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Specialized Mapping using Climatic Zones for Habitat Conservation

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Abstract Mapping of vegetation strata in Great Himalayan National Park Conservation Area (GHNPCA) was conducted using Remote Sensing and GIS. Mapping of major vegetation communities was done by using satellite imageries (FCC of IRS 1-B LISS II Sept/Oct 1993, scale 1:50,000). Ground truthing was carried out for preparation of interpretation key and classification scheme. Mainly the 11 Forest and 11 Non-Forest classes have been delineated in two density classes, viz., close forest (> 40% Canopy cover) and open forest (< 40-10% Canopy cover) for the entire study area. The total area of GHNPCA is estimated to be 1171 km^2. On the basis of Climate zoning using contours as climate separators, finally the 14 vegetation classes and 11 non-forest classes were generated including Temperate, Sub-Alpine and Alpine forests and grasslands, while slope grasses around habitation occupy 28.13 km^2. Escarpments including exposed rocks with slope grasses and Alpine Exposed Rocks with Slope Grasses are 211.12 km^2. The area under glaciers and snow is estimated to be 18.68 km^2 and 183.87 km^2 respectively. Grasslands form the highest cover in the GHNPCA and cover about 18.9% of the total area. Temperate Mixed Forests occupy majority of the forests is about 17.01% of the total area. The conservation area is also dominated by Alpine Grassland i.e. about 193, 89 Km^2. The main upper storey species in conifers are *Pinus wallichiana, Abies pindrow, Picea smithiana, Cedrus deodara, while broad leaved species Asculus indica, Quercus semecarpifolia, Quercus dietata, Betula utilis* are dominant in the study area. The information generated through vegetation mapping valuable for park authorities and can be correlated with the distribution of fauna and avifauna in different habitats. The specialized vegetation mapping on the basis of climatic zoning is seems to be useful for monitoring, assessing and as database will assist the wildlife managers in conservation of endangered species.

Keywords *Conservation; GHNPCA; Habitat; RS & GIS; Vegetation Mapping and Wildlife*

1. Introduction

Vegetation maps are precious as they are used as habitat maps for the characterization of ecosystem. The forest vegetation map is one of the parameter for assessing biodiversity. Therefore, qualitative and quantitative analysis of vegetation is required future monitoring. These plant community status maps also indicate the unique habitats in terms of disturbances and wealth. These maps have various

other applications in manmade and natural ecosystems for biodiversity characterization. The maps are of great importance for forest managers (stock mapping) and biomass estimation, wildlifers (Faunal studies) for long term monitoring. Monitoring is most crucial to evaluate the success of the management measures. For Great Himalayan National Park Conservation Area (GHNPCA) mapping of communities or habitats has been done to help Park Management to arrive at critical conservation strategies, specially seen in the context of biotic pressure from adjacent settlements for MFP collection, cattle grazing, illegal felling, poaching, and encroachment etc. in fast developing tourism and orchard in the valley of Kullu. The Conservation area represents unique biodiversity of cold region, a typical of Western Himalayas.

Conventionally the flora and vegetation has also been surveyed by (Bharti *et al*., 2011 & 2012; Singh and Rawat, 2000; Rawat and Singh, 2006). The significant works i.e. classification of forest formation by Champion and Seth (1968). In western Himalaya Polunin and Stainton (1984) dealt with the floristic and phytogeographical aspects. Recent studies on the flora and vegetation of high altitude areas of western Himalaya includes Behera *et al.,* (2000), Chandrashekhar *et al.,* (2003), Singh and Rawat (1999) and Kala *et al.,* (1997). With the emergence of technology and its capacities; repetitive coverage, mapping of inaccessible and large area within short time, the true picture of forest cover map emerges with reliable accuracy in mapping (Roy *et al*., 1992; Roy and Ravan, 1994). Mead *et al.,* (1981) and Roy (1996) has used satellite data habitat mapping. In this study to obtain the maximum contrast and phenological differences; vegetation mapping has been done using remotely sensed images.

2. Materials and Methods

2.1. Study Area

The GHNPCA encompasses nearly 1171 km^2 area including Sainj and Tirthan sanctuaries and the Eco-development Zone (EZ) lies between $31^0$33'00" N to $31^0$56'56" N lat., and $77^0$17"15" E to $77^0$52'05" E long., and altitude varies from 1344 to 6248 m. The GHNPCA typically exhibits temperate, sub alpine and alpine climate. Most of the area (approx 64%) falls above subalpine zone which remains snow covered during winter months. Broadly, three season can be recognised for the park area *viz*. summer (April to June), Rainy (July to September) and winter (October to March). The mean annual precipitation in western Himalaya at middle elevations ranges between 1000-2000 mm and more than half of it falls during rainy season and temperature of the area varies from minus 10°C to 35°C (Gaston *et al*., 1981).

The vegetation in the area is mainly temperate, sub-alpine and alpine. Based on the physiognomy and dominance, (Champion and Seth, 1968; Naithani, 2001) had also classified the area in 9 forest classes. The park is also known for its faunal diversity; 31 species of mammals (Vinod and Sathyakumar, 1999), 183 species of birds (Gaston *et al*., 1993; Ramesh *et al.,* 1999), and more than 125 species of invertebrates (Uniyal & Mathur, 1999).

2.2. Methodology

The forest type mapping has been done through visual interpretation of satellite data but hilly areas have shadow effect; hence many times it does not offer any clue except for ground truth collection. And realizing this fact intensity of the ground verification has been increased and information in shadow areas has been collected in the field and incorporated in mapping.

Reconnaissance survey was lead by preparation of base map. The study area is covered in 6 scenes and SOI toposheets etc. False Color Composites (FCC) of IRS –1B LISS II sensor, Geocoded data on 1:50,000 scales of September/October of 1993 have been used. During this process interpretation was tested and rectified where ever necessary along with maximum ground truth and the ground information like elevation. Interpretation key was finalized on the basis of tone, texture Physiographic,

altitude, type and vegetation association and with agreed classification; all thematic details have then been transferred to base map.

To meet the study objectives the classification scheme was designed. In higher Himalayas (GHNPCA), elevation has impact on the vegetation. The upper and lower temperate broadleaf forests have been merged together while temperate and alpine grasslands have been put together. However, with the help of contours these were separated in GIS domain. > 40% canopy cover has been delineated as closed forests and < 40% as open forest. Keeping in mind the requirement of wildlife habitats for future planning non-forest land cover has also been delineated. As per the classification scheme interpretation of satellite was finalized with the help of image elements like, tone, texture, association, location etc., and the ground features whereas the shadow areas were checked with ground verifications and appropriate rectification was performed accordingly. The final vegetation map was prepared on 1:50,000 scale. Overall 11 non-forest and 11 forest types were delineated.

3. Results and Discussion

Broad forest classes have been mapped in *e.g.* broadleaved forests of temperate zone, subtropical and temperate riverine forest were mapped together. Using elevation as the criteria these types can be broadly separated in GIS domain, consideration of elevation as important parameter as the vegetation changes with change in altitude. Grasslands are the most important as far as wildlife conservation and management is concern. They have also been treated as part of forest as these and are locally known as 'Thatch' or forest blanks. Total estimated area using GIS is about 1171 km^2. Northern aspects with higher moisture contents resulting rich unique flora. The general Landuse/cover map of the GHNP conservation is shown in Figure 1 with aerial estimation given in Table 1.

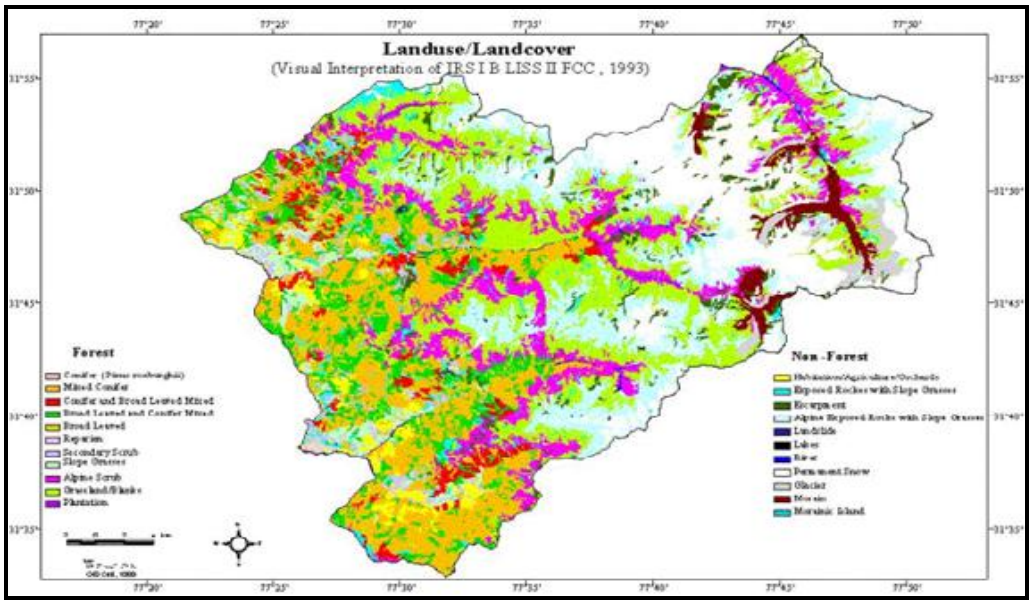

Figure 1: *Landuse/Cover Map, Great Himalayan National Park Conservation Area*

Table 1: *Aerial Estimation of Landuse/cover Categories in Great Himalayan National Park Conservation Area*

S.N.	Type	Area in Km^2
	Forest	
1	Conifer (*Pinus roxburghii*)	2.08
2	Mixed conifer	127.98
3	Conifer and Broad Leaved Mixed	33.16
4	Broad Leaved	66.62
5	Broad Leaved and Conifer Mixed	83.36
6	Riperian	0.14
7	Slope Grasses	25.92
8	Grasslands/ Blanks (Temp. sub Alpine & Alpine)	221.80
9	Secondary Scrub	22.28
10	Alpine Scrub	117.62
11	Plantation	0.16
	Non Forest	
1	Habitation/Agriculture/Orchards	25.55
2	Exp. Rocks with Slope Grasses	27.60
3	Alpine Exp. Rocks with Slope Grasses	149.73
4	River	4.35
5	Lakes	0.87
6	Escarpments	33.82
7	Landslide	0.41
8	Snow	184.01
9	Morian	24.24
10	Morainic Islands	0.48
11	Glaciers	18.82
	Total	1171.00

Basically the data has been visually interpreted with 11 forest and 11 non forest classes but as per the species preferences (*Western Tragopan* and Himalayan *Musk Deer*), the specific forest types and grasslands have also been extracted. The logical knowledge based approach has been applied in grid module with the help of climatic zoning through GIS domain using ARC/INFO software. The basis of extraction was on altitudinal variations as shown in Figure 2.

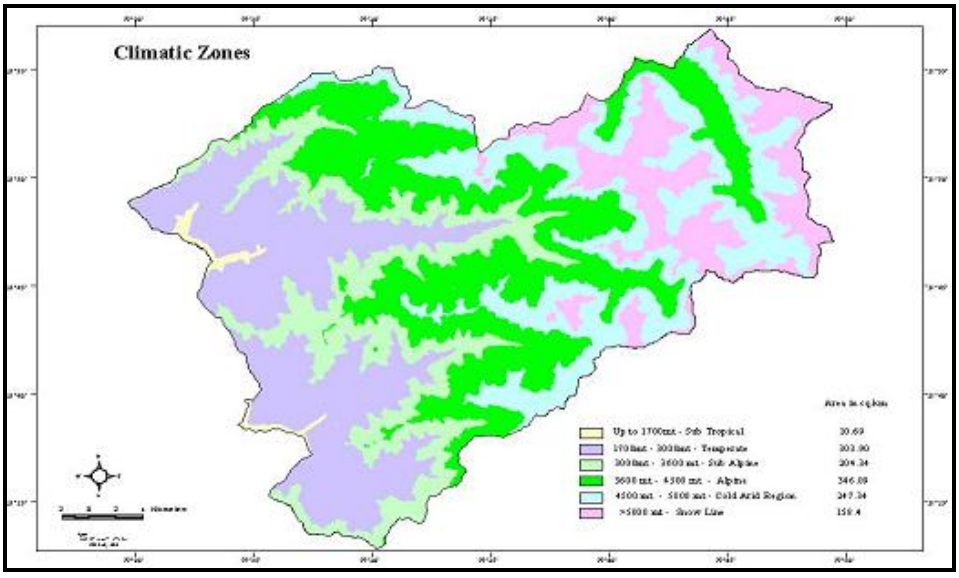

Figure 2: *Climatic Zones on the Basis of Elevations (Champion and Seth, 1968)*

The general types of Broad-leaved forest and Grasslands have been extracted into sub-tropical to sub-alpine broad-leaved forest and sub-tropical to alpine grassland respectively. On the basis of users choice this approach can be applied for extracting the different categories as per the different objectives (14 forest and 11 non-forest classes). The landuse/cover map along with extracted classes through GIS can be seen through Figure 3 and Table 2.

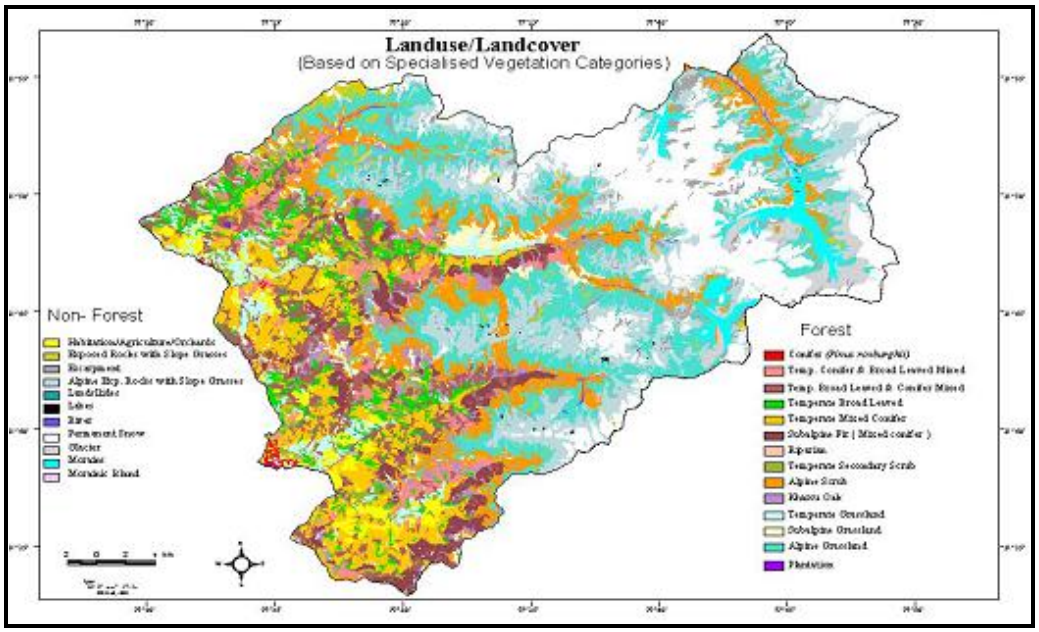

Figure 3: *Specialized vegetation Categories, Great Himalayan National Park Conservation Area*

Table 2: *Aerial Estimation of Vegetation Map Defining Additional Classes on the basis of Climatic Zoning*

S.N.	Class	Area in km^2	Percentage
1	Pinus Roxburghi	2.1	0.18
2	Temperate Mixed Conifer	82.39	7.04
3	Subalpine Fir	39.11	3.34
4	Temp. Conifer and Broad Leaved Mix	33.21	2.84
5	Temp. Broad Leaved and Conifer Mixed	83.44	7.13
6	Temp. Broad Leaved Forest	42.95	3.67
7	Kharsu Forest	23.7	2.02
8	Temp Grassland	31.7	2.71
9	Subalpine Grassland	22.25	1.90
10	Alpine Grassland	193.89	16.56
11	Riparian	0.14	0.01
12	Temp. Secondary Scrub	22.26	1.90
13	Alpine Scrub	117.71	10.05
14	Plantation	0.16	0.01
	Non Forest		
1	Habitation/Orchard Agriculture	25.53	2.18
2	Escarpments	33.69	2.88
3	Exposed Rocks with Slope Grasses	27.54	2.36
4	Alpine Exposed Rocks with Slope Grasses	149.89	12.80
5	Land Slides	0.42	0.04
6	River	10.78	0.92
7	Morrain	24.25	2.07
8	Lakes	0.86	0.07

9	Moranic Island	0.48	0.04
10	Glacier	18.68	1.58
11	Snow	183.87	15.70
	Total Area	1171.00	100.00

The delineation of specialized category with the help of contours particularly relevant in the spatial delimitation of subalpine forests, which is an ecotone between alpine grasslands and temperate forests. It also reveals the trends of climatic changes; this ecotone is valued as a unique habitat for representative, specialized, and sensitive elements, including distinct biological assemblages, native and endemic floral and faunal species, and richness of economically important species (Rawal and Dhar, 1997; Dhar, 2000). Subedi (2009) studied that under continuing climate change, tree species in these forests will be affected in different ways, and ranges will adjust at different rates and by different processes. Species have limited scope to move further in transition zones between the subalpine and alpine zones and are especially vulnerable to climate change (ICIMOD 2010).

Subtropical forests of Chir Pine (*Pinus roxburghii*) cover about 0.18% in Eco-development zone of the total area. Understory flora is less and is subjected to frequent fires and biotic pressure. Chir Pine forest occurs around Rolla, Sainj and Nevli villages. Temperate Mixed Conifer, Temperate Conifer Mixed with Broad Leaved and Temperate Broadleaf Mixed with Conifer Forests occupy majority of the forested land about 17.01% of the total area. Oaks are predominant species of these forests along with *Acer* sp. *Juglens regia, Rhododendron* sp. etc. Very good high density forests grow in the moist slopes (northern aspects) with rich understory and herbaceous plants with scattered *Taxus wallichiana*.

In complex terrain between subtropical and alpine areas the mixing of broadleaf and coniferous forests has been observed. Because of high moisture contents narrow gorges and valleys are supporting broadleaf forests whereas in drier regions coniferous forests are confined. 7% of the total forested areas are of this kind of forests. Broadleaf species like *Juglens regia, Prunus cornuta, Quercus semicarpifolia, Acer* sp., *Aesculus indica,* etc. and coniferous species like *Abies pindrew, Cedrus deodara, Picea smithiana, Pinus wallichii,* etc.

Alpine Grassland i.e. about 193.89 Km^2 is also dominating followed by Temperate Broad Leaved and Conifer Mixed is 83.44 Km^2 and Temperate Mixed Conifer is 82.39 Km^2; high biotic pressures (grazing). Scattered trees of *Picea smithiana* and *Pinus wallichii* with pure patches of *Cedrus deodara* were also near the area. These mixed forests have other species also like; *Taxus wallichiana* along with varying inter-mixing of broadleaf species as well. The pure patches of *Cedrus deoadara* and *Pinus wallichii* were also observed in Rolla-Shilt area with scattered *Taxus wallichiana.* Between Shilt to Rukhundi villages the patches of bamboo species with rich ground flora along with Lichens were also observed. Varying degree of species like, *Abies pindrew, taxus buccata, Quercus semecarpifolia, Acer acuinatum, Betula alnoides, Celtis sp.* are also observed.

In the subtropical and lower-temperate zones along with valleys covering an area about 1.90% dominated by secondary scrub and is associated with human activities. Between Nevli to Tung village the extensive scrub of *Berberis aristata* is spread on the southern slope. The villages like; Chipni, Galiyar, Bathad and Mashiyar were full of *Lonicera* sp. and *Indigofera* sp. (scrub vegetation) on the bunds and abandoned agricultural fields.

Between temperate forest and alpine vegetation the Alpine scrub (10.05%) was observed as transition. The dominant species are *Rhododendron companulatum and Betula utilis* as pure scrucb patches of *Betula utilis* around Rukhundi top and on northern aspects near Basleo pass. Dhela Thatch and Gumtarao area were observed with extensive growth of *Rhododendron companulatum* and *Betula-Rhododendron* scrub respectively.

Slope grasses mainly on the southern slope aspects have been observed around Baha in Sainj Valley and in Palachan Gad above Chipni village. In association with non-graminaceous plants, tall grasses like *Themeda triandra, Vitiveria ziznoides* etc. grow in the slopes and resting sites for shepherds are grasslands ('thatch'); mainly associated with ridges and peaks with a mixture of herbaceous plants and grasses like *Agrostis pilosila, Chrysopogon echinulatus, Themeda triandra, Andropogon* sp., *Oplismensus compositius and Paspalum* etc.

Subtropical and temperate zone villages and riverbeds were witnessed with Riverine forest in and around Rupa nala, Palachan gad, Dhela khad. Because of the shadow and very narrow belts along streams the mapping of these areas found difficult. The dominant subtropical Riverine species were observed; *Alnus nepalensis* and *Alnus nitida* as along with *Prunus* sp., *Pyrus* sp., *Girardinia* sp. and *Berberis* sp. *Hippophae;* the Temperate Riverine scrub were found before and after Shakti village. These grow along streams gregariously on raised riverbeds. The main species are *Rosa webbiana, Hippophae salicifolia and Sorberia tomentosa*. Viburnum sp. scrub was also marked during mapping between Shakti and Maror village.

Plantation forms only 0.01% of the area. Old plantation of *Pinus wallichiana* is in Jiva nala in Eco-development zone. About 40% of the total area is having less vegetation i.e. Exposed rocks (about 2.5%), Escarpments (2.88%), Alpine exposed rocks with slope grasses (12.80%), Moraine islands (0.04%), Glaciers (1.6%), Moraine (2%), Permanent Snow (15.7%) and Lakes (0.074%) etc., are important habitats for wildlife for fodder, shelter and breeding grounds.

4. Conclusion

Baseline information for vegetation cover i.e. 60% areas is under forests whereas non-forest area cover about 40% are equally important; a habitat of many species including endangered species whereas lakes are also the best sites for many wildlife including migratory avifauna. The information generated through vegetation mapping is valuable for park authorities and seems to be useful for monitoring, decision making and management and will also assist the wildlife managers in conservation of protected areas and their habitats.

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