FREEP-GHNP 02/06

Assessment of Floral and Habitat Diversity, and Collection of Baseline data to Monitor Vegetation of GHNP Conservation Area

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CONTENTS

		Page
Acknowledgements		i
Executive Summary		ii
List of Plates		iv
List of Figures		v
CHAPTER 1 : GENERAL		**1**
1.1	General Introduction	1
1.2.	Study Area Location	3
1.3.	Climate	4
1.4.	Topography	4
1.5.	Terms of Reference	4
CHAPTER 2 TASK 3(A) : MAP MAJOR VEGETATION COMMUNITIES		**5**
2.1.	Introduction	5
2.2.	Vegetation types in the study area	5
	2.2.1. Sub-tropical Pine Forest	6
	2.2.2. Temperate Moist Deciduous Forests	6
	2.2.3. Temperate Broadleaf-conifer mixed Forests	6
	2.2.4. Temperate Coniferous mixed Forests	6
	2.2.5. Temperate Broadleaf (Evergreen) Forest	7
	2.2.6. Himalayan Temperate Secondary scrub	7
	2.2.7. Birch-Rhododendron Scrub	7
	2.2.8. Alpine scrub	7
	2.2.9. Temperate grasslands	8
	2.2.10 Alpine Pastures	8
2.3.	Approach	8
2.4.	Vegetation Mapping	8
2.5.	Material and methods	9
	2.5.1. Materials	9
	2.5.1.1. Satellite Data	9
	2.5.1.2. Ancillary Data	9
	2.5.2. Methodology	9
	2.5.2.1. Base Map Preparation	10

2.5.2.2. Reconnaissance Survey 10
2.5.2.3. Ground Truth data Collection 10
2.5.2.4. Vegetation Mapping 11
2.5.2.5. Ground Check 11
2.5.2.6. Classification scheme 11
2.5.2.7. Final Interpretation 12
2.6. Results and Discussion 13
2.6.1. Mapping 13
2.6.2. Area Analysis 14
2.6.3. Discussion 18
2.7. Conclusion 21

3. CHAPTER 3 TASK 3(B) : PLANT COMMUNITY COMPOSITION AND STRUCTURE USING REMOTE SENSING 22
3.1. Introduction 22
3.2. Objectives 23
3.3. Approach 23
3.4. Materials used 23
3.5. Methodology 23
3.5.1. Information Collected 24
3.5.2 Laying of Sample plots 25
3.6. Results and Discussion 25
(a) Chir Pine Forest 25
(b) Broadleaf forest 26
(c) Broadleaf Mixed with Conifers Forests 28
(d) Mixed Conifer 29
(e) Conifers Mixed with Broadleaf Forest 30
(f) Secondary Scrub 31
(g) Subtropical Riverain Forest 32
(h) Temperate Riverain Forest 32
(i) Birch-Rhododendron Scrub Forest 34
(j) Alpine Scrub 34
(k) Slope Grasslands 35
(l) Grasslands /Blanks/Alpine Pastures 35
(m) Habitation /Agriculture/ /Orchard 35

CHAPTER 4 TASK 3(C) : ESTABLISHMENT OF RECORD OF MAPS **36**

4.1. Introduction 36

4.2. Map Records 36

4.2.1. Base map 36

4.2.2. Management zone map 36

4.2.3. Communication map 37

4.2.4. Settlement/Agriculture map 37

4.2.5. Drainage map 37

4.2.6. Contour map 37

4.2.7. Vegetation Map 37

5. REFERENCES **38**

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EXECUTIVE SUMMARY

1. Land Cover and Land Use mapping of the Great Himalayan National Park Conservation Area which is a part of Kullu District has been done on 1:50,000 using remotely sensed data of IRS 1B satellite. Six Geocoded satellite data sets of September/October of 1993 have been used. The total area of study is 1171 km^2. The area two main (Sainj and Tirthan) valleys and two smaller (Jiwnal and Palachan Gad). The Conservation area has four management zones.

2. Vegetation is the most important component of forest and wildlife management and baseline information on these inn the form of maps is basic requirement. Mapping has been done through visual interpretation of satellite data using standard method of interpretation. Reconnaissance survey was taken up to familiarize with study and prepare interpretation. Detailed ground truth was collected subsequently in Tirthan and Sainj valleys and Jiwa nala and Palachan Gad for visual interpretation and finalizing the interpretation key. Mapping was achieved after incorporating the information about the shadowed areas. A total of 22 classes, 11 in forested area including grasses and 11 in non-forested classes have been mapped. The classification scheme has been followed to suit the FREEP-GHNP Project requirement. Area analysis has been carried out and presented in the table. Good quality forest occurs in upper parts Tirthan and Sainj valleys. Photos of various vegetation type occurring in the area are also provided.

3. Grasslands (18.941%) form the highest cover in the area. Since most of the area is in temperate zones this region has both broadleaf and conifer formations along with mixed formation. Mixed conifers have about 10.929% of the area, which is the highest among forested area. Next highest is the Alpine Scrub (10.044%) followed by Broadleaf mixed with conifer (7.119%). Broadleaf (Ban & Kharsu Oak) occur in large patches on higher reaches and form about 5.689% of the area. Conifer mixed with broadleaf (2.83%) are less in area. Slope Grasses (2.213%) and Secondary Scrub (1.902%) occur in scattered patches. Riverain (0.011%) forest found in riverbed are less. Interesting formations of Hippophae and Viburnum are found around Shakti and on way from Shakti to Maror.

4. Structure analysis of communities has been done using stratified random sampling and depicting it graphically in the form of profile diagrams. Different storeys of vegetation have been studied and depicted graphically. Dominant, co-dominant and ground flora have

been noted and presented in the report. For species enumeration 20 x 20 m plots in forested areas, 10x10 m for shrubby vegetation and 1x1 m in grasslands have been laid and information on species (trees, shrubs, herbs, climbers etc.), location, slope, evidence of biotic pressure, soil, circumference at breast height, phenological stage etc. have been recorded in the field. A total of 66 sample plots were laid in the field. Forest type-wise species occurring in upper, lower and ground stratum have been identified and provided in the tables. Profile diagrams are also indicate the species found in different layers.

5. One of the objectives of the project has been to generate baseline information for future planning and management. Other than vegetation maps showing distribution of forest and other land uses, the other basic information on spatial extent of the Conservation area, different management zones, drainage, communication like road network, human settlement and location of permanent agricultural areas etc. has been generated in the form of maps on 1:50,000 scale. Area under different management zones is GHNP (765 km^2), Sainj Wildlife Sanctuary (900 km^2), Tirthan Wildlife Sanctuary (610 km^2) and Ecodevelopment Area (255 km^2). There are about 141 villages in buffer zone of the Conservation area.

LIST OF PLATES

Plate 1: Subtropical Conifer Forest (*Pinus Roxiburghii*) near Sai Ropa
Plate 2: Temperate Broadleaf Forest Near Rolla
Plate 3: Subtropical Riverain Forest on way from Nevli to Shakti
Plate 4: Broadleaf mixed with Conifer Forest near Rolla
Plate 5: Mixed Conifer Forest near Shilt
Plate 6: Conifer Mixed With Broadleaf Forest around Shangarh
Plate 7: Broadleaf Forest of Kharsu Oak above Shilt
Plate 8: Secondary Scrub on way from Nevli to Tung
Plate 9: Temperate Riverine Near Shakti
Plate 10: Betula-Rhododendron Scrub near Basleo Pass
Plate 11: Rhododendron Scrub near Rhukhundi Top
Plate 12: Temperate Grassland near Shakti
Plate 13: Temperate Grassland
Plate 14: Alpine Grasslands near Basleo Pass
Plate 15: Sub-Alpine Grasses on Steep slopes near Gumtrao
Plate 16: Land Cover/Land Use map of Conservation Area
Plate 17: Agriculture/Orchard near Tung

LIST OF FIGURES

Fig. 1 Subtropical Chirpine Forest near Dewri village

Fig. 2 Broadleaf forest (Moist temperate deciduous forest between)

Fig. 3 Kharsu Oak Forest near Shilt

Fig. 4 Broadleaf Mixed ConiferousForest near Rolla

Fig. 5 Temperate Conifer Mixed near Shilt

Fig. 6 Temperate Conifer Mixed with Broad leaf near Galiyar

Fig. 7 Deodar (*Cedrus deodara*) forest near Shangad

Fig. 8 Himalayan temperate Scrub

Fig. 9 Subtropical riverain forest near Ghusaini

Fig. 10 Betula Forest near Basleo Pass

Fig. 11 Betula-Rhododendron Scrub after Rukhundi top towards Gumtrao

Fig. 12 Alpine Scrub and Alpine Grassland near Gumtrao

Fig. 13 Temperate Grasslands Hill around Chipni

Fig. 14 Orchard near Tilhara Village,Tung

Fig. 15 Showing Base Map, Management Zone and main drainage

Fig 16 Communication Map of GHNP Conservation area

Fig. 17 Settlement Map (Ecodevelopment Zone)

Fig. 18 Drainage map of GHNP Conservation Area

Fig. 19 Contour Map of GHNP Conservation Area

Fig. 20 Land Cover/Land Use map of Ecozone

Fig. 21 Land Cover/Land Use map of GHNP

CHAPTER 1

ASSESMENT OF BIOLOGICAL DIVERSITY AND COLLECTION OF BASELINE DATA TO MONITOR VEGETATION OF GHNP CONSERVATION AREA

1.1. GENERAL INTRODUCTION

The biodiversity conservation has been the agenda item at national and international forums. The process of species evolution to the changed environmental conditions is a natural process of adaptation. However, past evidence suggest mass extinction of biodiversity due to changed climatic conditions. Many species evolve and are lost in the natural process of selection. However, such a loss has increased due to anthropogenic activities of man. Loss of habitats and forest fragmentation are seen as most vital causes of biodiversity loss. Thus inventory of biological wealth becomes more and more crucial for decision making and conservation strategies. Himalayan ecoregions are well known for their unique ecosystems at macro and micro-climatic levels, vastness of mountains and richness of biodiversity. However, these mountains are fragile ecosystems and play an important role in the climatic and economic condition of several countries specially India. The vegetation in the Himalayan ranges, which extend to almost 2500 km in length, experience great variations in altitude, latitude, rainfall, temperature, humidity and edaphic conditions. Western Himalayas experience less rainfall and humidity. All these contribute to the variability and development of communities.

Himachal Pradesh is one the progressive states in the Himalayas and has very high per capita income in Indian context. The state has very high potential of tourism. In spite of this the people are using land resources either for day to day requirement or for generating additional income through legally or illegally collection forest produce. The Himalayas are well known for medicinal plants used in traditional *Ayurvedic,* Tibetan, Yunani etc. systems of medicine. Western Himalayas are one of the major repositories of country's biodiversity. These resources have been exploited for many centuries. However, there has been over exploitation of these resources recent 5-6 decades which has lead to decrease in populations or total loss of the plant or biodiversity as a whole. Another reason for biodiversity loss has been the loss of habitats due to fragmentation of forests. Change in land use. Diversion of land for non-forestry propose has resulted in shrinking of forest or habitats. Therefore, it is very important for developing countries like India to conserve its biodiversity for future prosperity. There have

been efforts world over to save biodiversity from getting extinct. Action plans for the development the Himalayas have been suggested. Our efforts to achieve these goals have by declaring certain regions as protected areas (national parks and wildlife sanctuaries) or to protect watersheds. However, for long term management it is important to have the current status known through properly organized survey, inventory and documentation. Therefore, generation of baseline information becomes most important for long term monitoring and sustainable management of the resources.

The National Wildlife Action Plan (1982) of government of India addresses the need to conserving nation's biodiversity. One such effort has been taken up amidst Himalayan region through multidisciplinary approach. The Himalayas, extending to about 2700 km in length and average 200 km across, have played a very important role in evolution of species. These mountain ranges are well known for their climatic, floristic, faunastic and geological diversity as well as demographic. The Himalayas have floral elements from very off places as well. It has phytogeographical affinity with Siberian, Tibetan and Indo-Chinese flora. Some of the interesting plants from Siberia are found in very interior valleys of the Himalayas showing disjunct distribution.

The creation of Great Himalayan National Park was suggested by Gaston *et al*. in 1981 and lies in the middle and great (high) Himalayan region of Western Himalayas. It represents unique biodiversity of cold climate, a typical of Western Himalayas. The area receives good rainfall and moist condition favor good vegetation growth. The 'Great Himalayan National Park' area (*s.l*.) comes under biogeographic zone 2A (Rodgers & Panwar,1988). The present biodiversity is rich as compared to other areas under similar climatic conditions (Gaston *et al.,* 1981). Topographically the park varies a great deal and altitude varies from around 1800 m to 5000 m. Vegetation in park area is mainly temperate, sub-alpine and alpine. Area falls under 2A biogeographical zones and is representative of that type (Rodgers & Panwar, 1988). Some of the peaks have permanent snow cover. The plant communities in the area mainly are formations of coniferous and oak forests. Aspect has played a great role in the development of forests in the area.

The current trends of conservation strategy have been revolving around a certain or group of animal species. However, there is a change in the management approach which now tries to integrate the socio-economic aspects with conservation or protection of plants and animals in conjunction with modern technologies of information gathering like remote sensing and Geographic information System for analysis. In any planning and management current and reliable information is of utmost importance. Some of the management or conservation strategies like Joint Forest Management, Eco-development etc. have been very successful. These success stories suggest that protection or judicious exploitation of forest resources can be done better through the extension works and participation of local people and

government authorities. Ecodevelopment planning in the surroundings of Great Himalayan National Park has been supported by World Bank through Forestry Research Education and Extension Program (FREEP) and it is hoped that the combined efforts through people's participation will help to protecting and maintaining the biodiversity of the area. To realize such long term goals it is important to generate baseline data for planning and monitoring in the future. Remote sensing technology has been widely used world over to generate such information.

Traditional surveys have been very time taking and not cost effective. Mapping of natural resources, or habitats in particular, using satellite remote sensing provides latest qualitative as well as quantitative data/information. The technology, which provides synoptic coverage, acquires data at a periodic interval. Remote sensing technology is being widely used for forest/vegetation mapping throughout the world and in India, particularly, by various agencies viz., NRSA, FSI, IIRS etc., are involved in helping natural resource management through mapping and providing the current status. The technique has been appreciated for its bias-free data, cost and time saving, repetivity, synoptic coverage etc. Launch of a series of IRS satellites by India from 1988 onwards has ensured continuous availability of aerospace data at low cost. Mapping using remote sensing data has made it possible to map the extent and intermixing of forest communities especially in inaccessible areas, which was rather difficult through traditional surveying methods.

1.2. STUDY AREA LOCATION

The project area is in the western Himalayas in Kullu District of Himachal Pradesh. It lies between 31°36'28" to 32°51'58" N Latitude and 77°20'11" to 77°45'52" E longitude. It can accessed by from Kullu side by road from Aut and air. Sainj valley has road up to Nevli and Tirthan Valley is accessed by foot or horses only from Ghusaini. However, good road is up to Bathad from Banjar. Most of the area is forming part of the greater Himalayas. The study area is bounded in the north-west by Kunawar Wildlife Sanctuary, in east by Rupi Baba Wildlife Sanctuary and Pin Valley National Park in the north-eastern side. The area encompasses four main valleys, these are Sainj, Tirthan, Parvati and Jiwa valleys. The streams are part of the upper Beas river.

Administratively the area has been divided into different management zones. These are Ecodevelopment zone (EZ) is in the south-west, Tirthan Wildlife Sanctuary (TWS) in the south, Great Himalayan National Park (GHNP) in the centre and Sainj Wildlife sanctuary (SWS) in the North. Main land use Ecodevelopment area is agriculture with orchards and fields. Tirthan Wildlife sanctuary and Sainj Wildlife sanctuaries has Shakti and Maror villages. GHNP is surrounded from all directions by sanctuaries. Park Directorate is at Kullu and field station at Sai Rpoa.

1.3. CLIMATE

This part of the Himalayas have moderate to less rainfall during rainy season and humidity is low. However, the higher ranges greater Himalayas are snow capped and winter generally is very cold. During October to December rainfall is very low to nil. Temperate and alpine zones form maximum part of the study areas. Rainfall at middle altitudes varies between 1000-2000 mm (Gaston et al., 1981). Maximum precipitation occurs during monsoon season.

1.4. TOPOGRAPHY

The area has subtropical to alpine environmental conditions. Valleys up to Ghusaini and Sainj are relatively open. High peaks and deep valleys make this region very interesting. Hills in Tirthan valley after Rolla are very steep and cast long shadows in northern aspect having conifer forest. Valleys between Shakti and Baha are very narrow and steep. Sainj Valey opens up near Maror Village. These steep slopes still have very good vegetation. Valley behind Gumtarao has good forest on slopes. Landslides and avalanches also play an important role shaping the terrain.

1.5. TERMS OF REFERENCE

Efforts to conserve and monitor biodiversity will bear fruits only when the baseline information is available on the different aspects of flora, fauna, socio-economic and other problems and prospects. The main goal of the project is to evaluate floral and faunal diversity in relation to biotic and abiotic factors. To meet the goal a part of the study has been carried out with following Terms of Reference.

The following tasks were assigned:

Task 3(a): Map major vegetation communities using remote sensing data (images)

Task 3(b): Determine plant community composition and structure using remote sensing

Task 3(c): Establish record of maps for use by the researchers, consultants, WII faculty, Park Administration etc.

CHAPTER 2

TASK 3(A): MAP MAJOR VEGETATION COMMUNITIES USING REMOTE SENSING DATA (IMAGES)

2.1. INTRODUCTION

Forest type map assumes importance basically due to its direct usage as habitat map or ecosystem characterization. These plant community maps form the basis for further delineation of unique habitats in terms of their biological richness and disturbance. Such maps provide locational information and are extremely important to indicate natural habitats for bioprospecting for human welfare. These have found various applications in biodiversity characterization at different levels in natural and man-made ecosystems. Other application areas are habitat mapping for fauna as well as flora, forest management like stock mapping, monitoring, biomass estimation etc. Habitat mapping and biodiversity characterization are very important aspects in conservation strategies for long term monitoring. Remote sensing technology also offers to compare multi-temporal data for any monitoring purposes. Monitoring is most crucial to evaluate the success of the management measures. For this project 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, encroachment etc. in fast developing tourism and orchard in the valley of Kulu.

To carry out the above mentioned objective data of IRS-1B satellite LISS II sensor have been used. For mapping geocoded FCCs (False Colour Composites) on 1: 50,000 scale for the month of September/October of 1993 year has been used.. Forest type mapping has been done through visual interpretation of satellite data of IRS, which has been recommended for better results and information. 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.

2.2. VEGETATION TYPES IN THE STUDY AREA

As mentioned above the area falls in middle and high Himalayan formations and therefore altitudinal variations, aspect, terrain etc. have played important role in the community developments. Following forest Champion and Seth (1968) have described types.

2.2.1. Sub-tropical Pine Forest (9/C1b)

Subtropical pine forests occur in drier parts of the ridges and slopes from 1200 m to 1800 m depending upon the aspect and site conditions. Only pine, *Pinus roxburghii*, trees reach to the top canopy and second storey is very poor and has scattered trees and shrubs of *Rhododendron arboreum, Lyonia ovalifolia* etc. Ground flora is very much affected by the frequent burning. (Plate 1).

2.2.2. Temperate Moist Deciduous Forests (12/C1e)

Occurs in moist area with altitude varying from 1800 m to 2750 m. The top storey is formed by *Aesculus indica, Betula alnoides, Juglens regia, Acer caesium* etc. Lower storey is formed by *Rhododendron arboreum, Lyonia ovalifolia* etc. (Plate 2)

Along the river on the sides narrow belts of riverain forests of *Alnus nitida, Alnus nepalensis* and *Celtis* sp. etc. are found. (Plate 3).

2.2.3. Temperate Broadleaf-conifer mixed Forests (12/C1d; 12/C2b)

As the area has very rugged terrain, varying aspects etc. There is mixing of forest types. These are found in altitudes varying from 1900 m to 2500 m and have varying mixture of coniferous and broadleaf species. The top storey is occupied by *Picea smithiana, Cedrus deodara, Abies pindrow, Pinus wallichiana, Aesculus indica* etc. Lower storey consists of *Rhododendron arboreum, Oak* spp., *Acer* sp. etc. (Plate 4).

2.2.4. Temperate Coniferous mixed Forests (12/C3a)

Coniferous forests occur in between 2400 m to 3000 m altitudes. Several species of conifer are found growing together in varying degree of mixing. Top storey is of *Cedrus deodara, Picea smithiana, Abies pindrew, Pinus wallichiana* etc. And lower storey is formed by *Rhododendron arboreum, Acer sp. Betula alnoides* etc. (Plate 5).

Conifer Forest mixed with Broadleaf trees is also found in the area. The coniferous tree species are more than (60-) 70% (Plate 6).

2.2.5 Temperate Broadleaf (Evergreen) Forest (12/C2a) Kharsu Oak Forests

Oak formations in the area are quite prominent and extensive. Kharsu Oak forest occur at altitudes varying from 2500 m to 3300 m. Aspect has played a great role in the development of these forests and are found mainly on southern slopes/aspects. Top storey is formed by *Quercus semecarpifolia, Acer caesium* etc. And *Rhododendron arboreum, Betula utilis* etc occupy lower storey. (Plate 7).

2.2.6. Himalayan Temperate Secondary scrub

Human activity in some areas has lead to the degradation of forest cover and loss of local tree flora. In such areas secondary formations with scattered trees and shrubs intermixed with grasses have come up. Upper storey is made of trees like *Pinus wallichiana* and *Berberis* sp., *Lonicera* sp. etc occupy middle storey. (Plate 8).

Upper regions where the valleys open up have very specific formations of riverain forest or dense scrubs of *Hippophae* sp. and *Viburnum* sp. Bamboo formations are also found in the moist as well as dry areas. (Plate 9)

2.2.7. Birch-Rhododendron Scrub

At places there is mixing of Birch and Rhododendron species between 3000 m to 4000 m. These have been seen on northern aspects in the area. Top storey consists of *Betula utilis* and *Rhododendron campanulatum* and lower storey is of *Rhododendron anthopogon, R. lepidotum, Berberis* sp. (Plate 10)

2.2.8. Alpine scrub

Rhododendron community is major contributor towards these formations. This community occurs from 3300 m to 3800 m altitudes. Large impenetrable tracts of these are quite unique and are habitat for unique fauna and flora. *Rhododendron campanulatum* is the main species there (Plate 11).

2.2.9. Temperate grasslands

Temperate grasslands or could be called as grazing/pasture lands occur between 2500 m to 3500 m altitudes. Locally known as “thatch” are traditionally grazing grounds for wild as well as domestic animals (sheep). Grases like *Themeda triandra, Oplismenus compositues* and several species of *Primula, Gentiana, other Grasses* etc. occur here. (Plate 12), (Plate 13).

2.2.10 Alpine Pastures

Higher reaches of greater Himalayan ranges and interior of the Conservation area has vast areas of sub-alpine and alpine grasslands or meadows, commonly known alpine pastures. Pastures have a few species of grasses and several species of Primula, Ranunculaceous (*Caltha palustris, Ranunculus sp.)*, Brassicaceous (*Thlaspi, Draba, Arabis* sp.), *Saxifraga* sp. occur in these areas. (Plate 14), (Plate 15).

2.3. APPROACH

Vegetation mapping is being done using remotely sensed data through visual interpretation and ground observations. Standard methods are followed for mapping the vegetation wherein correlation between image elements and ground features has been established. The ground observations are widely distributed throughout the project area.

2.4. VEGETATION MAPPING

Vegetation is the single most important parameter for evaluation and conservation of biodiversity. Therefore, qualitative and quantitative status of the vegetation are basic requirements for strategy formulation and future monitoring. Aero-space technology is widely used for quick and repetitive coverage in a very cost effective manner. Each vegetation type has its inherent characteristics in terms of species composition, community structure, crown closure, age of plants and phenology. These subtle variations are captured by cameras/ sensors and recorded for further analysis. Thus remotely sensed images depict various earth features like vegetation, sand, rivers, barren rocks, agriculture, settlements etc. These images are available at various scales and band combination to the user for further interpretation as per users requirement or objectives. These images contain enormous information and to obtain these one needs to know the ground realities. In this particular exercise vegetation mapping has been carried out using remotely sensed images of September /October data of 1993. In

western Himalayas these months data is preferred to obtain maximum contrast among various features on the Earth and vegetation in particular. During this snow cover is minimal for alpine pastures mapping, habitat for many target species and community differentiation is better because of phenological differences.

2.5. MATERIAL AND METHODS

Vegetation mapping has been done based on the knowledge of the environmental conditions which govern the land use and land cover and vegetation in particular. Materials used during the vegetation mapping are:

2.5.1. Materials

2.5.1.1. Satellite Data

False Colour Composites (FCC) of IRS –1B LISS II sensor of September/ October of 1993 have been used. LISS II sensor has spatial resolution of 23.5´23.5 m. One scene covers nearly 148´148 km of the ground area. Bands used for generating standard FCC were infrared, red and green i.e. 4,3,2. Geocoded data on 1:50,000 scales have been used. The study is covered in 6 scenes of geocoded data on 1:50,000.

2.5.1.2. Ancillary Data

Mapping need accurate ground truth. Survey of India topo maps have been used during the field and interpretation. Other equipment used during field work are Ranger's compass, hypsometer, altimeter, tape camera and related stationery. During visual interpretation dynascan magnifier, interpretation table etc. have been used. Literature related to the vegetation of the area were of immense use and were used for correct recognition of vegetation types.

2.5.2. Methodology

For vegetation mapping standard methodology of visual interpretation has been adopted. Standard methodology includes use of image elements like tone, texture, shape, location, association, pattern etc. and ancillary information like elevation. These are also called interpretation elements.

2.5.2.1. Base Map Preparation

The mapping exercise began with preparation of base map of the area. Permanent features like road, rivers or any other cultural feature were taken on base map. The area has drainage density therefore only main streams were considered. Next step was to do preliminary interpretation of satellite data and generation of preliminary interpretation key. Then preliminary interpreted maps was taken to field.

2.5.2.2. Reconnaissance Survey

First reconnaissance survey of a short duration was carried out in the part of the Tirthan valley in the year 1995. This was done basically to understand the terrain and vegetation of the study area. Further, reconnaissance surveys were carried out in other areas to get a mental picture of the area and vegetation types and their associations. During this process interpretation was tested and rectified where ever necessary.

2.5.2.3. Ground Truth data Collection

The Earth features on an satellite data appear in different tones and textures. For correct identification it is extremely important to correlation image elements and ground features. Field trips were conducted to collect ground truth throughout the study area.

Routes followed were

(a) In Tirthan valley - Ghusaini-Rolla-Shilt-Rukhundi Top-Gumtarao and beyond and back was surveyed twice.

(b) In Palachan Gad - Ghusaini-Bahtad-Chipni-Galiyar- Basleo Pass- and back to Bathad/Ghusaini through different valleys was surveyed once**.**

(c) In Sainj Valleys - Nevli-Tung-Nevli was surveyed once. And area of Sainj-Shangarh-Lappa-Baha-Shakti-Maror was criss-crossed through the forests once. Shakti-Hemkhundi area was surveyed once.

(d) In Jiwanal Valleys - Sainj-Jiwanala to some distance and back and once syrveed.

Many more field tours were taken up the Shri Sunit Naithani, Research Fellow under this project to collect ground truth. During these trips information on vegetation types specially in

shadow areas were taken and incorporated in the mapping. Almost every vegetation types has been covered during these surveys. Every time interpretation was tested and improved.

2.5.2.4. Vegetation Mapping

Interpretation key was finalized and then the images were interpreted as per the objectives of the project and agreed classification scheme with other users as well as project team. All thematic details have then been transferred to base map on 1: 50,000 scale.

2.5.2.5. Ground Check

Ground check is most essential part of the mapping. It is important to user to know the accuracy of mapping. Final interpreted map was taken to field for ground check. About 100 points were marked randomly on the map for checking purpose before going to the field. These were selected keeping in mind the ground realities. Mapping accuracy has been estimated using these point information. Wrongly interpreted features or vegetation have been corrected after the ground check.

2.5.2.6. Classification scheme

The classification scheme has been designed to meet the project objectives and should be used directly by other researcher at present and future. Therefore, a few forest types like upper and lower temperate broadleaf forests have been merged. Similarly temperate and alpine grasslands have been put together. However, these can be separated in GIS domain by taking a appropriate contour height. However, sampling for describing community structure has been done in all classes. This was done after discussion with other participants or users of this data and keeping mainly their requirements. Two forest density classes have been attempted. Vegetation with > 40% canopy cover has been delineated as closed forests and < 40% as open forest. Non-forest land cover has also been delineated keeping in mind the requirement of Wildlife habitats for future planning.

A. Forest

(a) Conifer forest (Chir Pine Forest)
(b) Broadleaf forest (Ban Oak and Kharsu Oak)
(c) Broad leaf mixed with conifer (Broadleaf > 60%)
(d) Mixed Conifer (Western Mixed Coniferous Forest)

(e) Conifer mixed with Broadleaf (Conifers > 60%)
(f) Secondary Scrub (Chir Pine and Berberis)
(g) Alpine Scrub (Rhododendron and Betula)
(h) Slope Grasses
(i) Grasslands and Forest Blanks (Both temperate, sub-alpine and alpine pastures)
(j) Riverain
(k) Plantations

B. Non-forest

(l) Agriculture/Settlement/Orchards
(m) Exposed rock with slope grasses
(n) Escarpment
(o) Alpine Exposed Rocks with Slope Grasses
(p) Landslide
(q) Morainic Island
(r) Glacier
(s) Moraine
(t) Permanent Snow
(u) Lakes
(v) River

C. Density classes

(a) Closed Forest (Crown Closure > 40%)
(b) Open Forest (Crown closure 10 - 40%

2.5.2.7. Final Interpretation

The area has great altitudinal variations, deep valleys and steep slopes. High hills have shadows on the northern aspects. Elevation has impact on the vegetation. Interpretation of satellite was finalized based on the correlation established between image elements like, tone, texture, association, location etc. and the ground features as per the classification scheme. Attempt was made to check the ground features in shadow areas. Appropriate rectification was performed in these areas. Vegetation map finalized after proper annotations on 1:50,000 scale.

2.6. RESULTS AND DISCUSSION

Satellite data provide synoptic coverage of the land features. Therefore, it had advantages over traditional method of vegetation mapping. Vegetation maps provides locational information and area can be estimated. Interpretation of images has been using standard methods of visual interpretation as per the classification scheme mentioned above. The map was available for the other researchers for their use.

2.6.1. Mapping

The GHNP Conservation area was visited by the team for ground truth collection in various seasons. First reconnaissance survey was conducted to familiarize with ground features and terrain. The basic requirements of the visual interpretation were met by preparing interpretation key based on photo-elements like tone, texture etc. and the ground information like elevation. Consideration of elevation became necessary as the vegetation changes with change in altitude. Thus final interpretation has been done based on these parameters. The details of the interpretation are given in **Table 1a,1b**. And Land Cover and Land use map of the GHNP Conservation area has been prepared (Plate 16)

The Conservation area has mountains of greater Himalayas, therefore, lot of area is was under shadow. On FCC shadow areas appear very dark or black hence cannot be interpreted. Shadow areas, mainly on northern and northern-western aspects, were interpreted and delineated in the field using natural features after matching with satellite images. This was done in all valleys (Tirthan, Sainj etc.).

Mapping of vegetation has been done keeping the project requirements in mind. Vegetation has been mapped into broad forest classes e.g. broadleaf forests of temperate zone have been put together. Similarly riverain forest of subtropical and temperate are mapped together. It has been done assuming that the various forests types can be broadly separated in GIS using elevation as the criteria. However, for characterization of communities of vegetation observations and sampling have been done in each forest type. Categorization of vegetation has been done first into forest and non-forest classes. Forest has then been subdivided into 11 different types. Grasslands have also been treated as part of forest as these are most important in wildlife conservation and management. These can either form vast areas or are found in patches locally known as ‘Thatch’ or forest blanks. Equal importance to non-forest features is also given keeping again the requirement of the project for wildlife management for conservation. Eleven features have been delineated for this purpose.

2.6.2. Area Analysis

Conservation area has very good forests in Tirthan and Sainj Valleys. Total area of the conservation area is 1171 km^2. The area has been estimated using dot grid method, digital planimeter and GIS after careful digitization and proper projection. Two measurements of dot grid gave an area of 1239.49 and 1245.94 km^2 (average 1242.5 km^2). In GIS the area was 1270 km^2. This is based on the base map which was prepared from SOI sheets on 1:50,000 scale and then digitized. However, having accepted official figure of area i.e. 1171 km^2 accordingly error has been distributed accordingly among all the classes. Northern aspects having higher moisture contents harbor very rich unique flora. The area has varied land cover and land use. Ecodevelopment Zone has agricultural fields and orchards as the main land use. About 25% of the areas is dominated by lofty mountains and peaks with either permanent snow or experience snow fall during winter. Middle region has either thick forests of broadleaf, conifers or mixture of both. Area analysis of the Conservation area is given in **Table 2**.

Table 2.1a: Interpretation Key for (a) Forests Classes for visual interpretation

S. N.	Class (Mapping)	Tone	Texture	Physiography	Altitude m	Forest Type	Vegetation association
1	Conifer Forest	Bright Red	Medium to coarse	Moderate to steep slopes	600-1700	Subtropical Chir Pine Forest	Chir Pine – *Pinus roxburghii*
2	Broadleaf Forest	Bright red to deep red	Medium to coarse	Gentle to medium slopes (bouldery land)	1500-3300	Himalayan Moist Temperate and Kharsu Oak Forest	*Quercus floribunda, Aesculus indica, Betula alnoides, Prunus* sp. *Quercus semecarpifolia*
3	Broadleaf mixed with conifer	Various shades of red to brownish red	Medium to coarse	Gentle to medium slopes, spurs with good soil	1500-3000	Himalayan Moist Temperate Forest	*Acer sp., Quercus semecarpifolia, Betula utilis, Abies pindrew, Taxux, Prunus cornuta*
4	Temperate Mixed Conifer	Brownish red to dark brown	Medium to coarse	Moderate to steep slopes and aspects	1500-3000	Western Mixed Conifer and Moist Deodar Forest	Pinus wallichiana, Picea smithiana, Abies Pindrew Cedrus deodara
5	Conifer Mixed with broadleaf	Brownish red to bright red	Medium to very coarse	Gentle to medium slopes on good soils	1500-3300	Himalayan Moist temperate Forest	Pinus wallichiana, Abies Pindrew, Cedrus deodara, *Quercus floribunda, Aesculus indica,*
6	Secondary Scrub	Light Pink - shades of brown	Medium to coarse	Medium to higher slopes,	1500-3300	Temperate Secondry Scrub	Berberis chitria, Indigofera, Rosa, Pinus wallichiana
7	Alpine Scrub	Pinkish red / cyan yellowish	Medium to coarse	Gentle to moderate slopes (moist)	3000-3600	Moist Alpine Scrub	Birch-Rhododendrons formations
8	Slope Grasses	Whitish yellow to light pink	Medium to coarse	Steep Slopes	1500-2500		Poa and mixture of other of grasses
9	Grassland	Whitish yellow to light pink	Smooth to smooth	Gentle to moderate slopes	1500-3600	Temperate, subalpine and alpine grasslands	Poa sp., Agrostis sp., and other herbaceous plants like Primula sp., Gentiana sp., Aster sp., Brassicaceae
10	Riverain	Light to brownish red	Medium to coarse	River beds and on sides slopes	1500-2500	Himalayan Moist and Dry Temperate Forest	Alnus nitidia, Alnus nepalensis Hippophae sp., Myricaria sp.
11	Plantation	Redish brown	Fine to medium	Medium to higher slopes	1500-3300	Temperate zone plantation	Pinus wallichiana, with Abies, Acer sp.

Table 2.1b: Interpretation key for (b) Non-Forest Classes

S N.	Class (Mapping)	Tone	Texture	Physiography	Altitude m	Type	Vegetation association
12	Agriculture /Settlement /Orchards	Light pink to dark cyan to yellowish red	Medium to coarse	Very Gentle to Medium slopes	1300-2500	Temperate zone (Moist)	Wheat, Potato, Elucine, Apple, Peach etc.
13	Exposed rocks with slope grasses	Yellowish white to dark cyan	Medium to coarse	Steep to moderate slopes	1500-2500	Temperate zones	Various species of grasses with cliffs, rocks exposed
14	Escarp-ment	Dark cyan to dirty blackish	Medium to coarse	Very steep slopes	1500-2500	Temperate zone	Exposed Cliffs with scattered grasses
15	Lpine Exposed rocks with slope grasses	Yellowish white to dark cyan	Medium to coarse	Steep slopes	2500-3600	Alpine zone	Various species of grasses, Asters, Primulas, Crucifers, Scrophulariaceae
16	Land-slides	Cyan to bluish cyan	Smooth to medium	Steep to moderate slopes	1500-3600	Throughout	Exposed sand and boulders
17	Morainic Islands	Grey to dirty brown	Medium to coarse	Middle or margin of moraines	Above 3600	After and within moraine	Small pebbles
18	Glaciers	White	Fine	Upper most reaches	Above 3600	Above moraines	Glacier
19	Moraine	Grey to dirty grey and white	Medium to coarse	Medium to higher slopes in upper reaches	Above 3600	Below snow line in valleys	Morrain
20	Permanent Snow	White to dirty white	Smooth to fine	Gentle to medium slopes of N and NW aspect	Mostly above 3000	Above snow line	Permanent snow
21	Lakes	Dark blue to black	Smooth to fine	Pene plain	2000-4000	Higher reaches	Water bodies
22	Rivers	Dark blue to black	Medium	Valley bottom	1500-3600	Throughout	Water channel and sand

Table 2.2: Area Analysis of the Study Area

S.No.	Land Cover/Land Use Category	Area km²	Area in %
	Forests		
1	Conifer Forest (Chir Pine)	2.08	0.178
2	Broadleaf (Ban & Kharsu Oak)	66.62	5.689
3	Broadleaf mixed with conifer	83.36	7.119
4	Mixed conifers	127.98	10.929
5	Conifer mixed with broadleaf	33.16	2.83
6	Secondary Scrub	22.28	1.902
7	Alpine Scrub	117.62	10.044
8	Slope Grasses	25.92	2.213
9	Grasslands	221.8	18.941
10	Riverain	0.14	0.011
11	Plantations	0.16	0.014
	Non-Forest		
12	Habitation/ Agriculture / Orchard	25.55	2.182
13	Exposed Rocks with slope grasses	27.6	2.357
14	Escarpments	33.82	2.888
15	Alpine Exposed Rocks with slope grasses	149.73	12.786
16	Landslides	0.41	0.035
17	Moraine Islands	0.48	0.041
18	Glaciers	18.82	1.607
19	Moraine	24.24	2.070
20	Permanent Snow	184.01	15.713
21	Lakes	0.87	0.074
22	Rivers	4.35	0.371
	Total	**1171**	**100**

2.6.3. Discussion

Subtropical forests of Chir Pine (*Pinus roxburghii*) occur mainly in the Ecodevelopment Zone and cover about 0.178% of the total area. And good patches of forest can be seen in the lower reaches amidst orchards and agricultural fields. Under storey flora is less and is put to frequent fires. These forests have tremendous biotic pressure and at some places tree density very low. Chir Pine forest are occurring around Rolla and Sainj and Nevli. Towards Sangah from Sainj and Nevli very good forest of Chir Pine can be seen. At some places it has mixing with other trees also.

The most of the area has under temperate conditions and therefore, temperate broadleaf and conifer forests occupy majority of the forested land cover. Broadleaf forests have of lower and upper temperate have been shown together and cover about 5.6% 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 of this type grow in the moist slopes (northern aspects). Under storey is very rich in herbaceous plants. Taxus wallichiana is also found scattered in these forests. Tirthan valley between Ghusaini and Rolla have very good forests. Broadleaf forests between Lappa and Shakti is also good. The area has more of *Acer* trees. Kharsu oak form the upper belt of broadleaf trees in both Sainj and Tirthan valleys. The upper belt of both valleys have extensive forests of Kharsu Oak specially along drainage. Kharsu forests do not have very good ground flora. Moist broadleaf forests have high potential of minor forest produce. Gregarious formations of various tree species like, Kharsu oak is found around Shilt, upper reaches of Tung, Shakti, Hemkhudi thatch and towards Basleo Pass. Moru oak forest near Shangad, Kharongcha, above Bathad is heavily lopped. Formations of different sizes of *Acer* sp. near Lappa and above Rolla can be seen. *Rhododendron arboreum* formations grow around Kharongcha. Trees are mature and quite old.

Mixing of broadleaf and coniferous forests is very predominant in complex terrain between subtropical and alpine areas. Narrow gorges and valleys have higher moisture availability and support broadleaf forests whereas coniferous forests are confined to drier regions on the ridges. These forests form about 7% of the total forested area. The mixing of these patches could vary in proportions however broadleaf species are more dense. Broadleaf species like *Aesculus indica, Quercus smecarpifolia, Acer* sp., *Prunus cornuta, Juglens regia* etc. and coniferous species like *Picea smithiana, Pinus wallichii, Cedrus deodara, Abies pindrew* etc.

Coniferous forest cover maximum in the Conservation area which forms about 10.9% of the total area. Conifer forest have intermixing of several species. Middle temperate zone is occupied by with this type of forest. Pure patches of *Cedrus deodara* with scattered trees of *Picea smithiana* and *Pinus willichii* are found around Shangarh. Grazing of these forests around Shangarh is very high and under-storey is not so good. These mixed forests of conifers have trees of *Picea smithiana, Pinus willichii, Taxus wallichiana* along with varying inter-mixing of broadleaf plants as well. Broadleaf trees like *Prunus* sp., *Betula*, sp., Quercus sp. might also occur scattered. Rolla-Shilt area also has pure patches of *Cedrus deoadara* and *Pinus wallichii*. Taxus wallichiana occurs scattered in these forests. In our sampling we found it forest near Lappa and towards Basleo Pass. Conifer forest towards Tirthan are very dense and phytodiversity is also very rich.

Coniferous forest also have in some areas high mixture of deciduous or evergreen broadleaf trees. About 2.8% of the area has this type of mixed forests. Varying degree of species like *Cedrus deodara, Picea smithiana, Abies pindrew, taxus buccata, Quercus semecarpifolia, Acer acuinatum, Betula alnoides, Celtis sp*. and also patches of bamboo occur. Extensive bamboo patches can be seen from Shilt to Rukhundi. Ground flora is quite rich in these forests. Lichens grow very well in these areas.

Secondary scrub is found mainly in the subtropical and lower-temperate zone in all three valleys. The area covered by these is about 1.9% and are associated with human activities. These are the areas subjected to overgrazing or cultivation and then abandoned. Extensive scrub of *Berberis aristata* occur on the southern slope from Nevli to Tung. In Palachan Gad around Bathad, Mashiyar, Galiyar and Chipni. *Lonicera* sp. and *Indigofera* sp. scrub vegetation grows on the bunds and abandoned agricultural fields in the areas of Chipni and Galiyar. Scattered trees of *Pinus wallichiana* can also be seen in the steep sloppy areas.

Alpine scrub is found in the higher reaches throughout the Conservation area and form about 10% of the total area. It is transition between temperate forest and alpine vegetation. The dominant species are *Betula utilis* and *Rhododendron companulatum*. Each of these can be seen growing gregariously in the area. *Betula utilis* scrub occur in pure patches on northern aspects near Basleo pass and around Rukhundi top. Gumtarao surroundings have extensive growth of *Rhododendron companulatum* scrub, more so on the eastern and north-eastern aspects. Dhela thatch area also has very good scrub of Betula-Rhododendron. These area experience heavy snow fall every year and plants are adapted to these conditions.

Slope grasses mainly occur on the southern aspects on very steep slopes and form about 2.2% of the area. Extensive patches of these can be seen after Baha towards Shakti in Sainj Valley. In Palachan Gad large patches of these grow above Chipni and on the steep slopes of before Rukhundi top from Shilt. Tall grasses like *Themeda triandra, Vitiveria ziznoides* etc. grow in association with non-graminaceous plants.

Grasslands form the highest cover in the Conservation Area and cover about 18.9% of the total area. Which is a very good from wildlife point of view. The grasslands locally known as 'thatch' are mainly the resting sites used by shepherds or local grazers. These are mainly associated with peaks and ridges. Well known thatches are Hemkhundi Thatch, Dhela Thatch, Gumtarao thatch, Manoni Thatch etc. Grasslands of subtropical, temperate and alpine zone have been maped put together. These can however separated out in GIS by using elevation criterion. These thatches have a mixture of herbaceous plants. Grasses like *Themeda triandra, Agrostis pilosila, Andropogon* sp., *Chrysopogon echinulatus, Oplismensus compositius, Paspalum* sp.etc.

Riverain forest occur in subtropical and temperate zones and occupy about 0.011% of the area. In subtropical forest these can be seen around Ghusaini, Sainj, Nevli and riverbeds of Palachan Gad stream and lower reaches of Dhela khad near Lappa and Rupa nala. Mapping of these areas has been difficult firstly because of the shadow and secondly because these forest occur in very narrow belts along streams or on islands. Subtorpical riverain have *Alnus nepalensis* and *Alnus nitida* as the dominant species along with *Prunus* sp. and *Pyrus* sp., *Girardinia* sp. and *Berberis* sp. Temperate riverain scrub of *Hippophae* occur before and after Shakti towards Maror. These grow gregariously flat raised riverbeds and along streams. The main species are *Hippophae salicifolia, Sorberia tomentosa* and *Rosa webbiana*. An interesting patch of Viburnum sp. scrub occurs along riverbed in between Shakti and Maror in very moist and shady conditions.

Plantation is not much in the area and it forms only 0.014% of the area. Old plantation of *Pinus wallichiana* is in Jiva nala in Ecozone area.

A large extent of the conservation area is without vegetation which about 40% of the total area. Some of these areas are equally important from wildlife point of view. Exposed rocks with scanty cover of grasses (about 2.5%), Escarpments (2.89%), Alpine exposed rocks with slope grasses (12.78%), Moraine islands (0.041%), Glaciers (1.6%), Moraine (2%), Permanent Snow (15.7%), Lakes (0.074%) etc. are important habitats for wildlife for fodder, shelter and

breeding grounds. In some areas there are a few landslides. Landslides occur in very disturbed and non-forested area.

Ecodevelopment zone has a very complex land use. Habitation is associated with Agriculture and Orchards and relatively gentle slopes (fan-shaped fluvial deposits) and land with soil are under cultivation (unlike forested areas which have rock crop-outs, boulders and stones). About 2.18% of the area is under this land use.

2.7. CONCLUSION

Remote sensing technology offers quick and cost-effective method of mapping land features. IRS satellite data have been used successfully to map the Land Cover and Land Use of the GHNP Conservation area as per project objectives. The technology provides quick assessment of the areas for conservation planning. GHNP has very rugged terrain and accessibility is difficult. Remote sensing technology has been of much because we were able to map even inaccessible areas. Land cover and Land use information is most important for decision making and management and to know the current status of the vegetation. Baseline information on their location, distribution and area has been generated. And 11 forest/vegetation types and 11 non-forest features have been mapped using this technology. Area analysis has been done for each class. About 60% of the areas is under forests whereas non-forest area cover about 40% of the area. The area calculated through a base-map prepared using SOI sheets on 1:50,000 was about 100 km^2 higher than the official figure. The error has been distributed proportionally.

It may concluded from the findings that Conservation area has very good forest of temperate broadleaf and coniferous forests. Alpine pastures are the sites for many wild animals to graze. Snow covered area offer home for many animals.

CHAPTER 3

TASK 3(B): DETERMINE PLANT COMMUNITY COMPOSITION AND STRUCTURE USING REMOTE SENSING

3.1. INTRODUCTION

The range of Himalayan mountains vary greatly in height, aspects and topography, thus creating wide variety of microclimatic conditions. Distribution of vegetation is governed by climatic, edaphic and topographic conditions. Fragile ecosystem in the Himalayan region needs protection from changes in land use patterns. Change in land use pattern influences the composition of surrounding vegetation. Introduction of exotic species, especially weeds, has influenced ground flora in the Indian subcontinent. Therefore, monitoring of vegetation composition becomes a quite important aspect in forest management.

Community is a local association of several populations of different species. Phytosociological studies have been done to characterize vegetation structure and composition. **Composition of vegetation** can be described by the number of species present in all growth forms in vegetation. Traditionally vegetation composition has been based on ground surveys and laying of transects along or across the gradients. Listing of species at each level is primary requirement to carry out primary and secondary analysis of vegetation. **Structure of vegetation** can be described as to how these species are arranged vertically or horizontally or occupy the space in any ecosystem. Plants occupy various positions in the community to meet their requirements like sun illumination, moisture, nutrients etc. Such an analysis gives an idea about the ecological importance and role of the species in an ecosystem. As we all know the role of tree species in regulating the ecosystem is maximum mainly due to their long life and efficiency to accumulate biomass (forage as well as woody) for further use by animal and human beings.

Advent of remote sensing has provided the possibilities to look at the spatial distribution and arrangement of plant communities. It also provides visualization of different physiographic and topographic variations of the terrain and thus facilitates such studies. Richards (1952) stressed the need to depict community structure in semi-schematic profile diagrams. In India, phytosociological studies using remote sensing have been carried out by, Roy, et al. (1992) in Andaman Islands, Singh (1993, 1994, 1995) in Madhya Pradesh and Sikkim Himalayas. Profile diagrams are one the best methods to provide visualization of different strata in the

community and their spatial arrangements. This method of portraying the vertical vegetation stratification and structural association of plants provides immediate insight about the community. Community structure is depicted in three dimensions - height, depth (relative position) and crown cover.

3.2. OBJECTIVES

(a) Determination of plant community composition and structure using remote sensing.
(b) Generation of photographic evidence of each community.

3.3. APPROACH

In the present approach traditional as well currently used methods of studying community composition and structure have been followed. Stratified map of vegetation, obtained from remote sensing data, and ground based enumeration of species is subjected to phytosociological analyses. Structure of the vegetation has been shown through profile diagrams. In the present approach inputs from remote sensing technology have come in the form of stratified map of vegetation. Aerospace data provides information at community level and stratification of vegetation provides the opportunity to go for optimum sampling. Stratified random sampling is cost effective method of vegetation sampling.

Photographic evidence is the best proof. Photographs of various communities have been obtained. Photos have scanned and attached for posterity. Micro-environmental conditions lead to some change in species composition. Therefore, sampling has been done at different places to assess the variability as far as possible.

3.4. MATERIALS USED

Materials required for studying the composition and structure are mainly vegetation map, Survey of India maps, hypsometer, graph paper, measuring tape and related stationery like graph paper.

3.5. METHODOLOGY

Vegetation map prepared through visual interpretation in the **Task 3(a)** provided the locational and spatial information about the different major plant communities. For community analysis

profile diagrams have been made. Keeping in mind the accessibility, time and representatives, sample plots of were laid in each vegetation type. Size of plots was determined based on species area curve. After a few trials it was decided that plot size of 20´20 m size would be appropriate for forested areas and 1 x 1 m for grasslands for depicting the variability in composition and structure within the community. Ground flora varies in different seasons. Observations recorded here are for the months of May and November.

For each vegetation type a plot of 25´10 m was laid along the gradient. Sketch or line drawing of each tree inside the plot has been drawn on graph sheets at an appropriate reduced scale (1 mm = 20 cm) or smallest division of graph sheet is equal to 20 cm. Tree diameter was taken using ruler. Slope of the plot was obtained using hypsometer. Branching patterns, relative horizontal location, crown size etc. have been depicted for each community type along the gradient. Canopy has been depicted to give an idea of the crown shape and closer. The illustration made in the field were then drawn on fair tracing paper for the purpose of multiplication with appropriate scale. Species found in upper, middle, lower stories and ground flora have been listed. The plants which could not be identified in the filed were preserved and identified later using relevant flora and with the helps experts. Local names were also noted.

3.5.1. Information Collected

Following information were collected for each sample plot.

- Vegetation type (community type)
- Location (position)
- Species name: trees, shrubs, herbs, climbers etc.
- Slope (%)
- Average tree of each canopy layer
- Circumference at breast height
- Aspect
- Ground flora (in May)
- Crown diameter
- Altitude
- Climber, lianas etc.
- Phenological stage

3.5.2 Laying of Sample plots

Vegetation of an area can be expressed qualitatively as well as quantitatively. Various methods like line transact, systematic sampling, point method etc. are employed to study the structure of the vegetation. Most of these methods are time consuming and not economical and some of them are generally attempted in smaller study areas. In the present investigation stratified random sampling has been done. Satellite data has been classified through visual interpretation as per the classification scheme based on the reconnaissance survey and land cover/land use classes in the area. Sampling was done on homogeneous units. Samples plots were laid along the gradient and reference to North direction has been provided. For structural analysis normally 20´20 m plots are laid for woody vegetation and 1´1 m for grasslands and same has been followed here. As far as possible representative sites were selected for this purpose and marked on SOI maps.

3.6. RESULTS AND DISCUSSION

A total of 66 sample plots were laid in the covering all communities. Of these 46 were in communities with trees and shrubs and 20 were for grasslands. Following discussion is based on preliminary analysis based on the ground data collected and profile diagrams or illustrations made during the fieldwork.

(a) Chir Pine Forest: (Subtropical Pine Forest: Himalayan Chir Pine Forest, 9/C1b)

In the study area west and south-west has subtropical vegetation. Chir Pine (Pinus roxburghii) is the dominant forest species from Sai Ropa to Ghusaini and Southern aspects in Tirthan Valley up to Kharongcha. Forest around SaiRopa on the hills is good to disturbed. In Sainj valley very good forest can be seen on both sides on slopes Shangarh. At few places towards Shangarh from Sainj these are mixed with other broadleaf species. The ground flora is quite disturbed and subjected to grazing and fire. The density of trees is very less on slopes of Tung village and slopes around Nevli. Biotic pressure is high on these forests. Following is list of the species occurring in subtropical pine forest.(Plate 1), (Fig. 1).

Table 3.1: List of species of found Chir Pine Forest

Trees	**Herbs …..**
Pinus roxburghii	Hydrangium anamala
Lyonia ovalifolia	Oplismenus compositus
Shrubs	Centella asiatica
Rubus brunonii	Inula cappa
Berberis chitria	Pilea umbrosa
Rubus ellipticus	Pteris cretica
Berberis aristata	Sonchus aspera
Herbs	Gnaphalium hypoleocum
Desmodium triflorium	Smilax aspera
Galium rotundifolium	Salvia macrofitiana

Top storey is if *Pinus roxburghii*. Upper and middle storey is generally absent. Burnt stems of Pines indicate high disturbance due to frequent fires. Under stroey flora of shrub and herbaceous species is open to dense depending upon the biotic interference and boulders. Scattered shrub species like *Lyonia ovalifolia* and *Rubus ellipticus* along with *Berberis* spp. are the main species. Herbaceous plants include grasses and other common species, as listed in table 3.1.

(b) Broadleaf forest

Broadleaf forest of lower temperate and upper temperate vary in species composition. Lower temperate forest have *Aesculus indica*, *Populus ciliata* and *Quercus dilatata* as the top storey trees*. Rhododendron arboreum* forms first storey. Middle temperate boradleaf forest have trees of *Acer* sp., *Betula alnoides, Juglens regia, Prunus cornuta* etc. Scattered trees of *Taxus wllichiana* occur in the lower storey. Under storey consists of plants like, *Berberis, Impatiens, Strobilanthes, Polygonatum, Hedea* etc. Regeneration of Aesculus indica is quite good as is evidenced from the presence of different age group plants. (Plate 2), (Fig. 2).

Broadleaf forest of Kharsu Oak Forest (Himalayan Moist Temperate Forest: Upper Himalayan Western Forests, 12/C2a) occur in the upper reaches bordering alpine zone. Upper hills have very extensive stretches of “Kharsu” oak (*Quercus semecarpifolia*) and grow on very steep to

almost cliff slopes specially along seasonal shallow streambeds. Upper storey is of 20 m tall plants of *Quercus semecarpifolia*, and *Acer caesium* trees and can sometimes grow taller and share the top storey and in lower ecotone zone *Picea smithiana* and *Cedrus deodara* are also found. *Rhododendron arboreum* and *Acer caesium* occupy lower storey. Ground flora is relatively less thick and plants like, *Carex, Polystichum aculeatum, Viola, Polygonum, Cheilanthes farinosa, Rosa sericea, Viburnum, Geranium, Podophyllum, Polystichum squamossus, Lonicera,* etc. and young plants of *Quercus semecarpifolia and Rhododendron arboreum*. (Plate 7), (Fig. 3).

Table 3.2: Plants occurring in Broadleaf Forests

Trees	Ainsliea aptera
Viburnum nervosum	Desmodium triflorum
Prunus cornuta	Senecio rufinervis
Lyonia ovalifolia	Berginia ciliata
Quercus leucotrocophora	Bidens pilosa
Rhododendron barbatum	Hedera nepalensis
Taxus wallichiana	Senecio chrysanthenoides
Acer cappadocicum	Impatiens sulcata
Acer acuminatum	Carex nubegina
Celtris australis	Phacelurus speciosus
Quercus semicarpifolia	Polygonum affinis
Quercus floribunda	Galium aprine
Shrubs	Saussurea graciliforus
Desmodium elegans	Cynoglossum glochidiatum
Rosa serecia	Polygonum amplexicaulis
Astible rivularis	Pilea umbrosa
Prinsepia utilis	Oplimenus undulatifolius
Indigofera heterantha	Erigeron canadensis
Berberis chitra	Iris milesii
Viburnum nervosum	Rubus niveus
Cotoneaster affinis	Adiantum venustum
Pyrus pashia	Coniogramme affinis
Herbs	Diplazium esculantum L.
Iris milesiii	Oplismenus compositus
Fragaria vesca	Helictotrichon viresceus
Viola biflora	Salvia nubicol
Clematis montana	Parochetus communis
Viola serpens	Onichyum cryptogrammoides
Onychium japonicum	Centella asiatica
Girardinia diversifolia	Achyranthus aspera

(c) Broadleaf Mixed with Conifers Forests: (*Broadleaf mixed with conifer)*

Mixed coniferous forests occupy relatively large areas and mixing of broadleaf and coniferous plants occurs. Top canopy is occupied by *Abies pindrew, Aesculus indica and Aesculus indicia*. Very tall trees of *Abies pindrew* grow mixed with *Aesculus indica* . Abundance of *Aesculus indica* is more and middle aged trees of this occupy the middle storeys. Other species which are mixed share top canopy or upper storey are *Prunus cornuta, Juglens regia, Picea smithiana* etc. Ground flora is very rich because of thick humus layer and moist conditions and consists of *Polystichum, Hedera helix, Impatiens, Gallium, Adiantum, Urtica, Coniogramme fraxinea, Dryopteris sp., Cyrtomium sp., Asparagus sp., Vitis sp., Pteris cretica, Daphne papyracea, Clematis, Houtainya cordata, Calanthe, Pieris polyphylla, Smilacina* etc. A clump of bamboo is also recorded. There are a few dead trees (top part missing). (Plate 4), (Fig. 4).

Table 3.3. List of species in Broadleaf mixed with Conifer Forest

Trees	**Herbs**
Prunus cornuta	Diplazium fieldinzianum
Pinus wallichii	Asparagus filicina
Acer acuminatum	Clematis barbata
Juglans regia	Fragaria vesca
Aesculus indica	Oxalis acetosa
Abies pindrew	Pteris critica
Quercus semecarpifolia	Adiantum venutum
Picea smithiana	Malva verticillata
Shrubs	Aconitum tetrasepala
Viburnum nervosum	Senecio graciliflorus
Herbs	Leucas lanata
Urtica sp.	Calanthe tricarinata
Coniogramme fraxinea	Smilacina purpurea
Dryopteris sparsa	Urtica dioca
Cyrtomium caryotideum	

(d) Mixed Conifer: (Temperate Coniferous Forest)

Park has very extensive stretches of coniferous forest and play a very important role in the temperate ecosystem and grow on steep slopes. Phytodiversity of these forests is very high. Dominant species are *Cedrus deodara*, Abies pindrew, and *Pinus wallichiana*, which form the top storey, and trees up to 35 m tall can be seen. Huge trees of coniferous plants occur in the conservation area. At places these mixed with other plants like *Acer acuminatum, Picea smithiana* and form the first storey. Lower storey is *of Taxus wallichiana, Acer* sp., *Rhododendron arboreum*. In the under storey species like *Pteridium aquilinum, Geranium, Rubus ellipticus, Ranunculus, Dryopteris, Viola, Podophyllum emodi, Acer, Asparagus, Indigofera, Hedera helix, Rubia, Diplazium maxima, Carex, Impetiens, Fragaria vasca*, Oplismensu compositus etc. In shaded area the ground flora is very rich whereas drier southern slopes have less ground flora. *Pteridium acquilinum* is indicator of the disturbance in these forests. Occurrence of Podophyllum is important. Plants of Podophyllum are very rare. These forests do not have thick shrubby middle layer and look cleaner. *Rhododendron arboreum* forms the lower storey. (Plate 5), (Fig. 5), (Fig. 6).

Table: 3.4. Mixed Conifers Forest

Trees	**Herbs ....**
Cedrus deodara	Fragaria vesca
Pinus wallichiana	Geranium nepanesis
Juglans regia	Rubus ellipitcus
Rododendron arboretum	Acheranthus aspera
Pisea smithiana	Anemone rupicola
Herbs	Onychium contiguum
Phacelurus speciosus	Oplismenus compositus
Carex foliosa	Impetiens sp.
Podophyllum emodi	Asparagus recemosus
Clematis montana	Iris milesii
Rosa webbiana	Galium apparine
Rubia cordifolia	Diplaium maxima
Sphenomeris chinensis	Polystichum prescottianum
Carex cruciata	Dryopteris sparsa
Smilicina purpurea	Oxalis corniculata
Adiantum venustum	Hedera nepalensis
Senecio gracillis	Desmodium elegans
Senecio rufinervis	Indigofera heterantha
Pteris critica	Pteridium acquilinum
Viola serpens	Solidago virga-aurea

Pure formations of *Cedrus deodara* are found around Shilt and above Shangarh, around Hemkhundi Thatch and between Shakti and Maror. Wild monkeys were sited in coniferous forest near Maror (Fig. 7).

(e) Conifers Mixed with Broadleaf Forest

Coniferous trees are more in proportion than broadleaf trees. This type of mixed can be seen after Shangarh towards Lappa. Coniferous trees of *Cedrus deodara, Picea smithiana, Pinus wallichiana,Taxus wallichiana* etc. form the top storey. Intermixed with these are species of Acer, Prunus etc. Ground storey is more like that of broadleaf mixed with coniferous forests. (Plate 6)

Table 3.5 : list of species of conifer mix with broadleaf

Trees	**Herbs**
Cedrus deodara	Oxalis corniculata
Quercus glauca	Thelictrum foetidum
Picea smithiana	Geranium wallichiana
Abies pindrew	Impatience sulcuta
Quercus floribunda	Potentilla microphylla
Taxus wallichiana	Pilea umbrosa
Quercus semicarpifolia	Adiantum venustum
Acer acuminatum	Astrobilanthus atropurpures
Acer cappadocium	Oplismenus compositus
Acer caeseum	Viola biflora
Shrubs	Hedera nepalensis
Principia utilis	Grardiana diversifolia
Viburnum nervosum	Iris mellessi
Jusminum humile	Stipa roylei
Daphne papyracea	Anemone rivularis
Lonicera purpuresence	Geranium nepalensis
Rosa webbiana	Polygonum affinis
Herbs	Dryopetris sparsa
Goldfusia dalhousiana	Oxalis acetosa
Crotolaria cytosoidies	Smilicena purpurea
Onychium japonicum	Fragaria vesca

(f) Secondary Scrub: (Himalayan Temperate Parklands, 12/DS2)

In Eco-development zone southern slopes have long been put to lot of biotic pressure. Secondary scrubs are found intermixed with agriculture. Scrubby one has replaced original vegetation. *Berberis* species forms the top storey. *Artimisia, Carex, Hypericum, Rubia, Indigophera* etc. are other plants, which form the ground flora elements. Occasionally scattered trees of *Pinus wallichiana* are also seen. (Plate 8), (Fig 8).

Table 3.6. List of plants of Secondary Scrub

Trees	**Herbs ...**
Pinus wallichiana	Epilopium latifolium
Prunus cornuta	Swertia ciliata
Buxus wallichiana	Senecio chrysanthomoides
Shrubs	Micromeria biflora
Pyrus pashia	Anaphalis busua
Indigofera heterantha	Naphalium affine
Princepia utilis	Themeda anthera
Berberis aristata	Vitivaria zizinoides
Cotoneaster microphyllus	Erigeron alpinus
Sorbaria tomentosa	Verbascum thapsus
Spiraea canesence	Rubia cordifolia
Lonicera purpuresence	Salvia microffitiana
Astible rivularis	Trifolium repens
Rosa webbiana	Clematis cornuta
Indigofera atropurpurea	Potentilla nepalense
Berberis chitra	Draba astusa
Herbs	Selinum vegenatum
Potentilla argyrophylla	Valerina parvifolia
Asparagus racemosus	Viola serpens
Plectranthus rugosus	Plantago erosa
Pteris subquinata	Pimpinella diversifolia
Aster thomsonii	Artimisia maritina
Artemisia nilagirica	Polygonum amplexicaulis
Salvia hains	Viola biflora
Fragaria vesca	Athyrium atkinsonii
Polygonum decumbens	Geranium nepalense
Galium aparine	Oxalis corniculata
Cynoglossum glochidiatum	Onychium contigium
Sonchus asper	Microstigium nudum

Viburnum Scrub: A very interesting community of Viburnum was located on way to Maror from Shakti. A more or less pure formation of Viburnum grandiflorum. Patch is quite dense and pants are up to 5 m tall. Other species are listed in the table below.

Table 3.7: List of species in Viburnum Scrub.

Shrubs	**Herbs ....**
Viburnum grandiflorum	Polystihum setosum
Herbs	Pilea sp.
Dryopteris sparsa	Rubus niveous
Adiantum caudatum	Lecanthus peduncularis

(g) Subtropical Riverain Forest

Even though the valleys are narrow, riverbed at some places is quite wide. These riverbed and side slopes have different species composition. These are the formations of riverain forest. Two types riverain forests have been located in the study area.

Subtropical riverain forests have *Alnus nitida* and grow in narrow belts. Since these are very narrow and were under shadow on satellite data therefore could not be delineated. These are found in the riverbeds quite frequently from Ghusaini to Bathad and up to Rolla specially at the bends of rivers. In Sainj Valley riverbeds of Nevli and towards Baha areas have this type of forest. Good forest of this type can be seen along Rupa nala and Sainj river. Dela Khad after Lappa has moderately less disturbed forests of *Alnus nitida, Celtis tetrandra, Pyrus* species etc. *Girardinia diversifolia, Diplazium esculentum* etc. very common and grow abundantly. (Fig 9).

(h) Temperate Riverain Forest (Hippophae Scrub)

Pure disturbed as well as undisturbed patches of Hippophae salifolia are found around Shakti village. These found along the riverbed either on little elevated land or quite close to water. Trees are up to 8 m tall. Top canopy is Hippophae salicifolia (about 5 m tall). Presence of Girardinia diversifolia and Cannabis sativa indicates biotic disturbance. Epiphytic fern Pleopeltis is found in these patches. Other associates are Sorberia tomentosa, Rosa webbiana etc. Species found are listed in table below. (Plate 9).

Table 3.8 : List of plants Subtropical Riverain Forest

Trees	**Herbs ….**
Alnus nitida	Oxalis corniculata
Srhubs	Salvia macrofftiana
Berberis chitria	Achyranthus aspera
Sorberia tomentosa	Plectranthus rugosus
Rubus paniculatus	Diplazium fieldinziana
Prinsepia utilis	Diplazium esculantum
Desmodium triflorum	Polygonum recumbens
Herbs	Oplismenus compositus
Cuscuta reflexa	Solanum tuberosum
Tagetis minuta	Sonchus asper
Artemisia parviflora	Cannabis sativa
Girardinia diversifolia	Pteris cretica
Galinsoga parviflora	Fragaria vesca
Themeda anthera	Cyperus compressus
Chenopodium ambrosoides	Apluda mutica
Clematis gouriana	Bidens pilosa

Table 3.9 : List of species in Hippophae Scrub

Hippophae salicifolium	Achyranthus aspara
Sorberia tomentosa	Strobilanthus atropurpureous
Herbs	Cnetella asiatica
Rosa webbiana	Girardinia diversifolia
Polygonum capitata	Oplismenus compositus
Urtica parviflora	Diplazium fieldenzinum
Viola serpens	Cannabis sativa
Fragaria vasca	Cyathula tomentosa
Sorbus foliolosa	Siegesbeckia orientalis
Ivy sp.	Pleopeltis sp.

The inner Himalayan region in the Sainj valley important and unique formations along the riverbed are found. These are temperate riverain forests and are found in patches about 2 km before the Shakti to 5 km after towards Maror.

(i) Alpine Scrub: (Birch-Rhododendron Scrub Forest): (Dwarf Rhododendron Scrub)

Above the tree line occurs dwarf vegetation formed by Rhododendrons and *Betula utilis*. These are thick sometimes-impenetrable areas bushy vegetated areas. *Betula utilis* forms the top storey and first storey is formed by *Rhododendron companulatum*. Because of the pressure from snow most of the plants are bend towards down slope. Ground flora is mainly of *Rhododendron anthopogon*, Rosa webbiana, and young to middle aged *Rhododendron companulatum* plants. Ground flora is mainly of species of *Primula, Potentila* etc. (Plate 10), (Fig 10), (Fig 11)

Table 3.10 : List of plants in Birch-Rhododendron Scrub

Shrub	**Herbs**
Betula utilis	Agrostis pilosula
Rosa webbiana	Adiantum venustum
Rododendron campanulatum	Dryopteris komarovii

(i) Alpine Scrub (Deciduous Scrub)

Alpine scrub is mainly dominated by *Rhododendron companulatum* and *Rhododendron anthopogon*. These bushes can grow up to 4 m tall. Stems are much branched and slanted because of the pressure of snow i.e. adaptation to snow. The branching is very profuse and almost difficult to negotiate. Good formations can be seen Around Dhela Thatch, Gumtrao, Rukundi top and in small patches around Basleo pass. These are more or less pure formations, however sometimes *Betula* and *Quercus* trees might occur. (Plate 11), (Fig. 12)

(j) Slope Grasslands

On steep slopes around Shakti and upper reaches of Tirthan and Palachan Gad have extensive grasslands. The terrain is rugged and steep. Grass plants of Themeda triandra, Oplismenus, Agrostis etc.and other plants like Aster, Cheilanthes farinosa, Sedum, Colebrookia oppositifolia etc. occur intermixed. These are also pature areas. (Plate 12).

(k) Grasslands /Blanks/Alpine Pastures

Grassland may be very extensive as well as small as forest blanks. In forest blanks these are the camping sites of shepherd. Alpine grasslands commonly known as “thatch” are found either growing extensively or mixed with alpine scrub of Rhododendron on relatively protected slopes. Various species of *Primula, Potentilla, Carex, Gentiana*, etc. found abundantly. Grasslands near Chipni are quite extensive and used by villagers for grazing and fodder. Near Gumtarao these are the habitats of wild animals like musk deer.(Plate 14), (Fig 13).

Table 3.11 : List of species of plants in Temperate and alpine grassalnds

Herbs	Diplazium maxima
Themeda triandera	Erigeron multiradiatus
Verbascum thapsus	Salvia lanata
Rumex acetosa	Desmodium triflorum
Cheilanthus bicolor	Origanum vulgare
Artimisia parviflora	Brassica juncea
Erigeron canadansis	Selinum vaginatum
Campanulla argygrotricha	Achillium millefolium
Micromeria biflora	Galinsoga parviflora
Viola serpens	Grardiana diversifolia
Vetiveria ziznoides	Onychium contigum

(l) Habitation /Agriculture/ /Orchard (Apple Orchards)

Himachal Pradesh has found tremendous potential in horticultural crops. Apple orchards are everywhere and have become a ‘big’ source of income. Terraces with orchards are very common sites. Indigenous plants grow only on bunds and along nala or streams. Iris species is most commonly found. In agroforestry practices *Pyrus malus* (apple) and peach are grown along with various cereal crops like, wheat, maize, Elucine corcana, paddy, ‘karnkhan’ etc. (Fig 14).

(m) Exposed Rocks with slope Grasses:

Rocks are covered with scattered growth of grasses. Found in alpine zone above tree line. Themeda triandra, Oplismenus compositus, Agrostis sp. etc. are the grasses found in these slope grasslands (Plate 15).

CHAPTER 4

TASK 3(C): ESTABLISH RECORD OF MAPS FOR USE BY THE RESEARCHERS, CONSULTANTS, WII FACULTY, PARK ADMINISTRATION ETC.

4.1. INTRODUCTION

For management planning and execution it is very important that management has a good archive of maps at appropriate scale. Currently in India management planning for regional level natural resource management is carried out 1:50,000 scale. Baseline information need to be generated for better decision making process. Following maps have been prepared for use in management planning. These maps are ought to be used by the other researchers or consultants.

Following maps/layers have been prepared for further usage.

4.2. MAP RECORDS

4.2.1. Base map

Base map showing the boundary of study area, permanent features like river, main roads, village location, spot height etc. has been prepared. All maps will have these features common. Thematic details of forest map have been transferred on this base map. All the maps are fitted into this frame. (Fig. 15).

4.2.2. Management zone map

To mark the extent of the management zones boundary of different parks, wildlife sanctuary and ecodevelopment zones management zone map has been prepared. Area under different management zones is GHNP (765 km^2), Sainj Wildlife Sanctuary (900 km^2), Tirthan Wildlife Sanctuary (610 km^2) and Ecodevelopment Area (255 km^2) (Fig. 15).

4.2.3. Communication map

Communication map showing metalled and unmetalled road, pack track etc. has been prepared using SOI map to facilitate management. This map will be used for proximity analysis in GIS domain. (Fig. 16).

4.2.4. Settlement/Agriculture map

The project area has settlement or villages in the eco-dvelopment zone. Depending upon the population local people have been using natural resources. This map finds its utility in comparing the status of forest 20 or 25 years back and now. It will be used for proximity analysis and calculation of peripheral area impacted by these settlements. Since the villages are very small and as such cannot be detected very clearly on satellite data therefore map showing all the village/agriculture location have been taken from SOI maps. There are about 141 villages in buffer zone of the Conservation area (Negi, 1996). (Fig. 17).

4.2.5. Drainage map

Area has very high density of drainage. Drainage map provides information from 1st order to main river. (Fig. 18).

4.2.6. Contour map

Entire study area is mountainous and altitude, aspect and rainfall control vegetation. It will be used to generate slope map, aspect map, Digital Elevation Model, 3-D views, climatic zoning, habitat evaluation, etc. (Fig. 19)

4.2.7. Vegetation Map

Vegetation map has been prepared using IRS-1C (Indian satellite) data. Visual interpretation has been done to map different vegetation types. Two density classes (> 40 % and < 40 %) have been attempted while mapping. This map has been digitized in Arc/Info GIS environment and multiple copies can now be generated for distribution to be used by other researchers (Plate 16), (Fig. 20), (Fig. 21).

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