GEOMORPHOLOGICAL MAPPING FOR CONSERVATION USING GEOINFORMATICS

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Abstract

Geomorphology deals with surface features of the earth, their forms, origin and development. The increasing application of geomorphic interpretation through aerial photographs and satellite data facilitates the understanding of the relationship between landforms, habitat and planning processes. The study was conducted in Great Himalayan National Park Conservation Area (GHNPCA, 1,171 km^2) in Himachal Pradesh.

Mapping of major units were done by using satellite imageries (FCC of IRS 1-B LISS II Sept/Oct 1993, scale 1:50,000). Geomorphological mapping of the area was the main aim to understand the habitat and its relation with impact on management and conservation schemes. Nine categories have been delineated taking into account the topographical features also. Area under different categories has been determined- the total length of the major water divides and prominent facets calculated about 723.08 km^2.). Aerial estimation of escarpments was about 33.82 km^2 (3%). Exposed Rocks (2%), Alpine Exposed Rocks (13%), Escarpment (3%), Glacier (2%) and Moraines cover about 2% area. Besides that other topographical features have also been generated like; slope aspect, contour, drainage density, terrain complexity and digital elevation model.

The geomorphology is one of the important disciplines because various landforms are the result of intersecting causes. Their significance is related to conservation efforts. This will not only help to understand the distribution of species but also to understand any development plan in hilly terrain. The landslides and poor constructions have a negative impact because of their destructive nature. It is reflected through study that for hill development or landscape planning, geomorphology and its mapping should be on priority for proper understanding of management planning, species distribution, habitat suitability; protected area management as far as overall conservation is concern.

Key words:- *Habitat suitability, Conservation, Species distribution, Geomorphology and Geo-informatics*

INTRODUCTION

The discipline, deals with features of the globe, their origin, forms, their nature and development are termed as geomorphology by Davis, W.M. (1912). The roles of factors that are important to understand the geomorphology are lithology, stratigraphy, climatic variation and the regional basis for the development of landforms. The geomorphology is primarily concerned with present day landscape. As far as the Himalaya is concerned, its evolution was from middle Miocene to Recent. Himalayas are still active and taking shape in the form of disasters in many ways, that is why landforms are dynamic in nature with many climatic factors influencing them.

The human factor includes indiscriminate deforestation and unorganized planning (Singh *et al* 1994 & Naithani 2008). The increasing application of geomorphic interpretation through aerial photographs and satellite data facilitates the understanding of the relationship between landforms, Habitat and planning processes. The combination of landscape elements along with hydrology can be defined as habitat. It is a place, which supports food, cover, space for animals. The use of vegetation and geomorphology for habitat analysis is already practice in India (Roy *et al* 1986). Several studies and information gathered on altitude, aspect, slope, escape terrain have been worked out but not really emphasized the other landform features of landscapes which are equally important as far as developmental planning processes, landscape management and wildlife conservation is

concern. The various landforms can influence a habitat, conservation and developmental work in many ways like sloping gradient, elevation and aspect, altitude and water-divide affecting the quantity of solar energy, water, nutrients and other materials, while the slopes affect the flow of materials. Slope is also the deciding factor of intensity of disturbance, such as fire and wind, which are strongly influenced by the presence of vegetation (Swanson *et al* 1988). A number of workers have made an attempt to resolve the geological and geo-morphological complexity of the country and abroad using aerial photo's and satellite data, mainly are Gugan and Dowman (1988), Davis *et al*, (1989), Falcidieno and Spagnuols (1990), Tripathi, *et al* (1996) and Rao et al (1996). Specific objective for this study was geo-morphological mapping being an element of landscape governs the suitability of habitat parameter affecting developmental activities normal livelihood and off curse the distribution of species.

STUDY AREA:

Comprise of four management entities viz. Great Himalayan National Park (GHNP) about 754.40 km^2; Sainj Wildlife Sanctuary (90 km^2); Tirthan Wildlife Sanctuary (61 km^2) and Eco-development Area (265.60 km^2). GHNP, located in Kullu district of Himachal Pradesh (31^0 33' 00'' – 31^0 56' 56'' N and 77^0 17' 15''- 77^0 52' 05'' E). The major tributaries of Beas river *viz.* Tirthan, Sainj, Jiwa and Parvati. Basically the Himalayan soils are *in situ* in nature and belong to Podsolic group. Broadly, three season can be recognised for the GHNPCA *viz*. Summer (April to June), Rainy (July to September) and Winter (October to March). Depicted in Fig.1.

Fig.1.

The study area lies in Inner Himalayas in GHNP, Kullu district, Himachal Pradesh. The work was referred by many workers including Mishra (1993), who broadly emphasised the deformational set up as a result of different tectonic phases in Sutluj and Beas valleys. The major rock types in the area are quartzite, phyllite, slate, schist and gneiss along with granite.

These rocks have been folded, faulted and thrusted as consequences of different tectonic episodes Fig.2.

The GHNP has about 60% of its geographical area under forest cover (Naithani, 2001). Based on the physiognomy; Temperate to Alpine forest types can be recognised in the study area. The fauna of the park comprises 31 species of mammals Vinod and Sathyakumar (1999), 183 species of birds Ramesh *et al.* (1999). The mammals; Musk Deer (*Moschus chrysogaster*) and pheasant; Western Tragopan (*Tragopan melanocephalus*) are important endangered species in the conservation area.

METHODOLOGY: Geomorphological mapping- The geomorphologic map of entire project area has been prepared mainly through IRS IB LISS II 1993-94 satellite data on 1:50,000 scale. Some physiographic details were transferred from toposheets (waterdivide/spurs) to the base map along with the interpreted units through satellite data.

Data Used: Satellite data of IRS-113 LISS II FCC 2,3,4, Geo-coded hardcopy of September/October 1993, Ancillary data; secondary and other collateral data used in the study are as follow: Survey of India topographical maps No. 53 E/5, 53 E/6, 53 E/9, 53 E/10, 53 E/13, and 53 E/14 and Base map.

GIS Database: Using ARC/INFO UNIX based GIS, several other information were generated like; Digitization of thematic layers and labeling/attribute assignments and Analysis of area calculations for management zones using GIS.

RESULTS

Geomorphology:

Nine (9) major geomorphic units and seven (7) topographic Layers were delineated and generated respectively. The maximum area was covered by alpine exposed rock, which was about 149.73 sq.km. The minimum area was covered by morainic islands in the eastern part of the study area, which was full of glacial forms. The map is given in Fig.2.

Fig.2.
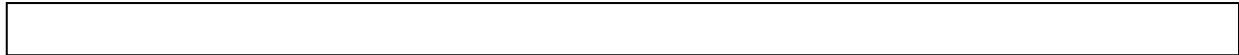
Geomorphic Units

Exposed Rocks: These rocks were well distributed in all the valleys. The rocks are well exposed in the middle portion of the park and are maximum in lower altitude zones of the study area. They cover an area about 27.60 km^2 (2%).

Alpine Exposed Rocks: The area above 3600m to 4500m, where slope factor and mass movement was rapid was considered alpine exposed rock. The rocks were well exposed in the higher elevations up to the last limit of the park. The area was estimated to be about 149.73 km^2 (13%).

Landslides: Landslides are the results of slope failure, may be natural (tectonic sensitivity, gravitation, seismic) or man-made (road construction, grazing, blasting, tree felling and mining). In the study area the existing landslides were mostly natural, occurring frequently in the study area especially in the rainy season. The aerial estimation of landslides was about 0.41 km^2 (.03%).

Glacier: The glaciers are the huge solid ice mass moving or retreating along the valley floor. The glaciations of the valleys have considerably modified the original topography, which has been sculptured by subsequent fluvial action. The glaciers, moraines and fluvoglacial deposits generally occur in this zone. The aerial estimation of glaciers was about 18.82 km^2 (2%).

Lakes: In the study area almost all the Lakes might have formed due to glacial erosion. More than 25 lakes were observed from the study area lying in the higher elevations through visual interpretation. The aerial estimation of all these lakes was about 0.87 km^2 (.07%).

Escarpments: Very steep faces of the rocks and particularly consolidated sediments are given such names as cliffs, scarps, escarpments, precipices etc. They usually occur on cohesive and resistant rocks with sharp crested ridges. The total aerial estimation of escarpments in the study area was about 33.82 km^2 (3%). The aerial estimation of escarpments mentioned earlier is based on visual interpretation of IRS IB LISS II FCC

1993. The layer of escarpments were also digitized through Survey of India (SOI) toposheets and the area of the map calculate through GIS was 43.22 km^2. The percentage difference between two areas was about 12.20%.

Moraine: Ridges and irregular deposits laid down by ice are termed as moraines. Some are associated with valley glaciers and others with ice sheets. Valley glaciers make lateral, medial, terminal and recessional moraines. The interpreted moraines may be primarily lateral or medial moraines. The aerial estimation of moraine was about 24.24 km^2 (2%).

Morainic Islands: Morainic Islands are infact-uplifted debris above the valley floor, carried out by the glacier. When the glacier melts it leaves a large part of debris in the valley. The aerial estimation of these forms was about 0.48 km^2 (0.04%).

Waterdivide/ Spurs: In the Himalayas major ridges and valley floor impede fire movement. This is an important aspect as far as the management of grasslands is concerned. It is noticeable the alpine grassland are distributed about 38% of the total vegetation in the conservation area. Besides that there are several other facets, which form important parts of study area. The total length of the major water divides and prominent facets calculated using GIS, was about 723.08 km^2.).

TOPOGRAPHIC LAYERS:

Besides geo-morphological map some other basic inputs through SOI toposheets were produced in GIS domain with the help of contours and drainages.

Drainage Density (DD): The water availability in any area is an important factor for the Mitigation Planning and off course for survival of any species. The study area seems to be homogeneous, but for precise analysis the drainage density was also prepared and determined with following formula-   Total no. of stream

Total area

Drainage Density was classified into four categories i.e. low, moderate, high and very high (Fig.6).

Contour: Relief is represented on the topographic maps by the contour lines. The altitude in the study area varies from 1344m minimum near Seund to maximum of 6248m at a peak in the east of the study area. The contours are not only the representative of elevations but

also the main source of depicting slope, aspect and DEM for any developmental planning with mitigative measures. The contour interval or 120m was considered because minimum mapable unit (one hectare) was taken into consideration.

Aspect: The aspect map was derived initially from contours (line coverage) to slope categories and than grid image. The map was generated according to slope angles in eight different directions. Though the aspect categories were decided according to species Himalayan Musk Deer (*Moschus crysogaster*) and Western Tragopan (*Tragopan malanocephalus*) preferences based on the sighting data, (K. Ramesh *et al* 1999 and Vinod *et al* 1999) but aspects are equally important for any long term planning process.

The maximum area was 237.1 km^2 found in North direction whereas the minimum area 119.4 km^2 lies in the East direction. The aspects according to slope angles in different eight directions is given in Table 1.

Table 1. ASPECTS ACCORDING TO SLOPE ANGLES AND AERIAL ESTIMATION

Slope: Slope map was derived from the contour map according to species (Musk Deer and Western Tragopan) preferences. The slope and aspect map was further used for habitat analysis. The aerial estimation is given in Table 2.

Table 2.   SLOPE CATEGORIES

Shape: Shape may consist of several elements i.e. concave, convex, straight and complex. For the characterization of topographic surfaces the methods given by Falcidieno and Spagnuolo, 1991 was used. The shape was generated through Digital Elevation Model (DEM) and categorized into three categories i.e. convex, concave and flat. The aerial estimation for the shape of study area is given in Table 3.

Table No. 3.   AERIAL ESTIMATION OF THE SHAPE

Terrain Complexity: The terrain can be expressed in the form of slope, shape but it can also be expressed as low, medium and high complexities. It was measured in GIS domain through DEM with 120 mt. of contour interval. The drainage and cliffs were also considered for better results. The whole idea was to capture maximum variability. The raster layer was considered for computation grid cell based variance for the entire spatial coverage. The aerial estimation is given in Table 4.

Table No. 4.   AERIAL ESTIMATION OF TERRAIN COMPLEXITY

Digital Elevation Model (DEM): To generate a DEM, a 120m contour interval was used after considering minimum mapable unit i.e. one hectare. Topogrid module a hydro logically correct grid of elevation from line and polygon coverages was generated. In this, contour data was used to generate a generalized morphology of the surface based on the curvature of the contours and also used as a source of elevation information. Stream data was used because they are powerful ways of adding additional topographic information to the interpolation, further ensuring the quality of the output DEM by Manual, GIS (ESRI, 1994).

DISCUSSION

Much of the observations (Geomorphic units) in this study are based on visual interpretation with convergence of evidences. It also includes the opinions of experts. In the park the exposed rocks may be a result of changing topography (Himalaya is tectonically sensitive) and may be because of mass movements from the area because of slope effect. They are in fact good habitat for prey and predator species.

Movement of ice in the past, which greatly steepened the valley walls, also formed escarpments. The difference in visually interpreted and digitized escarpment through Survey of India toposheets reflects the sensitivity of the area, which further indicates the loss of vegetation, wildlife, and on the contrary the escape terrain used by wildlife. So these areas may be the ecological sensitive areas. These areas are usually affected by annual rainfall, avalanches and manmade activities like construction, overgrazing and over tree felling. In view of this, the above geomorphic features need to be monitored on regular basis in order to evaluate their susceptibility. This study should be undertaken at micro watershed label preferably at cadastral level or 1:12,500 scale.

The water divides and spurs distinguish the major and minor watersheds. In general It was observed that southern slopes are warmer then northern parts, which may also influence the intensity of disturbances because of different slope conditions. The water divides and spurs usually act as firebreaks / fire lines at any site. Hemstrom (1982) in Pacific North- West USA has also reported, that major ridges and valley bottoms impede fire movements. It is noticeable that the length of water divide can play an important role for any hill station, developmental planning or even for protected areas.

In the study area grasslands was observed to be maximum (37.76%) of the total vegetative cover (excluding habitation/agriculture/orchards). This shows the grasslands covering large portion in the study area specially Alpine grasslands (17%). In the Himalaya this distribution is mainly govern by the altitude and gradient It means the grazing land/ pastures would be affected most if any change occurs in landscape topography due to of avalanches, natural phenomena or even by manmade interventions. This will lead to more disaster incidences and habitat loss.

It was observed by Dyson (1962), that a valley glacier may be a single ice stream or it may consist of a main stream and several tributaries similar to a river system. In the study area the modified landforms were; glacial lakes, moraines, U shaped valleys,

hanging valleys etc. U shaped and hanging valleys were observed. All these features were vary well developed in all the valleys of National Park.

The glacial lakes were also interpreted especially at higher reaches. Rounded to sub rounded topography depict the presence of glaciations in the past. Few lakes seem to originate by the moraine dammed basins (product of glacial retreat) (Campbell, 1914), are swampy depressions within the ground moraines. These may be the suitable areas for the migratory birds. This particular phenomena applies on all Himalayan belt, unfortunately very little information is available regarding the hydrology of such lakes. In many countries, glacial lake out bursts leading to down valley floods has been reported. It is therefore, essential that such lakes should be mapped and monitored. Viewing the inaccessibility of the terrain, the satellite remote sensing data can be of great help in this regard (Naithani, 2008).

CONCLUSION

For integrated studies geomorphology can be treated as one of the parameters, because various landforms are the result of intersecting causes. There are no doubts with changing scenario not only the human being but also the wildlife species make use of several change habitats.

Over the years due to large-scale natural resource exploitation majority of the watersheds become vulnerable towards landslides. As far as development, planning implementation and conservation is concerned; the landslides and poor constructions have a negative impact because of their destructive nature.

It is reflected through study that for conservation planning or landscape management it is a imperative to study the geomorphology and its mapping for proper understanding of landforms and their relation to species distribution and diversity, habitat suitability for better protected area management and wildlife conservation.

ACKNOWLEDGEMENT

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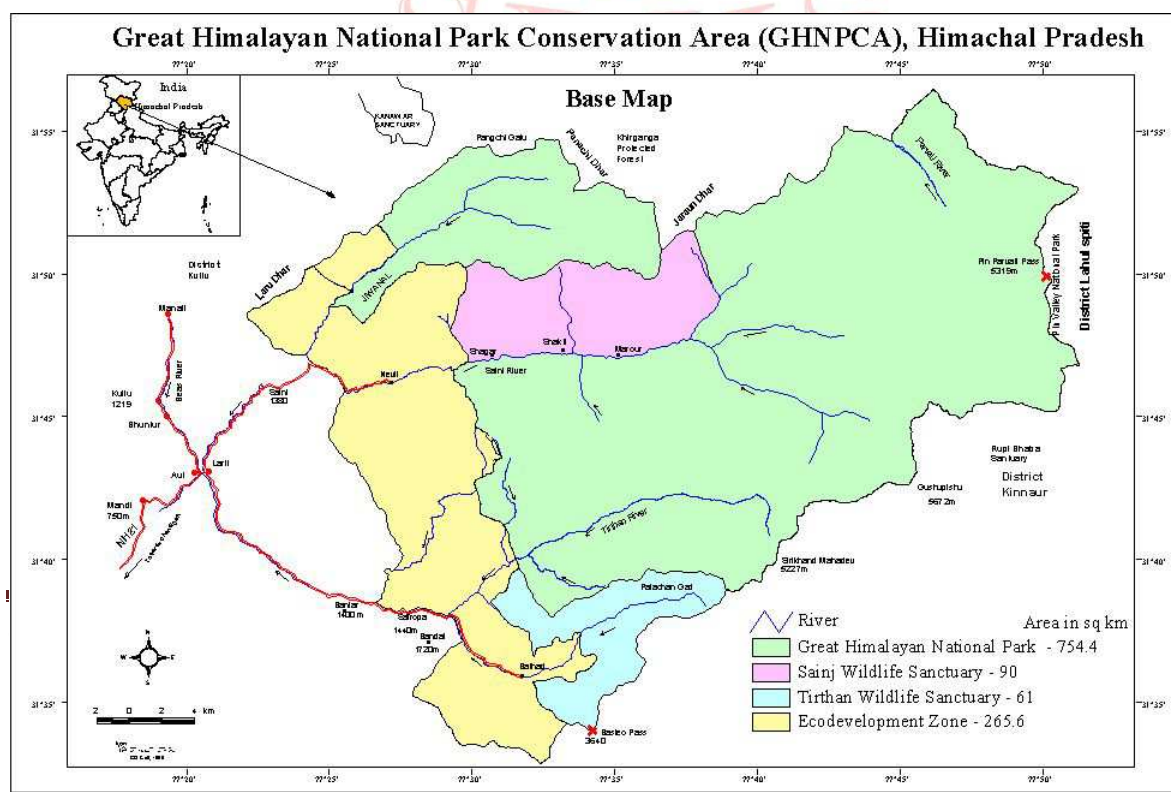
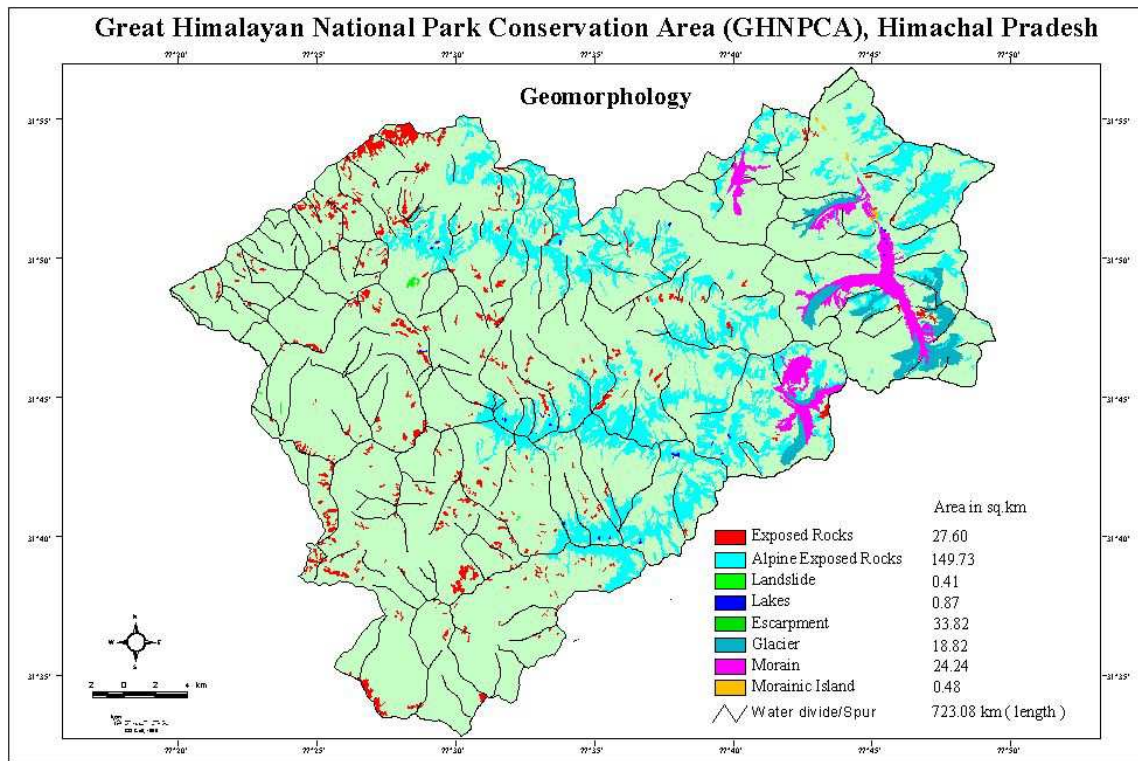Great Himalayan National Park Conservation Area (GHNPCA), Himachal Pradesh

Fig.1

Fig.2

Table 1. ASPECTS ACCORDING TO SLOPE ANGLES AND AERIAL ESTIMATION

Angle in Degrees	Directions	Area in km^2	Percentage
0-40	N	237.1	20
40-80	NE	125.2	11
80-120	E	119.4	10
120-160	SE	127.6	11
160-200	S	138.9	12
200-240	SW	151.7	13
240-280	W	141	12
280-320	NW	130.1	11

Table 2.   SLOPE CATEGORIES

In degrees		AREAL ESTIMATION OF SLOPES	
	Category	Area in km^2	Percentage
0-20	Low	221	19
21-50	Moderate	623	53
51-70	High	187	16
71-90	Very High	140	12
	Total	1171	100

Table No. 3.   *AERIAL ESTIMATION OF THE SHAPE*

Shape	Area In km^2	Percentage
Flat	0.04	0.003
Concave	604.61	51.63
Convex	566.35	48.36
Total	1171	100

Table No. 4.   *AERIAL ESTIMATION OF TERRAIN COMPLEXITY*

Class	Area In km^2	Percentage
Less complex	565	48.24
Moderately complex	414.46	35.40

Highly complex	182.54	15.60
Total	1171	100