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IDENTIFICATION OF PLANT SPECIES AND THEIR RELATIONSHIP WITH ALTITUDE AND SLOPE ASPECT: A CASE STUDY FROM NAINI LAKE CATCHMENT, CENTRAL HIMALAYA

ABSTRACT. In the Himalaya diversity of plant species is very rich in length and breadth of its spatial extent. Study area forms a part of the Central Himalaya where altitude is varying in between 1940m to 2615m. Changing slope aspect and altitude (micro-climate) have a close bearing on the distribution of species. Distribution of plant species was identified with the help of quick bird data with detailed goundtruth verification. Whereas, habitat characteristics i.e. altitude and slope aspect are identified using Survey of India topographical map. Finally, the analysis and interpretation part is carried out with the help of GIS software. Study reflects that Cupressus *torulusa* is found above 2190m concentrating in the southern and south eastern slope aspect areas only. However, presence of *Quercus Leucotricophora* is found everywhere without having any control of altitude and slope aspect. Earlier workers reported that *picea smithian (Spruce)* growth is limited from 2400m to 3600m. In the Himalayan region but in the study area we found its natural growth in the height of 2005m.

KEY WORDS: Plant Species, Satellite Image, Altitude, Slope aspect, Ground-Truthing, GIS

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INTRODUCTION

Naini Lake Catchment is surrounded by high hills with dense forest cover and dominated by Evergreen and Deciduous plant species and shrubs. Some species abundant and dominant in nature are *Quercus Leucotricophora, Quercus floribunda, Cedrus deodara, Cupressus torulosa, Aesculus indica* etc. The distribution of plant species in an area is determined by many factors such as climate, soil, slope aspect, altitude etc. Sometimes two or more species grows in a same place where the growing ecological criteria of species are similar. For e.g., *Quercus leucotricophora* grows in an association

with *Cedrus deodara, Quercus floribunda* etc and their growing environmental factors are similar (Troup 1921). Soil of catchment of study area comprises 70-80 % sandy and 20 % Clay concentration (Indianetzone.com). It is also found that the two different sides of the catchment having different soil chemical characteristics such as the one side having alkaline soil while the other is acidic. The variation and growth of plant species (including shrubs) are also found according to chemical properties of soil. Some species occurred according to pH value and moisture content of soil. For example, *Cupressus torulusa* occurred in the alkaline soil with well drained drainage system and south facing aspect. *Quercus leucotricophora, Cedrus deodara, Quercus floribunda* occurs in acidic to alkaline soil. The Nainital lake catchment receives 2488mm of average annual precipitation. In winter temperature drops to -5 degree Celsius while in summer it goes up to 29 degree Celsius (Kharkwal and Rawat 2010).

STUDY AREA

Naini Lake Catchment is situated in central Himalaya region of The Kumaun Himalaya. The altitude is ranging in between 1940 m to 2615 m with a spatial extent of 79° 26´´ 10´ E to 79° 28´´15´ E Longitude and 29°22´´0´ N to 29° 24´´ 45´ N Latitude. The catchment area is spread over 7.38 sq km with rugged terrain and steep slope. The Nainital lake is situated in the centre and surrounded by hills and peak with highest elevation of 2615m (Naina peak) (see Fig. 1). The Naini lake stores enough water and overflow in rainy season. The lake is also play a dominant role in modifying micro climatic conditions having influence on the surrounding vegetation growing conditions (Ram et al. 2004).

METHODOLOGY

A general methodology is shown through a flow chart (Fig. 2) indicating the data acquisition processing and interpretation. During the ground survey plant communities and species of each

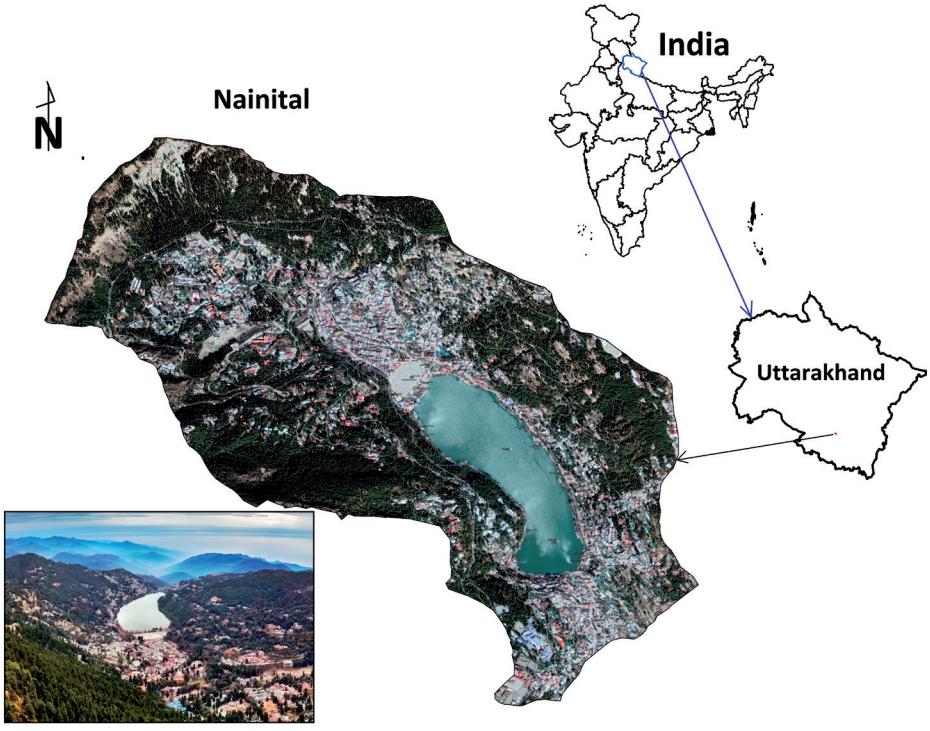


Fig. 1. Location Map of Naini Lake Catchment

community are identified. GPS locations of each identified species had been helpful to mark on satellite imagery during mapping. Off-ground processing includes study area delineation on Toposheet (53/O 7 with a scale of 1:50000) of Survey of India. Altitude and slope aspect is derived generating a DEM with help of 20 meter contours interval (see Fig. 6). The Quickbird II (March 2018, 2.48-2.63m resolution) high resolution data is used for visual interpretation for the identification of plant species in each community. Finally, the on-ground and off-ground information is stored in GIS platform to support the further processing.

Plant communities of the study area are classified as Broadleaved Forest, Needle Leaved Forest and Shrubs (Fig. 3). The dominant plant species in Broadleaved Forest Communities are *Quercus leucotricophora, Quercus floribunda, Aesculus indica, Populus nigra, Poulus ciliata*. Under the Needle Leaved Forest Communities the main species are *Cedrus deodara, Cuprusus torulusa, Auracaria, Abies pindro*. The dominant species in the Shrubs Communities present in the study area are *Berberis asiatica, barberis chitria, opuntia monacantha, Viburnum calinifolium, Coriaria nepalensis, Rubus niveus, Rubus ellipticus, Debregesia longifolia etc*

Species Identification

The high resolution imagery of spatial resolution 2.4m has been used to extract species information. The major species of Nainital are identified on the basis of crown diameter, texture, shapes, structure etc. High resolution imagery provides close view of canopy cover of forest. Based on the visual interpretation the canopy characteristics of major plant species mentioned are as below (Table 1).

Those species which are unidentifiable on satellite imagery are identified during field visit. Collected GPS location on field of the group of particular species and later overlay on the imagery to identify the location. The field photographs also captured along with altitude to understand and analyse the growing condition of species (Table 2).

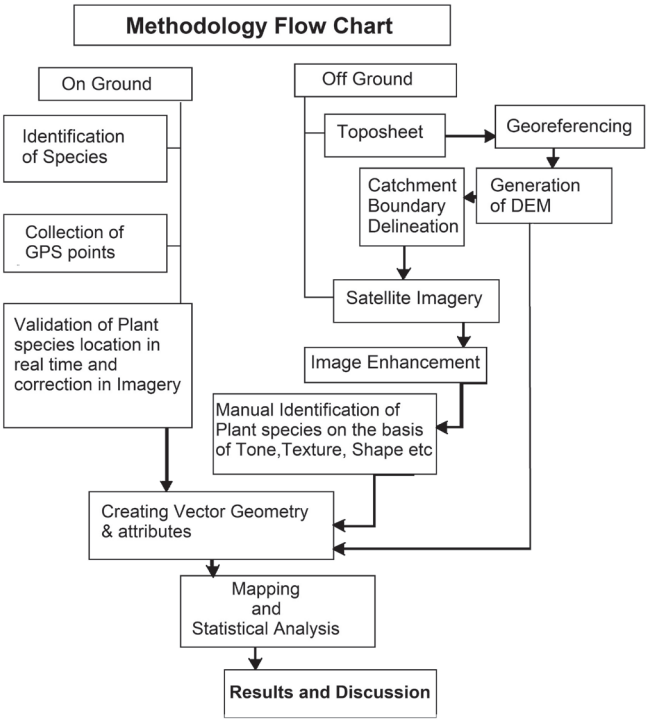
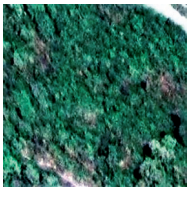


Fig. 2. Flow Chart

Table 1. Parameters identified in Satellite Imagery

	Species/ communities	Crown's Properties	Crown Picture
1	*Quercus Leucotricophora*	Shape: Round or like a shape of flower from the top. Colour: Shiny white & light Green Texture: Smooth Shadow area more visible within the group of trees. Density: Close canopy	
2	*Quercus floribunda*	Shape: Round but tilted in one direction Colour: Lightest green Texture: Coarse Mixed with Quercus Leucotricophora	
3	*Aesculus indica*	Shape: Symmetrical Colour: Faded green Texture: Uniform, Rounded Canopy	
4	*Cedrus deodara*	Shape: Rounded flat canopy Colour: Moderate Green Texture: Rough	
5	*Cupressus torulusa*	Shape: Tall and pointed top Colour: Dark green Texture: Rough	
6	*Mixed Evergreen & Deciduous plant communities*	It is a group of many species which grows together with high density. The species which are not able to identify in imagery are put into this class. In this group of species are identified in field.	
7	*Shrubs*	Shape: Mixed Green leaves with finer texture It looks like a layer of green rough carpet lying on the ground.	

RESULTS

Study substantiates that growth of any species or group of species or any associated species in a particular area somehow dominated by environmental factors. This study indicates areas at an altitude of 2090 m to 2190 m in south facing terrain comprises the Mixed Evergreen & deciduous plant communities in less majority but within the same altitude in the North aspect its growth has sufficient growth due to high amount of organic matter and moisture presence in the soil. The soil is alkaline in southern aspect while it is slightly acidic in northern aspect. The growth of mixed evergreen & deciduous plant communities in slightly acidic soil is good in comparison to alkaline soil.

Earlier study carried out by Chandra et al. (2016) indicates that the Oak forest grows in the region where pH level is acidic. It is confirmed during the field work that Oak forest is dominant in the areas where pH is acidic to alkaline. Troup (1921) found in his study that the high moisture availability in soil promotes the luxuriant Oak growth. Naini Lake Catchment shape is like a bowl as a result one side receives high insolation whereas other receives very less. The area which receives less sunlight is very moist the distribution and density of Oak is very high. The area which has less moisture in soil is covered with stunted and gnarled Oak tree.

In evergreen & deciduous forest some of the species variation is not clearly

Table 2. Identified Species on Ground during field visit

a) *Acer oblungum* an individual tree grows in *floribunda & Cupressus* forest. Elevation – 2110 m; Aspect: Southeast	b) *Cupressus & Floribunda* Forest: Forest floor missing due to snow and excessive rain. Elevation – 2123 m; Aspect: Southeast
	
c) Shrubs with Mixed tree species Elevation-2063m; Aspect: East	d) A forest patch of Mixed Species Elevation: 2220m; Aspect: South
	
e) *Populus ciliata*; Elevation-1980m; Aspect: Northeast	f) *Aesculus indica;* Elevation-2005m; Aspect: North
	

identifiable in satellite imagery due to high density within canopy. The diversity of plant species within evergreen & deciduous forest are *Acer oblungum, Litsea umbrosa, Ilex dipyrena, Julans regia, Fraxinus micrantha, Rhododendron arboretum, Myrica esculenta, Lyonia ovalifolia, Cornus macrophylla, Populus ciliata, Machilus duthei, Alnus nepalensis* etc. These groups of species cover major geographical area of forest comprising an area of 142.40 hectare (see Fig. 5). However, *Quercus Leucotricophora, Quercus floribunda, Aesculus indica, Cedrus deodara, Cupressus torulusa* are identified in satellite imagery (see Fig. 4).

Quercus leucotricophora is a dominant species in Naini lake catchment among all other native species covering an area of 78.23 hectare (see Fig.5). It is observed that the physical factors such as altitude, slope amount and aspect etc doesn't hamper its growth upto some extent. It may be because of suitable micro-climatic parameter of area such as precipitation, temperature, high insolation etc.

Micro-climatic or environmental factors of the study area having very suitable ecological conditions that provided suitability to grow many exotic planted species such as *Gingko biloba, Populus nigra, Araucaria canninghami* etc.

Under growth in the area of *Cupressus torulusa* and *picea smithiam* forest is very poor which lies in southeast and southern slopes. The seasonal grass grow for a few months but other species do not survive may be due to snowfall and very low temperature during winter. In his study Gornish et al. (2015) also pointed out that snowfall and very low temperature in the high altitude areas use to support only seasonal growth of plants.

Absence of under growth in scattered forest of *Cupressus torulusa* in southern aspect of basin appears due to frequent heavy rain in the basin as conifer species unable to intercept the rain and snow and causes the accelerated soil erosion. Surface runoff clears the ground along with newly dispersed seeds and small plants.

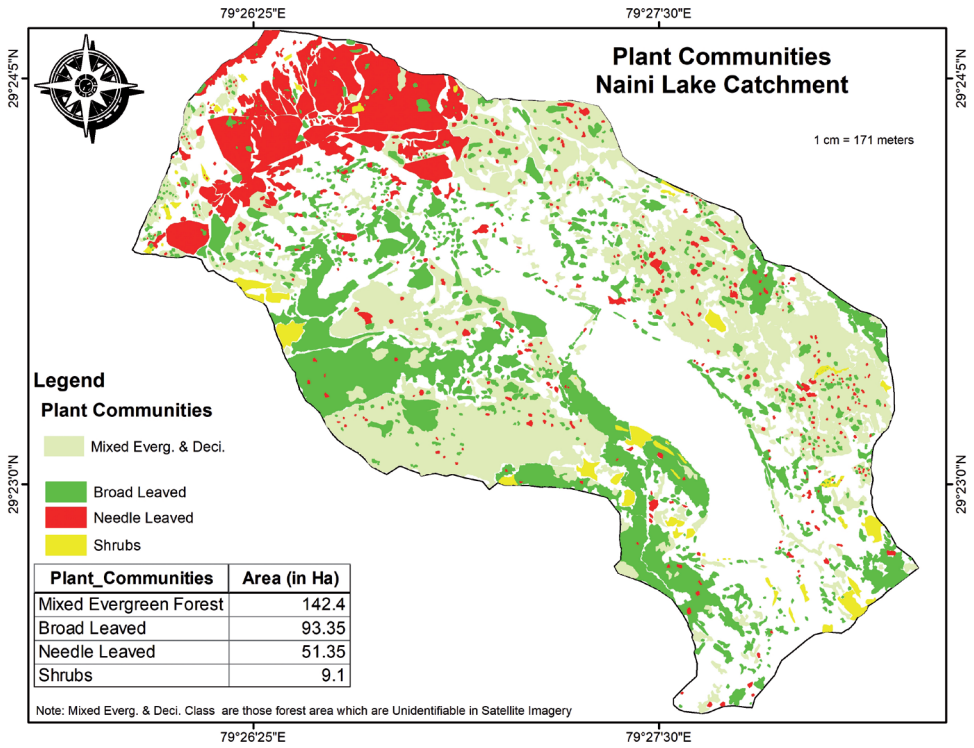
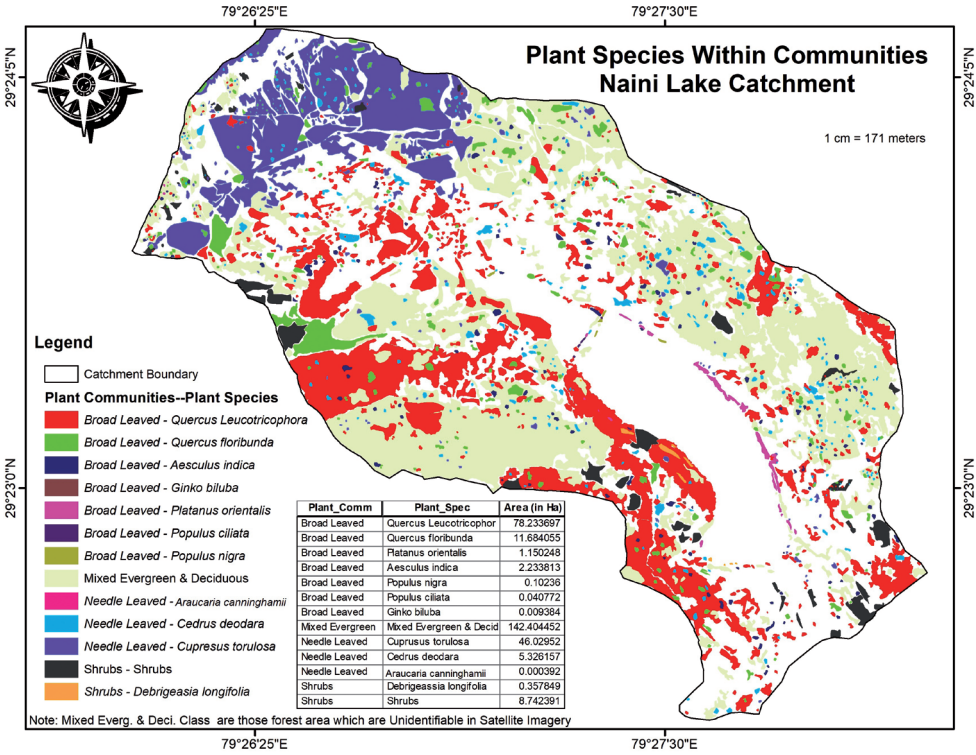


Fig. 3. Plant Communities mapped from Satellite Imagery



Plant_Comm	Plant_Spec	Area (in Ha)
Broad Leaved	Quercus Leucotricophor	78.233697
Broad Leaved	Quercus floribunda	11.684055
Broad Leaved	Platanus orientalis	1.150248
Broad Leaved	Aesculus indica	2.233813
Broad Leaved	Populus nigra	0.10236
Broad Leaved	Populus ciliata	0.040772
Broad Leaved	Ginko biluba	0.009384
Mixed Evergreen	Mixed Evergreen & Decid	142.404452
Needle Leaved	Cuprusus torulosa	46.02952
Needle Leaved	Cedrus deodara	5.326157
Needle Leaved	Araucaria canninghamii	0.000392
Shrubs	Debrigeassia longifolia	0.357849
Shrubs	Shrubs	8.742391

Fig. 4. Identified Plant Species in satellite imagery

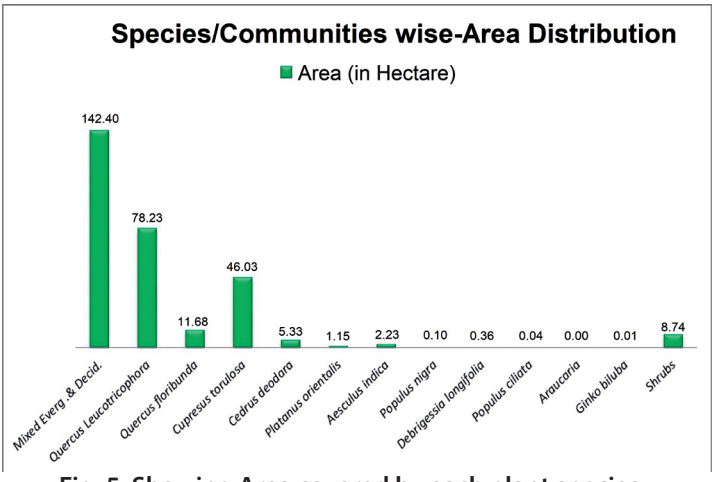


Fig. 5. Showing Area covered by each plant species

Altitude wise Distribution of Plant Species

The species *Evergreen & Deciduous, Quercus floribunda* and *shrubs* occurred abundantly at the altitude 2090-2190m. While the Cedrus *deodara, Aesculus indica & Quercus leucotricophora* grows well at an altitude of 1990-2090m and the *Cupressus torulosa* distributed well at the altitude 2090-2190m and 2390-2490m (see Fig. 7 & 8). The detail altitudinal zone wise area distribution of plant species are specified in Table 3.

Aspect wise distribution of Species

Quercus leucotricophora & Mixed evergreen & Deciduous species are well distributed in Northern aspect and cover 20,000-25,000

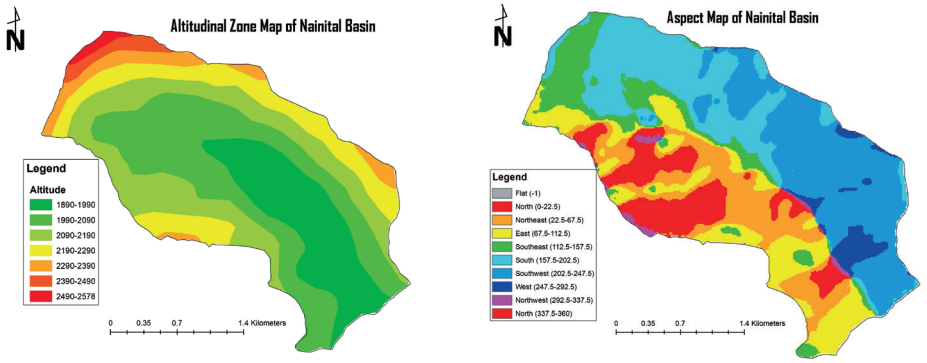


Fig. 6. Map of Altitudinal zone and Aspect

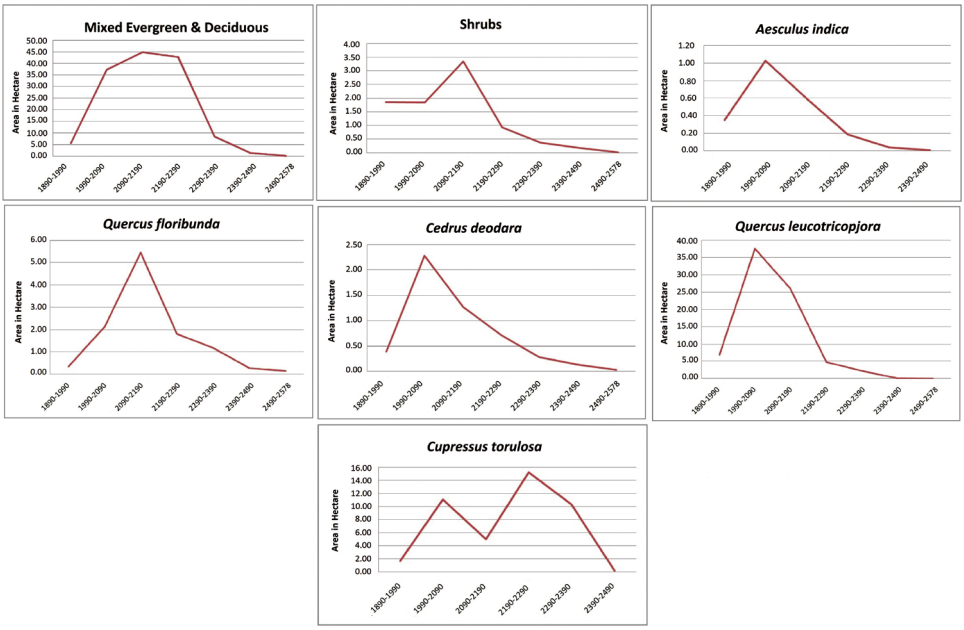


Fig. 7. Graph showing distribution trend of plant species in respect of altitude

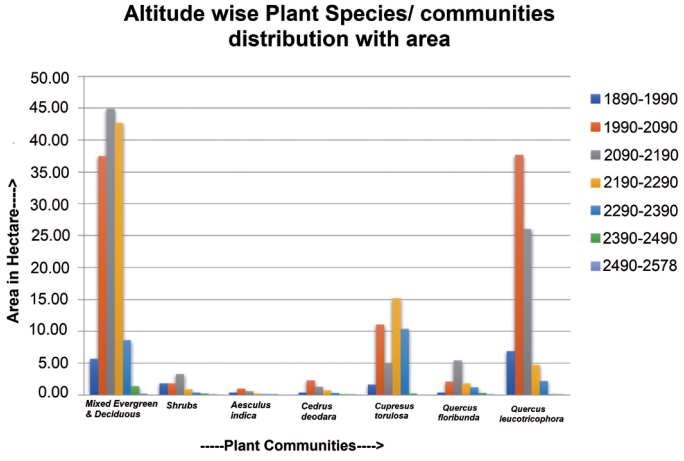


Fig. 8. Altitudinal zone wise area distribution of plant species

Table 3. Plant species with altitudinal zone wise area (in Hectare) distribution

Altitude (in m)	Mixed Evergreen & Deciduous communities	Shrubs	Aesculus Indica	Cedrus deodara	Cupressus torulusa	Quercus floribunda	Quercus leucotricophora
1890-1990	5.69	1.86	0.35	0.39	1.65	0.34	6.86
1990-2090	37.49	1.84	1.03	2.28	11.07	2.13	37.64
2090-2190	44.89	3.34	0.60	1.27	5.00	5.44	26.04
2190-2290	42.71	0.93	0.19	0.72	15.21	1.81	4.77
2290-2390	8.58	0.37	0.04	0.28	10.32	1.17	2.18
2390-2490	1.43	0.18	0.01	0.13	0.18	0.27	0.08
2490-2578	0.16	0.02	0.00	0.03	0.00	0.14	0.00
Total----->	140.94	8.53	2.21	5.10	43.43	11.30	77.57

m^2 area. *Cedrus deodar & Cupressus torulosa* cover 20,000-30,000 m^2 area in Southern aspect. However, the other species i.e. *Aesculus indica, Quercus floribunda & shrubs* are distributed constantly over the area irrespective of its bearing on the slope aspects (see Fig. 9).

DISCUSSION

Pre field and post field work based on remote sensing data provided accurate information on identification and mapping of forest species. Forest habitat characteristics especially altitude & slope aspect and their impact on forest species is carried out using GIS software.

The variation and impact of altitudinal gradients on vegetation structure and composition is not only found in Himalayan region but also in other parts of the world, one of such study carried out by Alberto et al. (2009) in the hills of Mexico

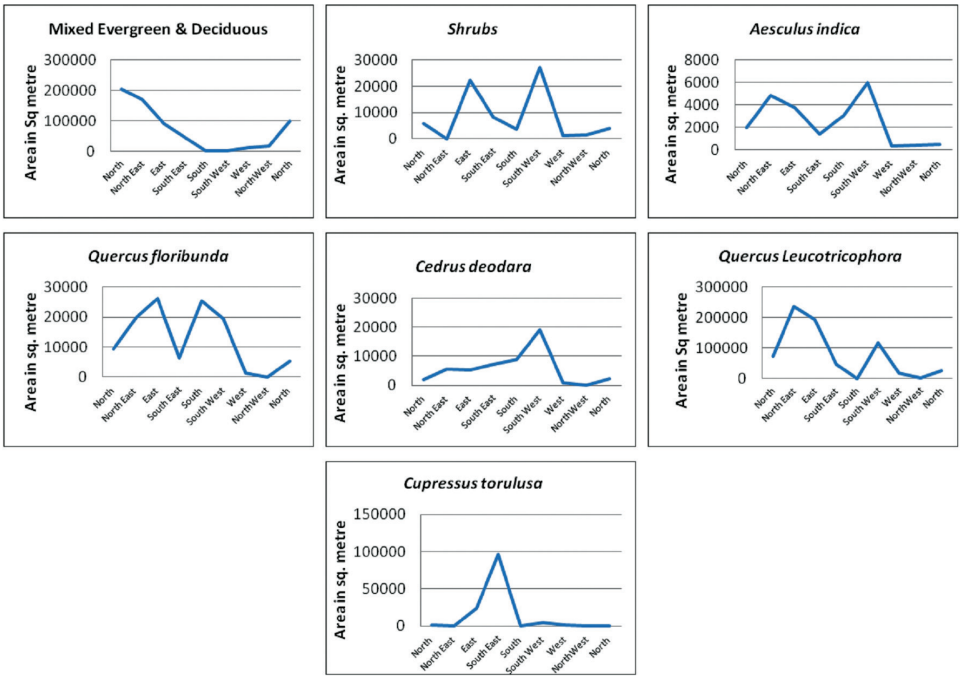


Fig. 9. Graph showing distribution trend of plant species in respect of aspect

at Mt. Cerro Verde. He found that altitudinal gradients are much more dominant than climatic factors to influence the vegetation structure. These findings match with our results as the local climatic variables are not influencing much the vegetation structure but altitude and slope aspect do have impact on it. The similar study undertaken by Sharma et al. (2009) in Garhwal Himalaya is also mentioned that species richness and diversity are largely controlled by morphometric features and climatic factors.

Altitudinal variation and slope aspect impact on identified species distribution is graphically explained. But to understand the actual trend in past decades to present the historical data required so that a comparative study can be made.

In the study area the occurrence of *Cedrus deodara* is everywhere, it occurs every where irrespective of slope aspects and soil conditions. But on the other hand Quercus leucotricophora grows in place where high moisture and drainage density. It is also plays as umbrella species because it supports to grow many shrubs and grasses under its canopy.

As the statistical data showing the distribution of Quercus leucotricophora is mostly concentrated in 1990-2190 metre and is decreasing in higher and lower altitude (see Table 3). The concentration of particular or group of species controlled by altitude is also found in the Qilian Mountain by Jin et al. (2008). They found that the vegetation growth and distribution is largely modified by rising altitude in mountain system.

Canopy texture, shape and colour are considered during visual interpretation of satellite data for species identification. Prior field knowledge of plant species characteristics and spatial distribution made easier to identify the forest species.

Overall observation indicates that species are scattered everywhere and some are confined to a particular altitudinal range and slope aspect.

CONCLUSION

Forest monitoring and management is an important task which is very essential to balance the ecosystem. The study is carried out to understand the plant distribution and occurrence with respect to changing elevation and slope aspects. High resolution satellite data are found to be quite helpful to make study accurate and time saving. Most of the plant species are easily identified in satellite imagery with the help of crown or canopy's structure, the plant diversity and forest cover can map easily.

Study indicates that the distribution of species is slightly affected by altitudinal variation. However, area under shrubs is more in the lower altitude and goes on decreasing towards increasing altitude. *Cupressus torulusa* is covers more are towards rising altitude particularly in the southern aspect of the cathchment.

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