attributed to indiscriminate herd flow to forest areas. The rapid expansion of such patches is a grave concern and if not checked will encroach the entire region and out compete the economic grass cover followed by reduced primary productivity. Thus, because of heavy grazing pressure, these pasturelands are getting depleted of palatable protein rich herbage. The little residual forage is in no way sufficient for limitless number of cattle pouring in these pastures. Spread of weeds like *Sambucus wightiana, Senecio chrysanthemoides* etc can safely be attributed to the indiscriminate grazing by an unlimited cattle population. These weeds being highly allelopathic have outcompeted the tree regeneration in the entire region. Similarly, rock outcrops have increased from 2000 to 2010 at the rate of 1.01 km^2/year and can be attributed to an uncontrolled grazing along higher altitudes. The important reasons for the drastic increase in rock patches are the upward movement of grazers in search of protein rich herbage. Furthermore, increased spatial spread of piospheres along low altitudes and pastures makes the transhumants to explore pastures on higher and steeper slopes, which accelerates the spread of rocky portions. The grazing along the higher altitudes increased bare rock portion in terms of increased solifluction and soil erosion. These processes further corroborate the spread of brown soils. All ecological syndromes due to grazing are pictured in **Fig. 5**.

Table 6 : Rate of change for different land cover classes observed from 1992 to 2010 in km^2/year

Land cover class	1992 to 2010	Remarks
Forest	-0.83	Decrease
Sub alpine Grasslands	-0.59	Decrease
Pyospheres (Degraded)	1.46	Increase
Alpine Scrub	0.48	Increase
Agriculture	-2.91	Decrease
Rock outcrops	1.01	Increase
Snow	-4.16	Decrease
Water body	1.20	Increase

Deforestation as ecological threat

Certain areas are being degraded at an alarming rate, especially the fringe areas of forests along tree line and isolated patches of deciduous forests due to logging, grazing, and human induced fire occurrences as direct clearance to grasslands, which may be intentionally or non-intentionally.[16,17] Major causes of deforestation are lopping, forest cutting and fires set during transhumant circulations. Forest fires are a huge threat to ecology and are generally the consequence of carelessness by transhumant communities who set forests on fire to improve the growth of grasses for their cattle.[5] These fires inflict heavy damage to the woods by killing the trees of all age classes in general and young regeneration in particular. The apparent survivals in the neighborhood too, are damaged under its impact. Furthermore, at the transit time transhumant pastoralists set fires to forests near their camp sites for the timber and fuel wood in the proceeding year. **Fig. 4** represents the total cumulative loss of forest by fires set by grazers in the valley of Kashmir.



Source : Digest of forest statistics 2005

Fig. 4 : Loss of forests area from 1995 to 2005

Transhumant impacts on physiography

Apart from mapping the rate of deforestation, it is necessary to understand the potential drivers (social, biophysical and climatic conditions) relating to the land cover dynamics. The anthropogenic pressures quantified in the present study have intensified for more than half a century and have been reported in the past. The main reason is marginality of land in the region with shallow and steep slopes resulting in low productivity. Thus, there has been tremendous increase in the livestock population and number of settlements, to extract maximum monetary benefits, which inturn leads to increased anthropogenic disturbances like land encroachments for grazing etc. Another important reason is land tenure, because a large proportion of rangelands in the region are state and community-owned areas that are communally grazed by livestock of the transhumant pastoralists. Under this system, grazing management is difficult or impossible and most often leads to degradation.[4]

Current condition of the degraded forests in the area has resulted into severe consequences like biodiversity loss[4], habitat loss[5], impact on soil, water quality[18,19] and other changes as summarized in **Fig. 5**. The increase in the area of grazing land is attributed largely due to regular cutting and lopping of the trees by the pastoralists who fulfil all their needs from the forests. As a result, there is an increase in size of the cattle camps. The incidence of loping the conifers and the broadleaved species, particularly near transhumant habitations is heavy enough. The malpractice mutilates a plant, cuts down its photosynthetic surface and ultimately causes its death. Further, the destructive practice of torch wood extraction is the source of great damage to the Kail trees adjoining the pasturelands, which has resulted in connectivity between the isolated patches.

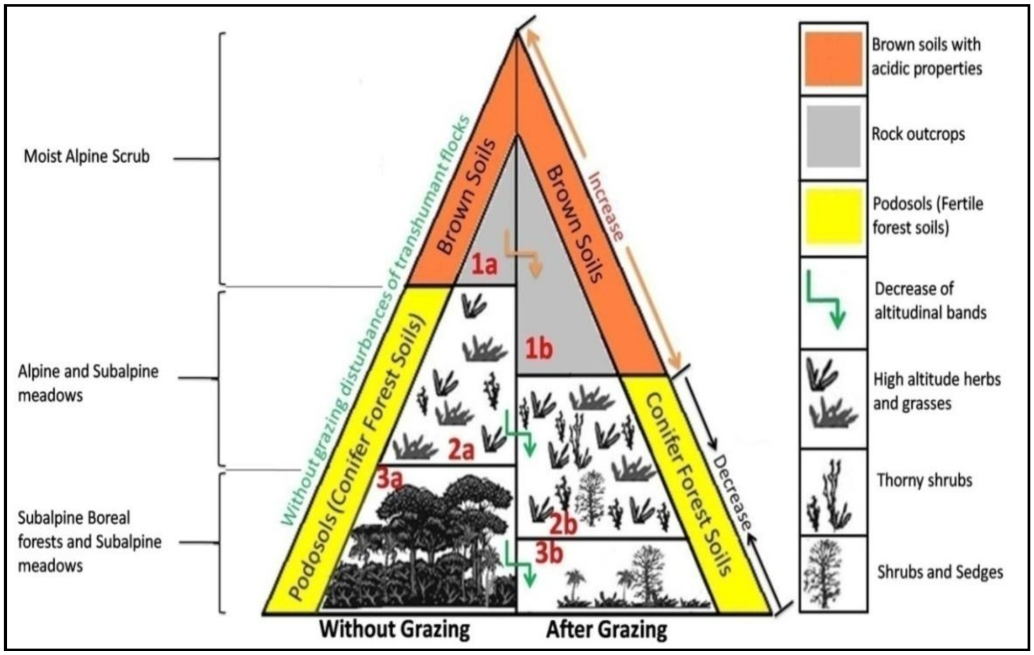


Fig. 5 : Syndromes associated with transhumant practices

(1a) Rock out crops less in area and brown soils less in extent; (1b) Rock out crops and brown soils more in area with depression in lower limit. (2a) Pasturelands with high altitude herbs and forbs; (2b) Pasturelands with increase in thorny shrubs associated with altitudinal depreciation. (3a) Forest area with high tree density; (3b) Forest area with less tree density, increased shrubs associated with altitudinal depreciation the loss of forest cover is further corroborated by lack of very poor regeneration in the area. Much of the secondary scrub is now colonized by unpalatable species such as *Vibernum faetens, Rumex nepalensis* and *Cirsium wallichii*[4] thereby forcing pastoral communities to shift to new areas or higher altitudes as evident from the socio-economic data and ground surveys. Status of the three conifer species (*Cedrus deodar*a, *Taxus buccata, Picea smithiana*) indicates that the number of sapling is extremely poor over the entire region.[16,6]

This indicates that seedlings are unable to reach sapling stage due to trampling and over grazing. An analysis of location of the camping sites indicates that 40% grazing encampments are on slope of >30° (near timberline). Therefore, due to the movement of cattle during snow thaw, soil is loosen and is eroded quickly[12] along such ares. Furthermore, the number of cattle belonging to these semi-nomadic communities has increased from 1950, posing a huge pressure on these sites.

CONCLUSION

The present study has quantified the major land cover changes in the study area. The changes like encroachment into forest land and deforestation rate provided crucial inputs for restoring the ecosystem at regional scale. The unregulated grazing by livestock around summer cattle camps have led to the loss of 14.50 km^2 (about 13.87%) of forest cover around the upper fringes of tree line during the last 30 years. Location-induced change like piosphere development and their propagation rate has been understood and upon these findings, it can be easily concluded that Himalayan ecosystems have a high resilience. The study reveals that current levels of pastoral practices and consumption of fuel wood by the herders in the valley are clearly unsustainable. Therefore, appropriate management intervene-tions and amicable solutions for better livestock management need to be initiated without further delay. With the current level of deforestation, it is necessary to preserve these habitats as they provide ecosystem service and societal benefits. The information generated in the present study is useful for formulating policies in conserving the native vegetation. There is an urgent need for rational management of the remaining forest for its survival in long term through the "Joint Forest Management Programme" for the benefit of the ecosystem through forest recovery and reforestation programme in tune with livelihood of local people and transhumants. For monitoring the camping sites in the valley, remotely sensed satellite data have proved to be effective. There is a need to assess the impact of grazing throughout the Western Himalayas.

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