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LANDSCAPE LEVEL VEGETATION CHARACTERIZATION OF LIDDER VALLEY USING GEOINFORMATICS

Irfan Rashid[1], Shakil Ahmad Romshoo[1], Mohammad Muslim[1] and Akhtar H. Malik[2]
[1]Dept of Geology and Geophysics, University of Kashmir, Srinagar, J & K, India, 190006
[2]Centre of Plant Taxonomy, University of Kashmir, Srinagar, J & K, India, 190006

ABSTRACT

The present study was carried out to understand the vegetation structure and dynamics of the Lidder Valley. The datasets used in the study include IRS-LISS III bi-seasonal satellite data, dated October 2005 and May 2006 having a spatial resolution of 23.5m. During the study, land use/ land cover was mapped using on screen digitization. Moreover, phyto-sociological sampling was done for the forest, pasture and scrub classes using Nested-Quadrat approach to characterize the vegetation. A total of 9 phyto-sociological parameters were analyzed which include the Frequency, Density, Abundance, Basal Area, Relative Dominance, Relative Frequency, Relative Density and Importance Value Index (IVI) of the respective species. A total of 13 categories of LU/LC were delineated from the given satellite data which include Himalayan Dry Temperate Forests, Snow, Agriculture, Bare Rock, Long Fallow land, Mixed Plantation, Moist Alpine Pasture, Moist Alpine Scrub, Open Scrub, Orchards, Settlements, Swampy Grasslands and Water bodies. The LU/LC statistics reveal that most part of the valley is covered by Himalayan Dry Temperate forests (42460 Ha), followed by Scrub (18573 Ha), Perennial Snow (17971 Ha.), Agriculture (10799 Ha.) and Apple Orchards (7482 Ha). Pinaceae, Rosaceae, Asteraceae and Compositeae were the dominant families. Forest samples were mostly mixed, with the trees belonging to Pinaceae being the most dominant. The phyto-sociological analysis indicated that the structural variations in the communities modulate spectral signatures of vegetation and form the basis to describe community structure subjectively and at spatial level.

Key words: Remote sensing, spatial analysis, phyto-sociology, importance value index, on-screen digitization

INTRODUCTION

Vegetation forms an important part of overall biodiversity and its spatial distribution patterns can provide vital inputs for bioprospecting. Vegetation analysis is important to quantify various land surface processes like landslides, avalanches, hydrology, erosion, water quality, biomass etc (Myneni *et al.*, 1997; Romshoo, *et al.*, 2002; Schwartz, 1999). Moreover, it determines the climate of a region (Claussen and Gayler, 1998). Vegetation also determines the fate of nutrients in biogeochemical cycling and energy flow (Romshoo, 2003). Remote sensing data from optical, radar, thermal and lidar sensors has a tremendous potential to measure vegetation attributes and land surface properties that could aid in modeling and assessment of the carbon cycle with better accuracies (Hoekman and Quinones, 2000; Romshoo, 2004). Remote Sensing technology has been used for generating spatial data on forest vegetation and land use using various digital classification techniques (Joshi *et al.*, 2005; Kellndorfer *et al.*, 1998; Kokaly *et al.*, 2003; Tsai and Philpot, 1998; Zhang *et al.*, 2003). Spatial database on vegetation types and status in a GIS domain has applications for landscape and habitat analysis (Pauli *et al.*, 2003; Saran *et al.*, 2003). The spatial, non-spatial data and other ancillary data sources are combined to generate habitat maps for evaluating environmental influences in various ecosystems (Marcot, 2006; Wilson *et al.*, 2003). Geospatial presentation of habitat status has become a key issue for planning conservation. Vegetation characterization of the habitat provides the basis of prioritizing the sites for biodiversity conservation effort (Roy and Tomar, 2000). Deforestation, commercial logging and overexploitation of forest resources has resulted in fragmentation of the landscape (Roy and Tomar, 2000). The application of remote sensing data in linking regional and landscape scales for assessing biodiversity and identifying the causes of depletion has been studied in several studies (Nagendra, 2001a, b; Nagendra and Gadgil, 1998). Geoinformatics plays a significant role in analyzing and understanding the dynamics of the landscapes and its relation with other components. The various parameters (*viz.*, patch shape, patch size, number of patches, porosity, fragmentation and juxtaposition) have been analyzed on a land cover map to spatially present the disturbance regimes (Roy *et al.*, 2000). Geospatial models are being used to delineate the spatial pattern of biological richness (Lindenmayer *et al.*, 2002). Disturbance is widely believed to be one of the main factors influencing variations in species diversity (Connel, 1978; Huston, 1979, 1994; Noss, 1996). The geospatial analyses has been used to assess the anthropogenic impacts on biodiversity at the landscape in Western Himalayan region. Relatively more biological rich area was observed where the magnitude of disturbance was less (Chandrasekhar *et al.*, 2003, Chandrasekhar *et al.*, 2001). Forest type maps were analyzed in conjunction with climate and topography in Geographic Information System (GIS) to categorize habitats a priori and then determined the relationship between remotely sensed habitat categories and species distribution patterns (Debinski *et al.*, 1999; Roy *et al.*, 2001; Porwal *et al.*, 2003; Ramesh *et al.*, 1997; Giriraj *et al.*, 2003). New frontiers in understanding the biodiversity richness, distribution, impact of causative factors for loss and conservation have been opened up in Geoinformatics where patch characteristics are analyzed to determine the impact of the human dimensions to establish disturbance regimes (Roy *et al.*, 2000).

The main objectives of the present study were to analyze the Vegetation using remote sensing data. Moreover, vegetation was characterized using phyto-sociological data. Landscape analysis of the study area performed by using SPLAM model and two important landscape parameters, interspersion and fragmentation are discussed in this paper.

STUDY AREA

The study area in the present research is Lidder valley (Fig 1). Lidder Valley which is one of the dozen major valleys of Kashmir lies between the geographical coordinates of 33°4'N-34°15'N latitude and 75°5'-75°32' E longitude with an area of 1250 km^2 approximately. The valley is nearly 50 km long and has a varied topography and exhibits altitudinal extremes of 1600m to 5200m. Its relief is diverse, comprising of steep slopes, alpine meadows and alluvial fans. The climate of the area is sub-humid temperate, experiencing maximum rainfall from March to May, while as heavy snowfall is received during December to February. The lower part of the valley is very fertile, hence, ideal for agriculture, whereas, the upper portion comprises of dense pine forests and lush green alpine pastures. The valley possesses a number of tourist resorts. Of them particular mention may be made of Pahalgam, Aru, Chandanwari, Baisaran, Kolahoi and Holy Amarnath Cave.

DATA SETS USED

The datasets used in the present study were satellite data and field data. IRS P6 LISS III Bi-Seasonal (October 2005 and May 2006) satellite data with a spatial resolution of 23.5m was used to map vegetation types. Moreover ground truth data pertaining to various land covers was also incorporated in the study. Phyto-sociological data was also collected to characterize vegetation. Besides, remote sensing and GIS softwares used in the study were Arc GIS 9.0, Arc View 3.2(a) and ERDAS IMAGINE 9.

MATERIAL AND METHODS

Champion and Seth classification (1968) was employed for classifying different vegetation types of Lidder valley. In order to map vegetation, multispectral bi-seasonal satellite data (IRS P6 LISS III) of October 2005 and May 2006 was visually interpreted using on-screen digitization technique at 1:50,000 scale. Bi-seasonal satellite data was used so as to discriminate deciduous and evergreen vegetation. This was followed by extensive ground validation in order to obtain a final and accurate

Fig. 1. IRS P6 LISS III satellite image of Lidder Valley

vegetation type map. For acquiring phyto-sociological data pertaining to various

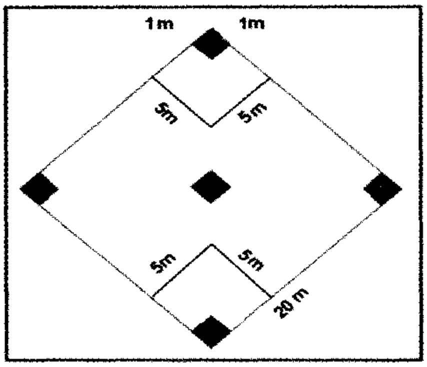


Fig 2. Nested Quadrat

vegetation types stratified random sampling technique was employed. Nested Quadrat (Fig 2) approach was used for carrying out phyto-sociological analysis. The principle of the sampling is to collect field data based on vegetation type strata to bring out vegetation type specific and macro habitat specific relative species abundance information along with other ecologically important variables. Hence, sampling addresses the basic issues related to composition, structure and function through appropriate distribution and intensity across spatial and temporal gradients. Remote sensing based vegetation type strata in conjunction with topography and climate serve as spatial framework to optimize for low sampling intensity and enhance the efficiency of distribution across the variability. Keeping in view of the available resources, time and variability of the study area, 0.001%-0.002% of the forest area of a given study region was sampled. Moreover, secondary layers - settlement and road themes were generated in GIS environment. Another aspect in the present study was the use of Spatial Landscape Analysis Model (SPLAM). The input data used to run SPLAM are Vegetation Type Map, Phyto-Sociological Data, Secondary layers in the form of Settlement and Roads. Preliminary results pertaining to fragmentation and interspersion were obtained from SPLAM. SPLAM generates a 3x3 pixel window and sweeps it over entire data layer. While calculating fragmentation, the model computes the number of forest and non-forest patches per unit area. In interspersion, the model counts the number of dissimilar pixels with respect to a central pixel. The overall methodology adopted for the current study is shown in Fig 3. Moreover, 11 phyto-sociological parameters were evaluated in the current study so as to characterize vegetation which include circumference at breast height (cbh) for tree species, Frequency, Relative Frequency, Abundance, Relative Dominance, Basal Cover, Importance Value Index (IVI), Shannon–Weiner Index, Density, Relative Density and % Invasiveness. The formulae for calculating all the phyto-sociological parameters are tabulated in Table 1.

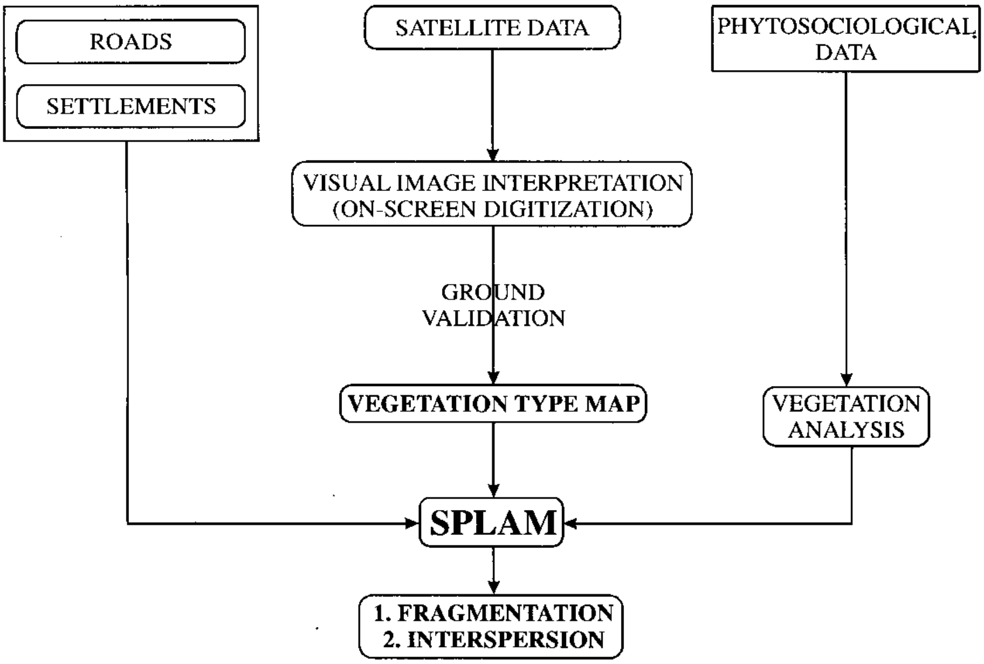


Fig 3. Scheme of the methodology followed

Table 1. Phtyo-Sociological Parameters

S.NO.	PARAMETER	FORMULA
1	FREQUENCY	$\left(\frac{\text{Number of quadrats in which species occur}}{\text{Total number ofquadrats stidied}}\right) \times 100$
2	RELATIVE FREQUENCY	$\left(\frac{\text{Frequency of a species}}{\text{Total frequencyy of all species}}\right) \times 100$
3	DENSITY	$\frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$
4	RELATIVE DENSITY	$\left(\frac{\text{Density of a species}}{\text{Total density of all species}}\right) \times 100$
5	ABUNDANCE	$\frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats in which species occur}}$
6	RELATIVE DOMINANCE	$\left(\frac{\text{Total basal area of a species}}{\text{Total basal area of all the species}}\right) \times 100$
7	BASAL COVER	$\frac{C^2}{4\pi}$ C is circumference at breast height (1.37m)
8	SHANNON WEINER INDEX	$-\sum_{i=1}^{s}\left[\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)\right]$
9	IVI	Relative Frequency+ Relative Dominance+ Relative Density
10	% INVASIVENESS	$\left(\frac{\text{Abundance of invasive species}}{\text{Total abundance}}\right) \times 100$

RESULTS AND DISCUSSION

Land Use and Land Cover

Fourteen classes of land use land cover were delineated in the present study (Fig 4,5, Table 2). These are Western Mixed Coniferous Forest, Snow, Moist Alpine Scrub, Degraded Forest, Bare Rock, Agriculture, Orchards, Fallow land, Moist Alpine Pasture, Mixed Plantation, Water body, Open Scrub, Settlement and Marsh vegetation. Western Mixed Coniferous Forest was the dominant class with a spatial extent of 254.81 km^2 while as marsh vegetation was the least dominant covering an area of 1.96 km^2. Forest were mixed and no pure patches of conifers were be found. Chiefly the tree species present in forests belonged to Pinaceae family which include *Pinus wallichiana, Cedrus deodara, Abies pindrow* and *Picea smithiana*. Moist Alpine Scrub and Moist Alpine Pasture was found at elevations greater that 3000m in Lidderwat and above Phisu top (Chandanwari). Mosses and ferns cover the ground with alpine shrubs and flowering herbs. Agriculture was dominated by rice, paddy and maize and usually found in low lying area or plains of the valley. There are two types of Orchards viz: Apple orchards and Almond Orchards though *Juglans regia* was also present at certain locations. *Salix sp, Populus sp* and *Robinia pseudoacacia* were the main species in Mixed Plantation. Open Scrub occurs at elevetions less than 3000m and is dominated by *Indigofera heterantha, Randia tetrasperma, Viburnum grandiflorum* and *Daphne mucronete*. Two main species characteristic of Marsh Vegetation were *Typha angustifolia* and *Phragmites australis*. Water body comprises of areas with surface water, either impounded in the form of ponds, lakes and reservoirs or flowing as streams, rivers, canals etc. Settlements are areas of human habitation developed due to non-agricultural use and that has a cover of buildings, houses, transport and communication.

Table 2. LULC Statistics of Lidder Valley

Class Name	AREA (km^2)
Western Mixed Coniferous Forest	**254.81**
Snow	179.71
Moist Alpine Scrub	176.09
Degraded Forest	157.55
Bare Rock	110.86
Agriculture	108.79
Orchards	73.02
Long Fallow Land	67.38
Moist Alpine Pasture	43.77
Mixed Plantation	32.63
Waterbody	17.49
Open Scrub	14.84
Settlement	7.13
Marsh Vegetation	1.96
Total Area	**1246.03**

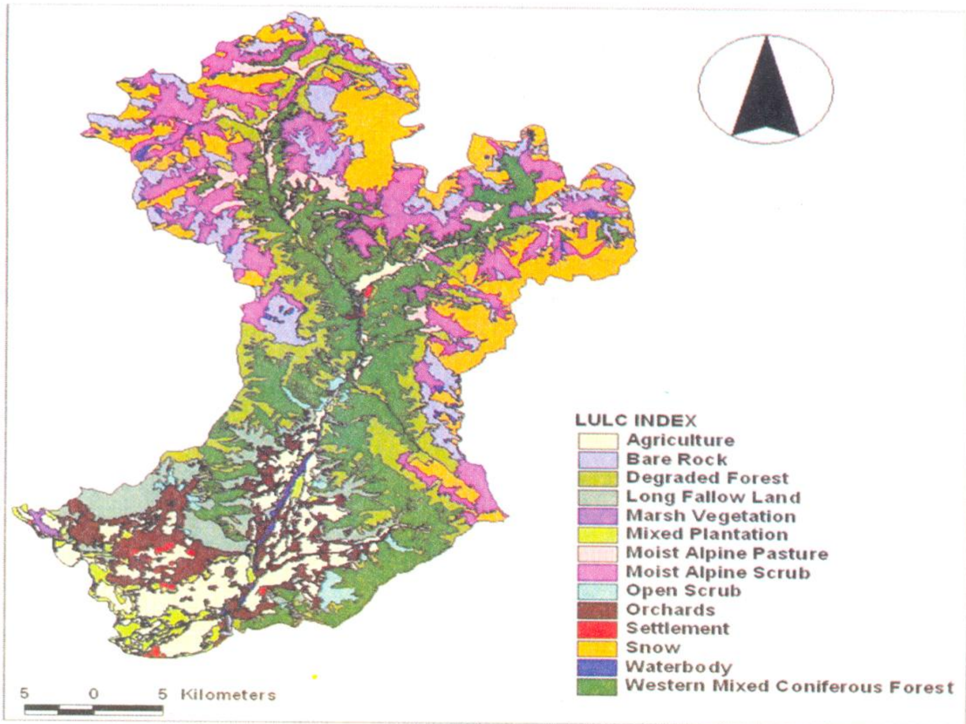


Fig. 4. Land Use Land Cover Map of Lidder Valley

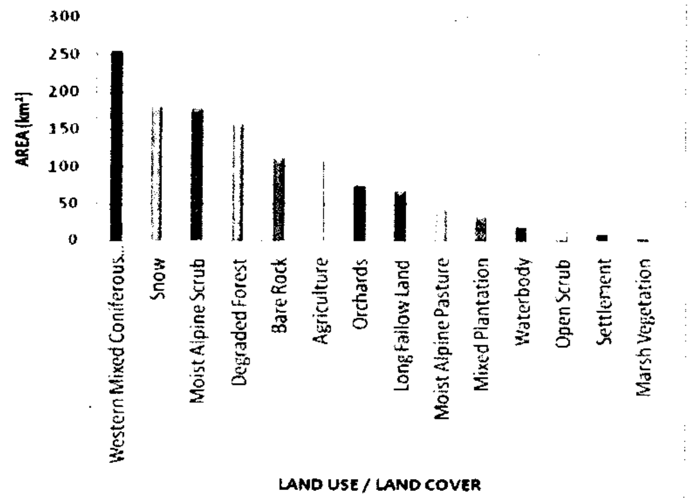
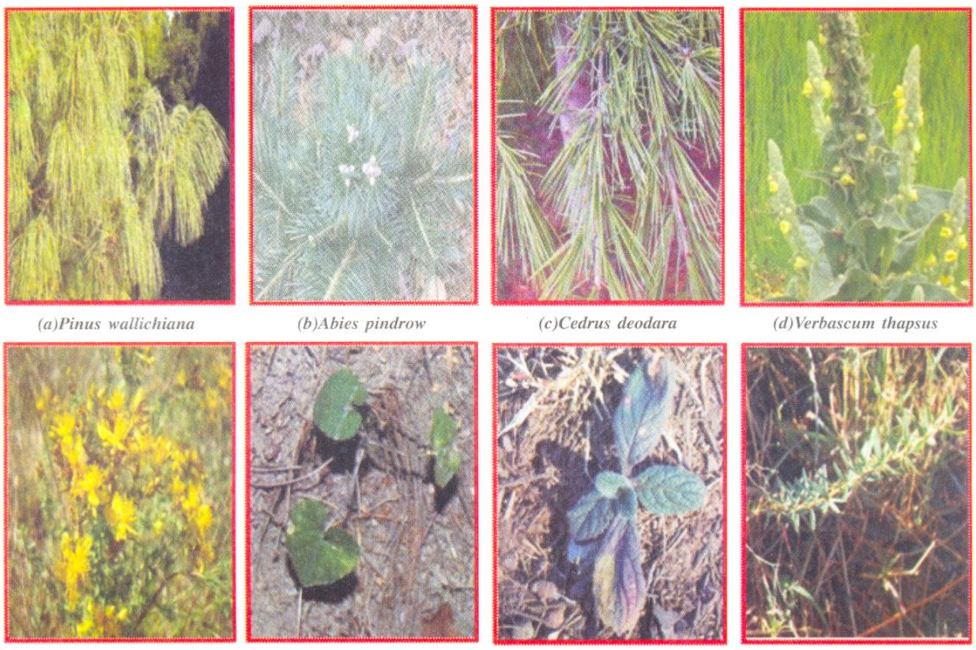


Fig. 5. LULC Statistics of Lidder valley

PHYTOSOCIOLOGICAL ANALYSIS

A total of 43 vegetation samples were taken so as to analyze phyto-sociology of Lidder valley (Fig 7). This included 26 samples taken for Forests 17 for Scrub (11 for Shrubs and 6 for Pastures). 84 plant species were found which include 67 herb species, 8 shrub species and 9 tree species. Some plants (most of the herbs and some shrubs) were having medicinal values associated with them. The dominant plant families include Pinaceae (trees), Rosaceae (shrubs), and Asteraceae, Compositae (herbs). The results of phytosociological analysis are tabulated in Table 4. As per the phyto-sociological results, the abundance of *Gentiana kuroo (0.3)* is lowest among all the species quantified. This is followed by *Podophyllum hexandrum (0.42)*. As per IUCN, these species fall under Critically Endangered and Endangered categories. Hence, the results are in accordance with IUCN Red List Category. The only invasive species found was *Sambucus weightiana* whose invasiveness was 0.96%.



(a)Pinus wallichiana *(b)Abies pindrow* *(c)Cedrus deodara* *(d)Verbascum thapsus*

(e)Hypericum perforatum *(f)Viola odorata* *(g) Ajuga bracteosa* *(h)Berberis lycium*

Fig 6(a-h). Common plant species of Lidder valley

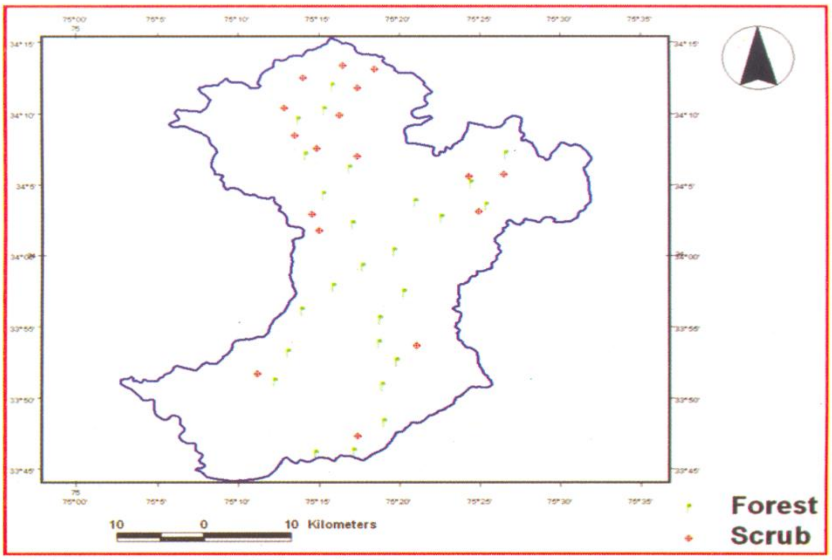


Fig 7. Location of phyto-sociological samples

Table 3. Some plant species of Lidder valley

Herbs	Shrubs	Trees
Podophyllum hexandrum	*Viburnum grandiflorum*	*Pinus wallichiana*
Sambucus nigra	*Rosa webbiana*	*Abies pindrow*
Bergenia straecheyi	*Crotoneaster spp.*	*Cedrus deodara*
Gentiana kuroo	*Parratiopsis jacquemontiana*	*Picea smithana*
Prunella vulgaris	*Berberis lycium*	*Juglans regia*
Datura stramonium	*Indigofera heterantha*	*Acer negundo*
Geranium nepalensis		*Robinia pseudoacacia*

Table 4. Phyto-sociological analysis

S.No.	Parameter	Highest Value	Lowest Value
1	*cbh*	3.42	0.254
2	Frequency	83.33 *Viburnum grandiflorum*	1.56 *Chrysenthemum spp.*
3	Rel. Frequency	6.82	0.12
4	Density	182.56 *Cynodon dactylon*	0.06 *Gentiana kuroo*
5	Rel. Density	22.78	0.01
6	Abundance	81.4 *Cynodon dactylon*	0.3 *Gentiana kuroo*
7	Rel. Dominance	45.9 *P. wallichiana*	0.07 *Gentiana kuroo*
8	Basal Area	4.37 *P. wallichiana*	0.06 *Juglans regia*
9	IVI	50.16 *P. wallichiana*	0.65 *Podophyllum hexandrum*
10	Shannon-Wiener Index	1.321	0.621

SPLAM MODEL SIMULATIONS

A spatial model incorporating ground based biodiversity attributes of the landscape elements, land use change patterns, disturbance regimes of the landscape and terrain complexity was used to delineate the spatial pattern of biological richness using Spatial Landscape Analysis Model (Chanderashekhar *et al.*, 2003; Debinski *et al.*, 1999; Roy and Tomar, 2000). Interspersion (Fig 8) and Fragmentation (Fig 9) of Lidder valley were computed. Interspersion represents spatial intermixing of the vegetation types. Higher value of interspersion means dispersal ability of the central class will be low or reduced or in other words the influence of resistance by neighbors will be much which may lead to the extinction of the central class. From Fig 8, it was observed that there is high interspersion around Pahalgam, Anantnag town, Chandanwari, Wularhom village, Khiram and low lying areas of Lidder valley. High interspersion in these areas can be

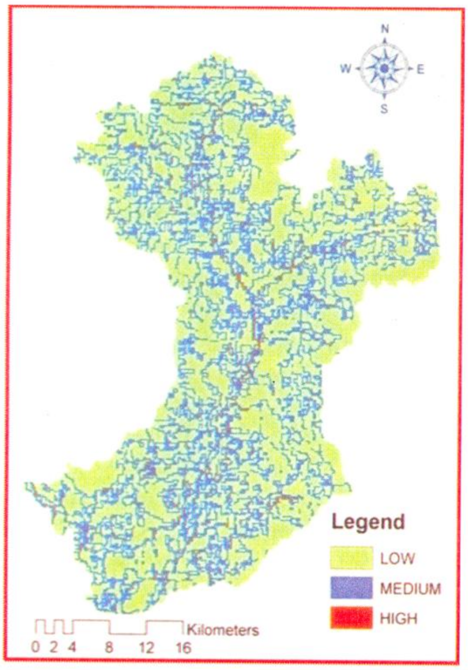


Fig 8. Interspersion map of Lidder valley

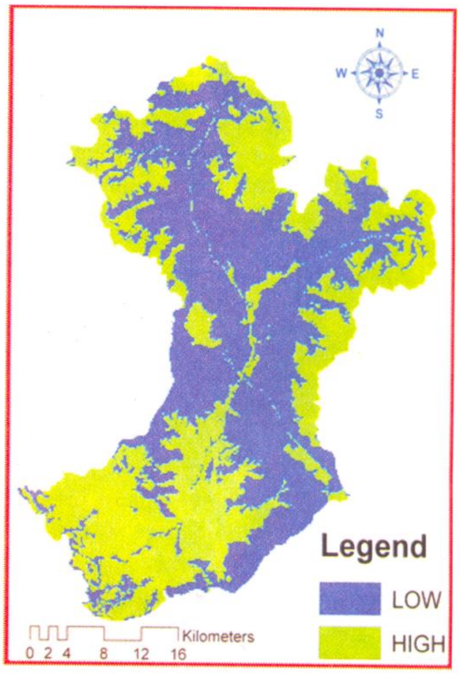


Fig 9. Fragmentation map of Lidder valley

attributed to the smaller patches of different Land Use Land Covers in these areas. Low interspersion was observed around Hapatnar, Marhama, Khiram, Kolahoi glacier because of the fact that these areas have large homogenous patches of same land cover. One of the most apparent manifestations of human activities is habitat fragmentation, which is a result of reduction in the size and increase in the isolation among patches of native habitat. Fragmentation is one of the parameters for landscape evaluation and is directly linked with survival and conservation issues. Highest habitat fragmentation was observed around Poshipathar, Sekivas, Pahalgam town, Mattan, Marhama as these areas posses little or no forest cover. Huge and dense forest patches were mapped around Hapatnar, Gratnar, Langanbal, Owur and hence, fragmentation was very low in these areas. From the above results it was observed that those forest areas which have high interspersion are fragmented as compared to those which have low interspersion. Therefore, chance of habitat destruction or species extinction is more in these areas. Moreover, high fragmentation coupled with high interspersion at the lower elevation (plains) and higher reaches of Lidder valley can be attributed anthropogenic pressure and heterogeneity in land-cover.

CONCLUSIONS

Comprehensive and spatially explicit

vegetation type information, one of the basic inputs for species and habitat conservation, is not readily available to the decision makers and planners in the state. This is an attempt to establish scientifically a regional and locale specific databases on species distribution pattern and associated biophysical controls. Using two-date remote sensing data, we characterized the Lidder valley into 14 different land use and land cover types using the Champion and Seth vegetation type classification. Different forest types and meadows are occupying substantial land area in the study area. Further, using the phyto-sociological data from 43 widely distributed sample sites, we determined the various vegetation parameters that give a better indication of the health and vigor of the vegetation in the area. Using a GIS based landscape analysis model, SPLAM, we assessed the interspersion and fragmentation status of the region. All this information on vegetation types, vegetation parameters and the landscape analysis was incorporated in a geospatial database in GIS for easy access, analysis, manipulation and storage. It is hoped that this baseline database shall be used by various researchers and government agencies for monitoring the changes and assessing the impacts of various forces assessing including climate change on vegetation.

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