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Assessment of Land Use Land Cover and Dominant Forest Cover Along Altitudinal Gradient of Bageshwar District, Kumaon Himalaya, India

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Abstract Study of forest resources of any region or country is essential requirement for sustainable growth and development of forest ecosystem. Assessment of forest resources of any particular region will help us to know the actual status of the ecosystem. Realizing the importance of forest resources, the present study was conducted to analyze the major forest types with their composition and distribution based on spectral reflectance using Landsat 8 data along altitudinal gradient of Bageshwar District, Kumaon Himalaya. In the study area, this is the first time to identify and classify the dominant forest tree species with spectral reflectance which overcome the conventional field survey method. The study area was classified into 5 major land use land cover classes which include 4 forest classes viz. Mixed Deciduous Forest, Pine Forest, Mixed Pine Forest and High Altitude Mixed Forest and all other classes into one as Non-Forest class which include Snow Cover, Scrubs, Agriculture, Settlement and Dry River Bed. The study area contributes about 72% forest area and 28% non-forest area. Among the 4 forest classes, pure pine forest is the dominant forest class ranges from 1300 MSL to 2300 MSL and occupied 39% of total forest cover followed by high altitude mixed forest ranges from 2400 MSL to 3600 MSL and occupied 28% of forest cover, mixed pine forest ranges from 1300 MSL to 2400 MSL and occupied 27% of forest cover and the least is the mixed deciduous forest ranges from 677 MSL to 1300 MSL and occupied 6% of forest cover. The dominant tree species of whole forest cover is the *Pinus roxburghii* (Chir Pine) occurred in both pine forest and mixed pine forest followed by *Quercus* spp. (Oak) dominant in mixed pine forest and high altitude mixed forest. The analysis of forest class area at different aspects shows that both mixed deciduous forest and mixed pine forest has a similar pattern in distribution, maximum at southern aspect followed by eastern aspect and least at northern aspect. But in the case of pine forest, distribution pattern is completely opposite when compared with both above mention forest classes. The distribution pattern of high altitude mixed forest shows more or less equal distribution patterns at all the aspects. The study illustrate the capabilities of Landsat 8 data spectral reflectance of vegetation in identification and distribution of dominant forest species along altitudinal gradient and create database for mapping, species specific estimation of biomass and carbon pool at large area.

Keywords Forest resources, Ecosystem, Spectral reflectance, Deciduous forest, Kumaon Himalaya.

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Introduction

The presence of forest area in a region, country and globally play a significant role in sustainable development of the environment. As the forest represents the biotic component of ecosystem, any disturbances in forest can create degradation of the environment such as loss of habitat, unbalance in water cycle, soil erosion, carbon sequestration. The forest ecosystem of Himalayan region is a very fragile ecosystem which prone degradation due to any changes cause by external factors. Thus, the study of forest composition, structure, diversity and habitat are very essential elements for sustainable management and protection of forest in Himalayan region. Singh and Singh (1987), Singh et al. (1987) reviewed the information on the vegetation of Himalaya forest. They also classified the forest types on the basis of mean annual temperature and mean annual rainfall. Besides the rainfall and temperature, altitudinal gradient also play an important role in forest composition and distribution in Himalayan region. Thus an environmental gradient which is related to abiotic factors such as temperature, rainfall, altitude, topography, humidity provide a good topic of investigation for variation in species composition and diversity. Kharkwal et al. (2005), mention that although plant community of a region is a function of time however, altitude, slope, latitude, aspect, rainfall and humidity play a role in the formation of plant communities and their composition. All these abiotic factors have been explained with reference to climate, productivity, biotic interaction, habitat heterogeneity and history (Willig et al. 2003, Qian and Ricklefs 2004). Mountain regions around the globe usually show very diversity and unique climatic and edaphic factors which provides existence of distinct forest types and high diversity in biological communities, which help in supporting high level of endemism (Gentry 1993).

Earlier, some of the studies have described the distribution and composition of vegetation of Kumaon (Singh and Singh 1984, Tiwari and Singh 1985, Upreti et al. 1985, Singh and Singh 1987, Dhar et al. 1997) and Garhwal Himalaya (Nautiyal et al. 2004, Anthwal et al. 2006). The Himalayan forest vegetation has highly diverged in composition along altitudinal gradient. The occurrence of forest vegetation types along altitudinal gradient are tropical dry deciduous forest, sub-tropical dry deciduous forest, temperate forest, alpine and alpine meadow above timberline (Singh and Singh 1992). Saxena et al. (1985), Adhikari et al. (1992) have also described the altitudinal variation in vegetation and vegetation types with change in altitudinal gradient. Along with altitude, the diversity and composition of forest also changes from place to place due to variation in topographical features such as slope, aspect (Singh 2006). Beside the altitude and topography, the geology and soil types also have influence on composition and distribution of vegetations cover (Puri et al. 1983). Though the composition and distribution of forest changes place to place, forest areas are mainly dominated by *Pinus roxburghii* (Chir Pine) and *Quercus* species (Oak). The present work provides detailed information about land use land cover classes, vegetation composition, major forest types of Bageshwar District, Kumaon Himalayan region. Our results generate data based on land use land cover classes, distribution and composition of vegetation types along altitudinal gradient and at different aspects base on digital image classification of satellite data which help in mapping of distribution and composition of vegetation cover of entire study area.

Materials and Methods

Study area

The Bageshwar District comes under the Eastern Kumaon region of Uttarakhand State in North India. It has an area of 2,298 km^2 and lies approximately between 29°40'50" to 30° 19'10" North latitude and 79°28'5" to 80° 9'40" East longitude. It has an annual precipitation of 1221 mm with an annual average temperature of around 20.4 °C. The warmest month is June with an average temperature of 27.3°. The coolest month is January, with an average temperature of 11°C. The climate of the entire study area in influenced by monsoon pattern of rainfall.

The study area occupies altitudes ranges from 677 to 6610 m MSL (Fig. 1). The climate typically comes under the sub-tropical types in low altitudes and the moist temperate types in high altitudes. The temperate region of higher altitudes receives moder-

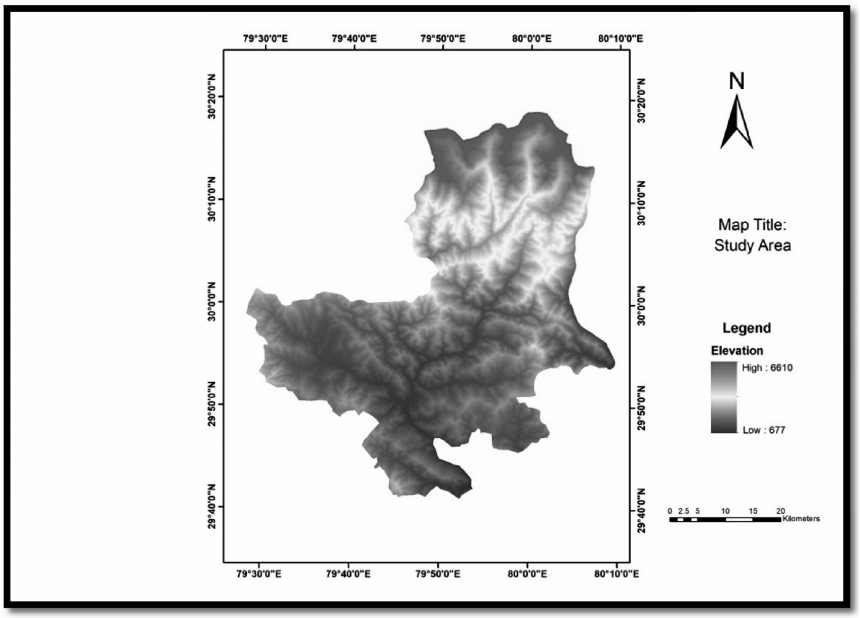

Fig. 1. Study area.

ate to high snowfall in the month of December to February.

Satellite data and analysis

In the present study, Landsat 8 satellite data of November 06, 2016 was used for image classification for land use land cover mapping. Radiometric correction of satellite data was performed using FLAASH model of ENVI software to remove the topographic and atmospheric effects. Orthorectified Landsat TM satellite image was used as a reference image for image to image registration. For generation of major land use land cover classes map, supervised classification using maximum likelihood classifier (MLC) is carried with image processing software ENVI 4.8. The maximum likelihood classification algorithm was selected because it has the ability to incorporate the statistics of the training samples before assigning the land covers to each pixel. For image classification, 16 training sets of each land use classes were chosen as ground control points (GCPs). The study area is classified with 9 land use land cover (LULC) classes including 4 major forest classes namely High Altitude Mixed Forest, Mixed Pine Forest, Pine Forest, Mixed Deciduous Forest and with 5 Non-Forest classes namely Agriculture, Dry River Bed, Scrubs, Settlement and Snow. All the classes other than 4 forest classes were merged into 1 class as non-forest class. Distribution of each forest class at different aspects also analysis using digital elevation model (DEM).

Survey and sampling

During the survey of the study area, the ground truth verification of all the non-forest classes and 4 major forest types according to elevation, tree species composition and their distribution were identified and verified. All the land use land cover classes sampling points data and physiographic factors (i.e. altitude, aspect) were recorded with coordinates using handheld GPS. All the 4 major classified forest types according to the elevation and composition of dominant tree species are given in Table 1.

Results

LULC classes

Among all the 9 classified land use land cover classes,

Table 1. Forest type with elevation and dominant tree species.

Sl. No.	Forest class	Altitude (m)	Dominant tree species
1	Mixed deciduous forest	677–1300	*Mallotus philippensis, Toona aliata, Holoptelea integrifolia, Macaranga pustulata, Anogeissus latifolia*
2	Mixed pine forest	1300–2400	*Pinus roxburghii, Quercus leucotrichophora, Quercus floribunda, Betula alnoides, Cedrus deodara, Acer caesium, Aesculus indica*
3	Pine forest	1300–2300	*Pinus roxburghii*
4	High altitude Mixed forest	2400–3600	*Quercus semecarpifolia, Abies pindrow, Abies spectablis, Betula utilis, Rhododendron arboretum, Rhododendron barbatum, Acer cappadocium*

pine forest is the dominant class which occupies about area of 644 km^2 which contribute about 28% out of total area of 2298 km^2, followed by high altitude mixed forest, mixed pine forest, snow cover, scrubs, mixed deciduous forest, agriculture, settlement and dry river bed as shown in Fig. 2.

In the present study, after merging of all non-forest classes in 1 class, whole area was finally classified into 5 major land use land cover classes with 4 major forest classes viz. Mixed Deciduous Forest, Pine Forest, Mixed Pine Forest and High Altitude Mixed forest according to elevation and tree species composition and all others as Non-Forest class which include Snow Cover, Scrubs, Agriculture, Settlement and Dry River Bed as shown in Fig. 3. When we consider the forest and non-forest area of study site, major land cover is the forest area. Out of total study area of 2298 km^2, about area of 1655 km^2 (72%) comes under forest area and area of about 643 km^2 (28%) comes under non-forest area.

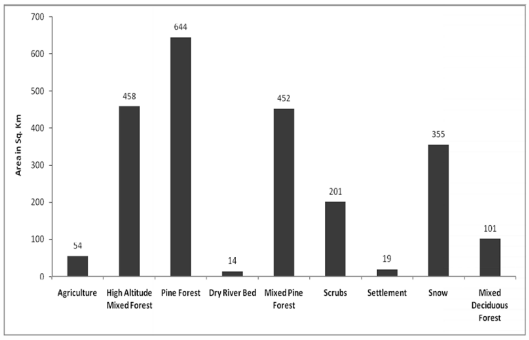

Fig. 2. Graph showing area (km^2) occupied by land use land cover classes.

Tree species composition

At present study site, altitude of classified mixed deciduous forest ranges from 677 m to 1300 m MSL and occupies about area of 101 km^2 out of total geographical area of 2298 km^2 and total forest area of 1655 km^2 which contribute about 4.40% of total geographical area and 6% of total classified forest area. Its contributes least forest area among other forest classes. The identified dominant tree species in this class were *Mallotus philippensis, Toona aliata, Holoptelea integrifolia, Macaranga pustulata* and *Anogeissus latifolia.* The diversity and richness of shrubs also more as compared to pine and high altitude mixed forest. The mixed pine forest, altitude ranges from 1300 m to 2400 m MSL which occupies area of 452 km^2. It contributes about 19% of total geographical area and 27% of total classified forest area. At altitude of 1200 m to 1400 m MSL, is the transition zone between mixed deciduous forest and pine forest/mixed pine forest from where pine belt strat and extended up to altitude of 2300 m MSL. The dominant tree species found in this class were *Pinus roxburghii, Quercus leucotrichophora, Quercus floribunda, Betula alnoides, Cedrus deodara, Acer caesium and Aesculus indica.* It has also more shrub diversity and richness as compared to pine forest and high altitude mixed forest and richness gradually decreases with increase in elevation.

The classified pine forest here represents pure pine forest i.e. *Pinus roxburghii*. It extends from altitude of 1300 m to 2300 m MSL and occupies area of 644 km^2 which contributes 28% of total geographical area and 39% of total classified forest area. It was the

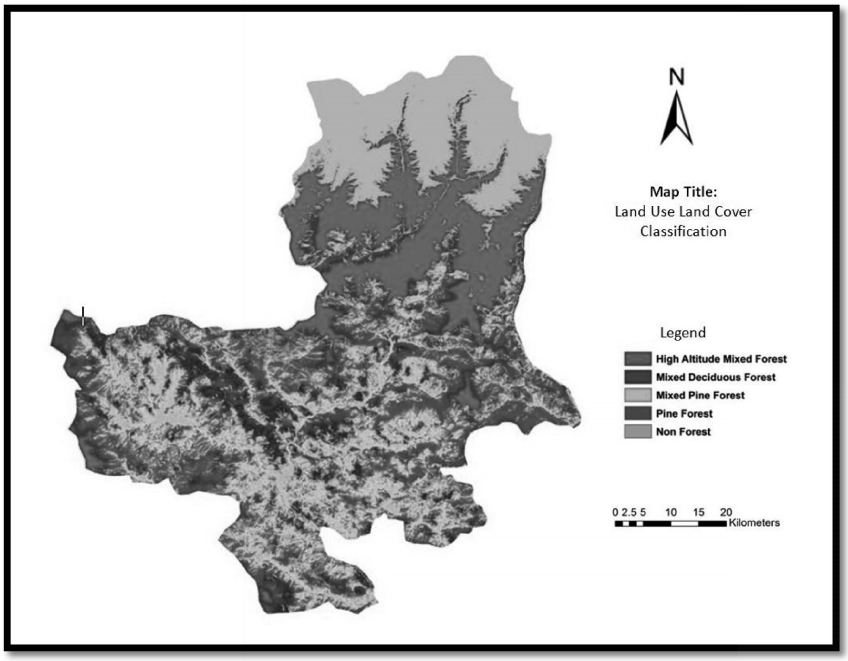

Fig. 3. Classified land use land cover map.

dominant forest class and contributes highest forest area among 4 classified forest classes. Pine forest exhibited absolute dominance in terms of basal cover as compared to other classified forest classes which support least diversity of surubs species. *Lantana camara* was the dominant shrub in this forest. The high altitude mixed forest is the second dominant classified forest class ranges from altitude of 2400 m to 3600 m MSL. Its occupies area of 458 km^2 which contributes 20% of total geographical area and 28% of total classified forest area. It has less shrubs diversity and richness as compared to mixed deciduous forest and mixed pine forest. The diversity of shrubs sharply decreases in higher elevation. In this class, the dominant tree were species were *Quercus semecarpifolia, Abies pindrow, Abies spectablis, Betula utilis, Rhododendron arboretum, Rhododendron barbatum* and *Acer cappadocium.*

Distribution of forest class at different aspects

The distribution of classified forest classes at 4 different aspects were analysis using digital elevation model (DEM), whose area wise distribution are shown in Fig. 4.

The both mixed deciduous forest and mixed pine forest shown similar patterned of area distribution and occupies maximum area at southern aspect (36% and 40%) followed by eastern aspect (33% and

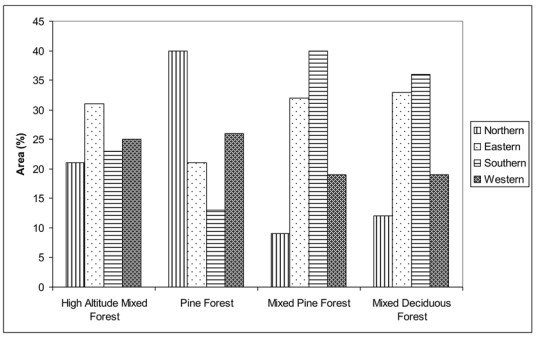

Fig. 4. Distribution of classified forest class at different aspect.

32%), western aspect (19% and 19%) and northern aspect (12% and 9%) respectively. In the case of pine forest, maximum area under northern aspect which contributes about 40% total pine forest followed by western aspect (26%), eastern aspect (21%) and (13%) southern aspect. In high altitude mixed forest, maximum area under eastern aspect (31%) followed by western aspect (25%), southern aspect (23%) and northern aspect (21%). But in this class, less variation in distribution of area in the all aspects that is more or less equal in distribution in the all aspects.

Discussion

In the present study, among the LULC classes, forest cover was the major class which categorized into 4 forest classes namely Mixed Deciduous Forest, Mixed Pine Forest, Pine Forest and High Altitude Mixed Forest according to elevation and dominant tree species. Among 4 classes, pine forest occupies maximum area and mixed deciduous forest occupies least area. The mixed pine forest and high altitude mixed forest shows more variation in distribution of tree species along altitudinal gradient. The analysis of distribution of different forest classes at different aspects revealed that mixed deciduous forest and mixed pine forest shows similar patterned in distribution and pine forest shows just opposite in distribution pattern of both forest classes. The high altitude mixed forest shows more or less equal in distribution in all the aspects.

The classification of forest class on the basis of spectral reflectance of vegetation cover in satellite imagery gives very good information of distribution of vegetation cover along altitudinal gradient. The variations in spectral reflectance of vegetation cover on satellite image help in digital image classification through image pro cessing software. In the past, authors have analyzed and documented the forest cover on the basis of species composition, distribution and community structure by plot sampling techniques along altitudinal gradient (Saxena et al. 1985, Adhikari et al. 1992, Rawal and Pangtey 1994, Dhar et al. 1997, Hussain et al. 2008). In this study, classification of forest covers types mainly done by analysis of variation in vegetations spectral reflectance along altitudinal gradient though digital image classification as mentioned in results. Earlier, some authors classified and documented forest types on the basis of dominant tree species by surveying and sampling along altitudinal gradient (Saxena and Singh 1982, Ram et al. 2004, Kharkwal and Yaswant 2010). The composition of dominant tree species in classified forest types of the study area along altitudinal gradient found to be similar with earlier reported (Singh and Singh 1987, Dhar et al. 1997).

In the study area, *Pinus roxburghii* and *Quercus* sp. were found to be dominant tree species of forest covered. The occurrence of *Pinus roxburghii* (Chir Pine) starts from altitude of 1300 m MSL up to 2300 m MSL (Ralhan et al. 1982 and 1985). In some areas, it distributed from altitude of 1000 m MSL. The pine forest mainly occurred as pure pine forest with absolute dominant basal cover and *Lantana camara* as a dominant shrub in the forest (Saxena and Singh 1982). *Quercus* species represent the climax species of the study area whose altitudinal distribution varies place to place. Generally its distribution starts from altitude of 1400 m MSL to 3300 m MSL. Some authors documented that, *Quercus* species distributed between 1000 m MSL to 3500 m MSL and the dominance of particular *Quercus* species depends on altitudes (Singh et al. 2016). Among the *Quercus* species, *Quercus leucotrichophora* found to be distributed from altitude of 1300 m MSL to 2200 m MSL, with high abundance between 1800 m - 2000 m elevation. In the past studies Singh and Singh (1986), Rana et al. (1989), Zobel and Singh (1997), Singh and Raat (2012) have reported and documented the occurrence of *Quercus leucotrichophora* between 1000-2500 m elevations, with high abundance around 2000 m elevation. At the elevation between 2000 m to 2400 m, *Quercus leucotrichophora* also associated with *Quercus floribunda* and *Quercus lanuginosa* and disappeared gradually with dominant of *Quercus semecarpifolia* beyond 2400 m elevation which is distributed up to 3000 m MSL. In the past studies, Singh et al. (1994), Singh and Singh (1986) also reported that *Quercus semecarpifolia* present between 2366-3000 m and 2400-3600 m respectively. The classified forest type viz. mixed pine forest between elevation 1300 m to 2300 m was dominant with tree species of *Pinus roxburghii, Quercus, leucotrichophora* and *Quercus floribunda* which were also associated

with other tree species such as *Persea odoratissima, Bauhinia retusa, Betula alnoides, Cedrus deodara* and *Acer caseium* (Saxena and Singh 1982).

In high altitude mixed forest, the identified dominant tree species were *Quercus semecarpifolia, Abies pindrow, Aesculus indica, Rhododendron arboreum, Betula utilis, A. caesium, Rhododendron barbatum, R. campanulatum* and *Acer cappadocium* which were similar as reported by Rawal et al. (1994). In the past studies, similar tree composition and distribution also reported elevation ranges between 2400 m to 3600 m MSL (Adhikari et al. 1991, Rawal and Pangtey 1994, Gairola et al. 2008). This classified forest types also support good basal cover of shrubs species like *Thamnocalamus spathiflora, Arundinaria falcata, Berberis umbellata* and *Chimonabambusa jaunsarensis* (Rawal and Pangtey 1994).

When we consider the distribution of forest types in different aspects, all classified forest types were found to be variation in distribution pattern. Saxena and Singh (1982) reported the variation of distribution of forest type on different aspects on the basis of dominant tree species. In the present study area, the distribution of all the 4 classified forest types in 4 different aspects viz. northern, eastern, southern and western aspects shown that, mixed deciduous forest and mixed pine forest were found that the growth of tree species were more on warmer slopes that is on southern and eastern aspects and poor growth on northern aspect. It is may be due to both forest types, mixed deciduous and mixed pine forest required more sunlight interception and also keep both the slopes warmer during day time. In the case of pine forest, majority of area occupied on northern aspect followed by western aspect. These 2 aspects much cooler than eastern and southern aspects due to shading effect of Terrain. It may be due to that, *Pinus roxburghii* prefers relatively cooler aspects for better growth and development. Dwivedi and Mathur (1978) also reported that the growth of *Pinus roxburghii* was poor on warmer slopes. The distribution of high altitude mixed forest found to be nearly uniform in all the aspects. It may be due to that the microclimatic variation due to aspects differences in higher altitude is very less and thus may not be so much influencing on vegetations.

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