Impact of Anthropogenic Activities on the Forest Ecosystem of Nanda Devi Biosphere Reserve, Garhwal, Uttarakhand

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KEY WORDS: People. Forest. Environment. Nanda Devi Biosphere Reserve. Anthropogenic pressure. Garwal. Himalaya. Uttarakhand.

ABSTRACT: The area of present study is situated in the protected area 'Nanda Devi Biosphere Reserve' of Garhwal Himalaya (Uttarakhand). The area has unique features in all aspects of biodiversity conservation having distinct religious and cultural faiths, climatic conditions and soil characteristics due to its wilderness location on one hand and the natural habitat of tribal communities on other. The people of the study area belong to ethnic groups called 'Tolchha' and 'Marchha Bhotia'. Thus, the tribal people of Nanda Devi Biosphere Reserve have a long history of high dependency on their adjoining forests for their household needs and livelihoods for generations since time immemorial. In this study, estimation was made for dependency of the tribal people on the natural forests and their quantification of uses of fuel wood, fodder and other NTFPs have been attempted. Based on this study, it was observed that the villagers near the road have low dependency on their adjacent forests as compared to the villagers of remote and inaccessible locations. Rain-fed agriculture is the major occupation of the people though simultaneously they dependent on forests for their livelihood. They collect a large amount of fuel wood, fodder, NTFPs such as medicinal and aromatic plants, wild edible fruits and vegetables etc. for their home requirements. Declining forests resources with increasing population and increasing demands of the people for their living and for their livestock on the forests require optimal management of available resources. These aspects of anthropogenic pressure on the natural forest ecosystems of the Himalaya have been discussed.

INTRODUCTION

The present study was conducted in the buffer zone of the 'Nanda Devi Biosphere Reserve'. It is situated in the Himalayan highlands Biogeographic province-2B in India. The area is completely protected since 7th January, 1939. When it was declared as a sanctuary, now it has been included in the list of 'World Heritage Site' since 1992. The area is reputedly one of the most spectacular wildernesses having qualitatively as well as quantitatively unique biota, cultural heritage, religious faith, climate and soil type in the world. Whereas, geographically it falls between 30°17'N to 30°41'N latitude and 79°40'E to 80°05'E longitude and make headwaters of

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Dhauliganga and Rishiganga, tributaries of the national river Ganga in Uttarakhand. The study area comprises of heterogenous landscape with respect to topography, natural vegetation and microclimate. Whereas, geologically it constitutes N-W to S-E trending belt and occurs in a higher grade of metamorphism represented by mica gneiss, kyanite-silliminate and leuco-gneisses. The parent material mainly represents crystalline rocks and comprises of garnetiferous mica, schists, garnet mica and mica quartzite.

The Central Himalaya with its dramatic differences in altitude and climate supports a great variety of forest ecosystems. The moist montane evergreen broad-leaved and mixed coniferous are found between 1500 to 3500 m elevation zone (Singh *et. al.*'84). Major protected areas such as 'Nanda Devi Biosphere Reserve' is situated in this zone and they contain even the sub-alpine and timber line forests, alpine grazing lands and perpetual snow cover zone. Three basic farming systems are supported by the vast forest resources of the Central Himalaya. These are: livestock farming. mixed livestock-crop and mixed crop-livestock farming system. Though, the first two types used to be the predominant farming systems of 'Nanda Devi Biosphere Reserve' area, the last one is becoming more prominent during the last 20 years or so. Such changes impose drastic changes in natural resource use pattern and change the dependency of local inhabitants on forests near their habitations. Majority of rural people in the Himalayan region use multipurpose tree species for their household needs (fuel wood, fodder, timber and NTFPs etc.) and such resource utilization in the region existed for many centuries. The dead, dying, decaying, diseased trees and branches are quite sufficient for the domestic needs throughout the year (Bahuguna,'82). Understanding this dependency of villages on adjoining forests is a complementary aspect of interdisciplinary study, which helps in identifying the various economic groups of any region and their biomass energy requirements. Thus the chief aim of present study is to assess the fuel; fodder and minor forest produce extraction patterns from adjoining forests of the villages.

MATERIALS AND METHODS

Through the participatory discussion was held in adjoining villages (Lata, Reni and Peng villages exists in buffer zone) of the forests and assessment of resources viz., fuel wood, fodder and minor forest produces extracted from the forests was made. This information was verified with field samplings during various collection trips in different seasons. The collected information and field data were analyzed for household size, where possible and indigenous knowledge systems about food supplements, medicine were also documented. The following methods were used for authentic data collection from the field.

RECONNAISSANCE SURVEY

A rapid survey was conducted in six forests and their adjoining villages to collect the baseline information to get acquainted with the villagers about the forest based resources (Silori and Mishra,'96). The baseline information of the forests and its resources were collected by rapid interviews with the people from various walks of life and age-groups. These were mainly informal and semi-structural interviews (Burgess,'82; Clarke,'86; Mukherjee,'95). The baseline information at village level was collected by interviewing headmen of each village (Gram-Pradhan, Sarpanch etc.). Based on this baseline information, detailed questionnaires (Clarke,'86) were designed for door to door survey.

Questionnaire Survey

Two types of questionnaires were designed for the quantification of extracted forest resources viz., un-structured and structured type of questionnaires (Clarke,'86). The un-structured type of questionnaire, basically involved asking questions in random fashion. Information generated in this way served as a baseline for designing detailed structured questionnaires. The structured questionnaire involves asking the questions in same order to different individuals so that the response gathered from various individuals could be compared. This included two types of questions viz., open and close ended questions. The open-ended questions provided an opportunity to respond to express their views freely, while close-ended questions had a narrow range of response and were designed for that information only. Which have limited scope of answers and it was easy to code them during data entry and analysis. About 10% households of various classes (small, medium and large sized households)

were randomly selected from each village for assessment of forest resource quantification.

Information Gathered from Secondary Sources

Simultaneously, the information was also collected from the Government and Semi-Government Department such as Forest, Revenue, Zila Bhesaj Sahkari Sangh, Animal Husbandry Department and NGOs etc. The fuel wood consumption (kg fa^{-1} yr^{-1}) was estimated on the basis of personnel observations made in each sampled households (small, medium and large) over a period of 24 hours by adopting a weight survey method and requested to the heads of each sampled households to monitor and consume the fuel wood that would be burned during that particular day. The fuel wood was weighted by spring balance and then left in kitchen (about 25 kg wood bundle) of the sampled households and politely give some instructions to burn the wood only from the lifted bundle of 25 kg in the kitchen of sample households. On the next day returned to each sampled households, the remaining wood was further weighted and deducted from the original bundle of 25 Kg. That was lifted on the previous day in the kitchen of the sample households to calculate the actual consumption of fuel wood day[1] (Maikhuri and Gangwar,'91). The fodder consumption was estimated based on the daily fodder consumed by the livestock and average quantification for each category of livestock. Thus the total fodder quantity based on the number of livestock belonging various categories (cattle, bovine, equine) were estimated (Nautiyal,'98). The study area is illustrated in Figure 1.

RESULTS

Three villages (Lata, Reni and Peng) are situated in close proximity of the selected forests along with elevation ranging from 2100 to 2500 m on various aspects. Only Lata village has some community forest, managed by the local council. The other two villages (Reni and Peng) do not have any such type of forest land in their jurisdiction (Table 1). All these

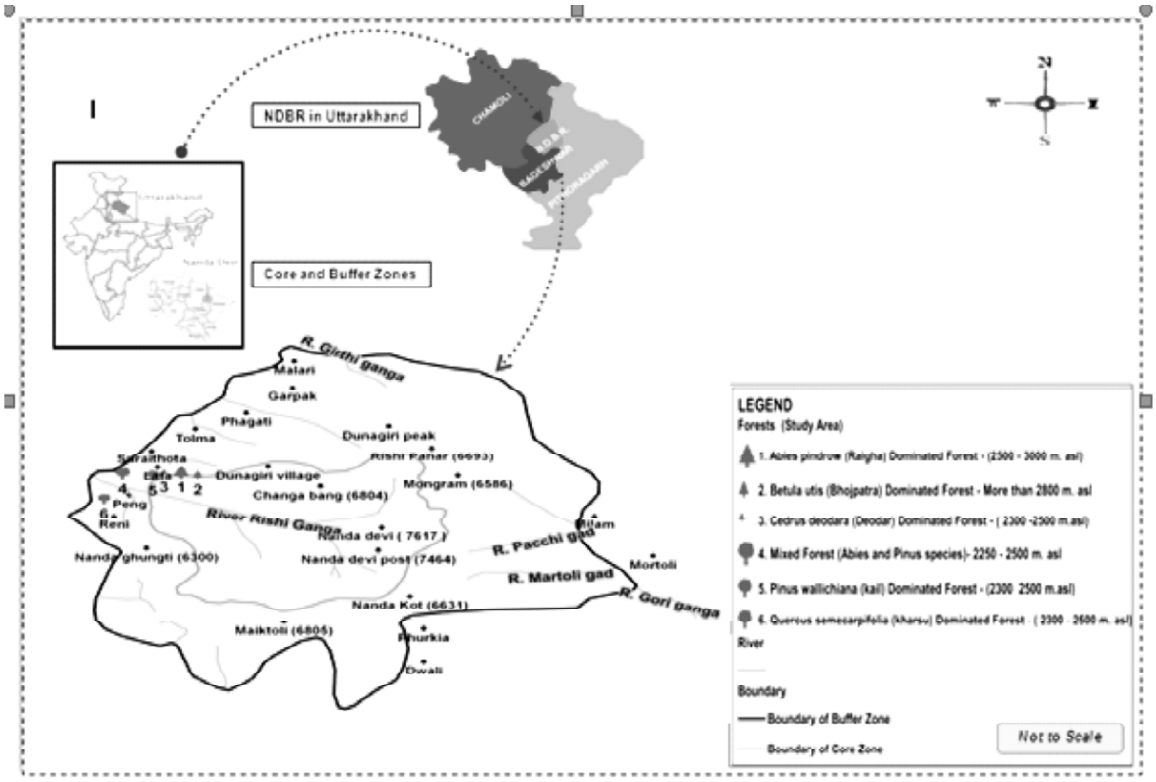

Figure 1: Location map of the study area (Nanda Davi Biosphere Reserve)

TABLE 1

Salient features of the study villages in the buffer zone of "Nanda Devi Biosphere Reserve"

Parameters	Study Villages		
	Reni village	Lata village	Peng village
Elevation (m. asl)	2100	2250	2500
Aspect	N-W	N	S-W
Area under community forests (ha)	—	4.34	—
Area under cultivated land (ha)	10.88	84.88	14.60
Distance from road head (km)	on road head	on road head	4 Km.
Total Households	59	77	31
Small sized (1-4 members)	22 (37.3%)	28 (36.4%)	15 (48.4%)
Medium sized (5-8 members)	28 (47.5%)	41 (53.3%)	15 (48.4%)
Large sized (> 8 members)	09 (15.2%)	08 (10.3%)	01 (03.2%)
Total Population	295	433	206
Male	131 (44.41%)	205 (47.34%)	93 (45.15%)
Female	164 (55.59%)	228 (52.66%)	113 (54.85%)
Total Livestock Population	530	655	272
Cattle (cows and bullocks)	152 (28.68%)	264 (40.30%)	138 (50.74%)
Bovine (Sheep and Goats)	376 (70.94%)	385 (58.78%)	134 (49.26%)
Equine (Horse, Donkey, Mule)	02 (0.38%)	06 (0.92%)	0 (0.0%)

villages like others in the buffer zone depend for all their requirements on forests existing in their vicinity. Lata is the biggest village with 77 households and Peng is the smallest one with 31 households. The households with 5-8 members are predominant in all villages and households with more than 8 members are few. The females out number the males in all the villages and bovine are the mainstay of the livestock though the number of cattle are equally less.

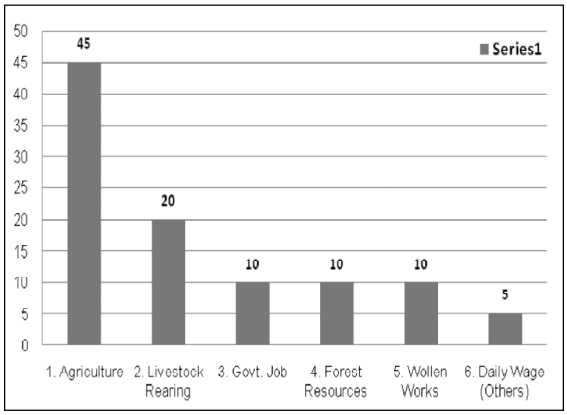

Figure 2: Occupational categories of population (%)

Rain-fed agriculture is the main occupation of more than 45% households (Figure 2) than followed by livestock rearing (20%), Govt. jobs, forest resources collection and woolen handloom works are other occupations, where households of studied villages depend for their livelihoods. A summarized list of the species preferred by the buffer zone villagers for various domestic needs is given in Table 2.

The food supplements and medicinal values of the plants are the major uses for which these resources are harvested. Most of these resources are collected mainly during summer and rainy seasons, as they are available during these periods. The number of resources collected during the winters is least, as their availability is least due to harsh climatic conditions. The moisture contents and fuel wood characteristics of the some prominent trees and shrub species is summarized in Table 3.

Most frequently used species for household fuel supply are *Quercus semecarpifolia* (Kharsu), *Abies pindrow* (Ragha), *Cedrus deodara* (Devdar), *Populus ciliata* (Syan) have high moisture contents while *Betula utilis* (Bhojpatra) and *Viburnum cotinifolium* (Ghyanu) have low moisture contents. The average fuel wood consumption for each category of households in studied villages is given in Table 4.

TABLE 2

Species preferred for various domestic needs by the buffer zone villagers of NDBR

Prominent species		Categorization of forest resources						
Scientific Name	Vernacular	Fl	Fd	Timber		Oils	Wef/v	Mis
				Mj	Mn			
(A) Tree species								
Quercus semecarpifolia Smith	Kharsu	*	*	x	*	x	x	x
Cedrus deodara Loud.	Devdar	—	x	*	x	*	x	x
Pinus wallichiana Wall.	Kail	—	x	—	x	x	x	x
Betula utilis Wall.	Bhojpatra	—	*	—	x	x	x	+
Rhododendron anthopogon D. Don	Taksu	—	x	x	x	x	x	x
R. companulatum D.Don	Semaru	*	#	x	*	x	+	x
(B) Shrub/Grass species								
Artemisia maritima Linn.	Safed-purcha	x	—	x	x	x	x	+
Artemisia nilagirica Cl.Pomp.	Kunja	x	—	x	x	x	x	+
Arundinaria falcata Nees	Ringal	x	—	x	*	x	x	+
Berberis asiatica Roxb.	Kilmora	—	x	x	x	x	+	+
Berberis lycium Rp. Royle	Kilmora	—	x	x	x	x	+	+
Buddleja paniculata Wall.	Pharpatia	—	—	x	x	x	x	+
Cotoneaster baccillaris Wall ex.	Ruins	—	—	x	x	x	x	x
Desmodium elegans Dc.	Chamla	—	*	x	x	x	x	x
Prinsepia utilis Royle	Bhenkal	—	x	x	x	*	x	+
Indigofera heterantha Wall.	Saginu	—	*	x	—	x	x	+
Viburnum cotinifolium D. Don	Ghyanu	—	x	x	*	x	+	x
Wikstroemia canescense Meissn	Mario	—	—	x	x	x	x	x
Nepeta discolor Royle	Khirku	—	—	x	x	x	x	+
(C) Miscellaneous species								
Deplezium esculentum Retz. SW.	Lingura	x	x	x	x	x	*	x
Morchella esculenta Wall.	Guchchhi	x	x	x	x	x	*	x
Parmelia cirrhata Wall.	Jhula	x	x	x	x	x	x	+

Legend

(i) Forest Resources: Fl - Fuel wood; FD - Fodder; Wef/v - Wild edible fruits and vegetables and Mis - Miscellaneous.

(ii) x means no use; + is other uses; * means highly preferred; - means less preferred by the villagers and # refers to the leaves are highly poisonous for livestock.

TABLE 3

Species preferred for various domestic needs by the buffer zone villagers

Prominent species		Moisture (% ± SE)	Fuel wood characteristics
Scientific name	Vernacular		
Abies pindrow Royle	Ragha	55.47±1.25	High density wood and low ash contents.
Betula utilis D. Don	Bhojpatra	24.35±1.95	Medium density wood and low ash contents.
Corylus jazquemontii Dene	Kabasi	20.69±1.31	Medium density wood and low ash contents.
Cedrus deodara Loud.	Devdar	58.38±2.20	High calorific value and high ash contents.
Cupressus torulosa D. Don	Surai	23.98±0.87	Medium calorific value and high ash contents.
Pinus wallichiana Wall.	Kail	28.27±2.05	High calorific value and high ash contents.
Populus ciliata Wall.	Syan	64.87±1.91	Medium and low density wood
Quercus semecarpifolia Smith	Kharsu	60.85±2.85	Very high density wood and low ash contents.
Taxus baccata Linn.	Thuner	54.36±2.99	High density wood and low ash contents.
Berberis aristata DC.	Kilmora	23.78±1.30	High density wood and low ash contents.
Desmodium elegans DC.	Chamla	15.32±0.68	Medium density wood and high ash contents.
Viburnum cotinifolium D.Don.	Ghyanu	27.68±0.58	High density wood and low ash contents.

TABLE 4

Average daily consumption (kg fa^{1} day^{1}±se) of fuel wood in the studied villages

Household category	Reni village	Lata village	Peng village
Small sized household (1-4 members)	9.20±0.50	11.50±0.75	14.80±0.60
Medium sized household (5-8 members)	15.78±0.75	18.00±1.50	24.65±1.50
Large sized household (> 8 members)	18.08±08	24.65±2.00	26.30±2.50

The Reni village have reported least fuel wood consumption on household basis while, Peng village have reported highest value. However, the total village requirement is highest (458.88 t yr^{-1}) in Lata and least (225.59 t yr^{-1}) in Peng village (Table 5).

TABLE 5

Average annual consumption (t yr^{1}±se) of fuel wood in the studied villages

Household category	Reni village		Lata village		Peng village	
	No. of hhs	Quantity	No. of hhs	Quantity	No. of hhs	Quantity
Small *(1-4 members)*	22	73.88±1.00	28	117.53±2.75	15	81.03±1.50
Medium *(5-8 members)*	28	161.27±3.75	41	269.37±4.75	15	134.96±3.50
Large *(> 8 members)*	09	59.39±1.25	08	71.98±0.50	01	9.60±0.00
Grand total	59	294.54±6.00	77	458.88±8.00	31	225.59±5.00

The crop-by-products contribute 58 to 63% of total fodder used for stall feeding in the studied villages (Table 6).

The rest of fodder is collected from the adjoining forest trees (21 to 25%) and grasses from the forest floor and community lands (16%). The total fodder consumed for stall feeding in three studied villages is not significantly different and also the estimated total fodder requirements (Table 7).

TABLE 6

Annual quantity of fodder (t yr^{1}±se) collected in the studied villages

Study villages	Type of fodder used			
	Crop-by-product	Forest fodder	Green leaves & Grasses	Total Quantity
Reni village	122.865±5.321	41.810±4.765	30.456±3.549	195.131±13.635
Lata village	130.799±8.542	56.850±3.654	37.560±2.711	225.209±14.907
Peng village	120.673±6.255	48.246±3.549	33.577±3.566	202.496±13.370

TABLE 7

Annual fodder requirements (t yr^{1}±se) for livestock feeding in studied villages, values in parentheses represents % of the total fodder required

Livestock feeding habits	Study Villages		
	Reni village (%)	Lata village (%)	Peng village (%)
Stall feeding *(Cattle and buffalo)*	195.131±13.635 (41.56%)	225.209±14.907 (42.03%)	202.496±13.370 (40.65%)
Out grazing *(Bovine and equine)*	274.321±8.546 (58.44%)	310.635±13.675 (57.97%)	295.549±11.744 (59.35%)
Grand total	469.452±22.181	535.844±28.582	498.045±25.114

The estimated fodder consumption through open grazing by the bovine and equine based on average feed requirements works out to be 58 to 59% of the total requirements in the studied villages. Most of the litter for animal bedding collected from the forests particularly during dry period of the year (Figure 3). The average quantity of non-timber forest products (NTFPs) harvested from the surrounding forests in study villages is given in Table 8.

Figure 3: Women collecting litter from the forests for animal bedding and manure

TABLE 8

Average quantity (kg fa^{1} day^{1}±se) of various NTFPs collected in the studied villages

Type of NTFPs	Study villages		
	Reni village	Lata village	Peng village
Wild-edible fruits	4.89±0.85	3.75±0.50	9.32 ±1.35
Wild-edible vegetables	56.72±3.95	43.46±3.70	107.95±7.56
Edible and medicinal oils	1.29±0.50	0.98±0.25	2.45±0.75
Ingredients of traditional tea	3.79±0.75	2.91±0.56	7.23±1.85
Medicinal and aromatic plants (MAPs)	15.18±2.55	11.63±2.30	28.89±0.00

The wild food supplements such as wild-edible fruits and vegetables constitute a major part of harvest followed by medicinal plants. Such harvests are significantly highest in village Peng compared to village Lata and Reni. There are a varieties of medicinal and aromatic plants (MAPs) used in treatment of various diseases and disorders, some among them have high economic and social values are illustrated in Figure 4, 5 & 6.

Figure 4: *Rheum australe* (Dolu): an important medicinal plant used by buffer zone villagers

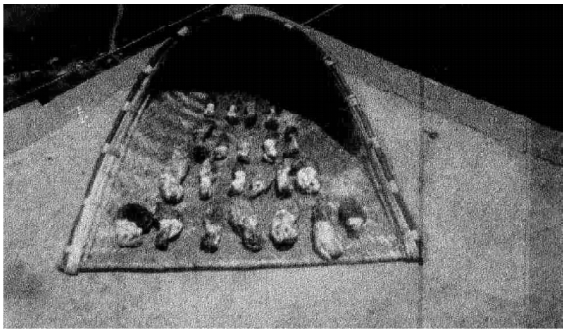

Figure 5: *Morchella esculenta* (Guchchhi) is collected for income generation due to high demand in the market

Figure 6: *Betula utilis* (Bhojpatra) bark is used in religious ceremonies and parties

Sometimes, all households' members are engaged in forest resources collection. The children have negligible role in most of the households' activities in the studied villages. While, women are backbone of the household economy not within the studied area but also a common situation in all rural areas of the Himalyas.

Out of the ten identified households' activities, rural women plays significant role as a major contributor in 6 tasks while men contribute in 4 activities. The division of households' works among men, women and children in response to each activity in various proportions is shown in Table 9.

TABLE 9

Division of works among family members in response to natural resource collection

Type of forest resources	Division of labor based on gender issues and age		
	Men	Women	Children
(A) Fuel wood			
Fuel wood collection for household needs	Minor	Major	Negligible
(B) Fodder and grazing			
Fodder collection from forests	Negligible	Major	Minor
Lopping/pollarding in forests	Minor	Major	Negligible
Collection of organic matter (litter *etc*.) for animal bedding and manure	Minor	Major	Negligible
Open grazing	Major	Minor	Minor
(C) Timber			
Tree cutting/saw mills installation for timber preparation	Major	Minor	Negligible
(D) Non-Timber Forest Produces (NTFPs)			
Collection of wild edible fruits & vegetables for household needs	Minor	Major	Negligible
Collection of wild edible fruits & vegetables for sale and trade	Major	Minor	Minor
Collection of aromatic and medicinal plants (MAPs) for household needs	Minor	Major	Negligible
Collection of aromatic and medicinal plants (MAPs) for sale and trade	Major	Minor	Minor

A variety of products like food, vegetables, beverages *etc*. are prepared by the tribal people in the studied areas using various non-timber forest resources such as traditional tea is one of them. It is being prepared by using the mature bark of *Taxus baccata* (Thuner). The mature thick bark (3/4 part) of *Taxus baccata* (Thuner) tree up to the height of about 90-120 cm from the ground is peeled off for making traditional tea (Saltish tea). The bark is sun dried and grinded and makes fine powder. This powder is thoroughly mixed with hot water and some amount of salt in a traditional wooden hollow cylinder and pours about 2 to 3 tea spoon purified butter (Ghee) in a bowl. This drink is generally called 'Mani-ki-chay' (Saltish tea) in local dialects of tribal communities in the studied areas. This beverage is hot and nutritious having good anti-cancer property. It is mostly preferred by the local inhabitants during severe cold in winter. It is a good substitute of coffee because milk production is very low or almost negligible in the study area. The wooden article (pot) used for preparation of traditional tea (Saltish tea) has been illustrated in Figure 7.

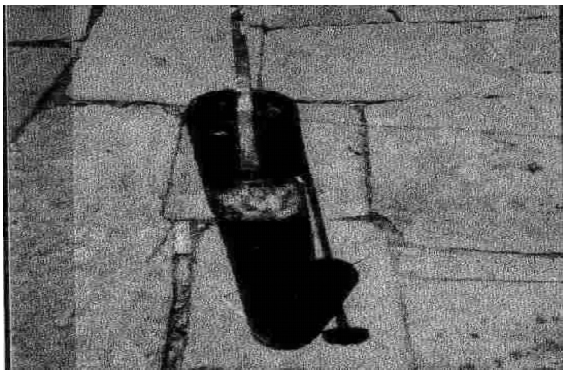

Figure 7: Wooden article used for making traditional tea (Mani-ki-chay) of *Taxus baccata* (Thuner)

The capita^{-1}yr^{-1} values of fire wood and fodder consumed and harvested by the villagers in different parts of the central Himalaya has been described in Table 10.

CLIMATE CHANGE

Shifting of Timber Line Vegetation

Due to impact of the global warming on environment, shifting of timber line vegetation is a significant universally accepted phenomenon in the alpine zones of the world. The studies conducted in neighboring areas of China have reported that the greatest impact of global warming and climate change in nature may be seen in the response of vegetation shifting.

TABLE 10

Consumption of firewood and fodder in Nepal and Indian Himalayan region

Country/Region	Firewood consumption (kg capita ^{1} yr ^{1}) on fresh weight basis	Fodder harvested from forests (kg capita ^{1} yr ^{1}) on fresh weight basis	References
(A) Nepal			
High elevation villages	688	4194	Mertz,' 1990
Hilly region of Nepal	640	—	Campbell & Bhattarai,'84
(B) Indian Himalayas (Garhwal Himalaya)			
High elevation villages	1155	3992	Singh,' 89
Reni (NDBR)	1047	4181	Present Study
Lata (NDBR)	1317	5685	Present Study
Peng (NDBR)	1599	4824	Present Study
Hilly region of Kumaon	567	2273	Singh,' 89
Hilly region of Kumaon	544	—	Pandey & Singh,' 84
High elevation of Garhwal	631	—	Bhatt *et. al.,'* 94

Several other observations and interviewed with local people show that the alpine birch (*Betula utilis*) has moved toward the Tundra ecosystem over the last twenty years. In order to verify the fact by researchers Rawat & Kumar from Kumaon University studied the timber lines in the watersheds of glacial rivers with relevant satellite digitized data and tools. From 1972 to 2010, an average trend of timber line sifting is 19.21 m yr^{-1}. The variation results of timber line as per available data are illustrated in Figure 3 and data shown in Table 11. The snowfall nearby studied areas is occasionally occurs due to rapidly change of the global climate. This is due to the serious impact of anthropogenic pressure on nature through over exploitation of natural resources in response to increasing population at an alarming rate.

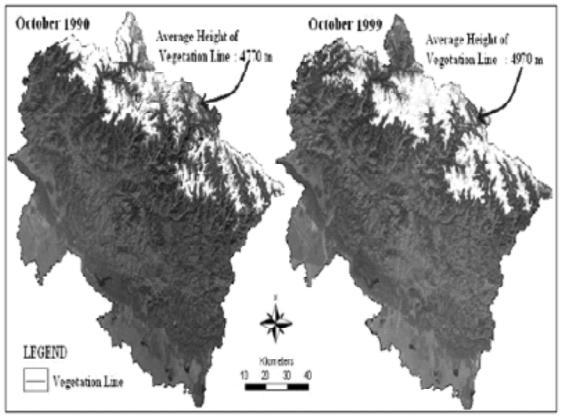

Figure 8: Copy of FCC showing Geographic Location of Timber Line in Uttarakhand

Source: Rawat & Kumar, Interim Report by Uttarakhand Centre on Climate

TABLE 11

Average trend of timber line shifting in Garhwal Himalaya

Year	Average height of timber line	Duration (Year)	Shifting rate of timber line vegetation Variation (m.)	Rate (m. yr^{-1})
1972	4920 m	0	0	0
1990	4770 m	18	150	8.33
1999	4970 m	27	350	12.96
2010	5350 m	38	730	19.21

Source: Rawat & Kumar, Interim Report by Uttarakhand Centre on Climate Change (UCCC), Kumaon University, Nainital, March, 2011

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