Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand

Thesis

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By

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CERTIFICATE

This is to certify that the thesis entitled **"Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Forestry** with major in **Agroforestry** of the College of Post-Graduate Studies, VCSG Uttarakhand University of Horticulture & Forestry, Bharsar, is a record of ***bonafide*** research carried out by **Miss. Deepika Rawat, Id. No. UUHF/14267** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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We, the undersigned, member of the Advisory Committee of **Miss. Deepika Rawat, Id. No. UUHF/14267,** a candidate for the degree of **Master of Science in Forestry** with major in **Agroforestry**, agree that the thesis entitled "**Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand.**" may be submitted in partial fulfilment of the requirements for the degree.

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Dedicated

To

MY BELOVED

Father (Late Govind Singh Rawat)

&

Mother (Jhapika Rawat)

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Leave to future generations....

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Ranichauri *Deepika Rawat*

July, 2016 *(Author)*

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ABBREVIATIONS USED

%	Per cent
&	And
/	per
^{0}C	Degree Centigrade
et al.	et alia
etc.	and so on
Fig.	Figure
i.e.	that is
max.	Maximum
min.	Minimum
viz.	Namely
Spp.	Species
m	Meter
msl	Mean sea level
S.D.	Standard Deviation
CEU	Cattle equivalent Unit
Avg. CEU	Average Cattle equivalent Unit
kg/day/HH	Kilogram per day per household
kg/day/cattle	Kilogram per day per cattle
kg/day/village	Kilogram per day per village
PRA	Participatory Rural Appraisal

CHAPTER1 INTRODUCTION

In many of the developing countries, forests are the main source of fuelwood, timber for house construction and fodder for livestock. The presence of trees, outside the forest has more significance in satisfying the daily domestic needs of the inhabitant of these hilly areas (Shah, 1982; Pant and Singh, 1987). Traditional agroforestry systems are well established in Garhwal Himalayas since times immemorial. Fodder and fuel wood are the two most important livelihood resources for mountainous regions, of the Himalayas. Fodder plays a critical role in the crop, livestock, manure and soil nutrient cycle in traditional farms in the mountains of the Himalayas. In Indian mountain villages fuelwood is the only main source of energy, supplying almost the entire cooking energy requirement.

The agroforestry practice is estimated to produce 100 million cubic meter timber/pulp wood for industrial and domestic use and 150 million tones firewood, and approximately 15 million tones organic matter through leaf fall, carbon sequesters 60 million tons annually in tree components (excluding in soil and that locked in the wood products), and generate employment for 4000 million person/days/annum in nursery and plantation activities. The value of wood/pulpwood produced is estimated to be around Rs 10,000 billion and that of firewood as Rs 30,000 million (Dhiman *et al.,* 2013). As per the results of household consumer expenditure survey conducted by National Sample Survey Organization in the year 2007-2008, over 77 percent of household in rural area of country continued to depend on fuelwood, 7 percent use dung cake and only 9 percent use LPG. In urban India, 62 percent of household use LPG as major fuel for cooking and 20 percent use fuelwood.

In India, about 70% of energy requirement is fulfilled by the fuelwood, collected from the forests and nearby sites and about 50 million tons of wood are removed every year. The consumption of fuelwood is by now one of the most significant reasons for forest loss in many countries, and the estimates indicate that fuelwood accounts for over 54% of the total global harvest per annum (Osei, 1993). The fuelwood demand in the country ranges from 96 to 157 million tons, including a rural demand of 80–128 million tones, thus raising the consumption level to 148–242 kg per capita (Bhattacharya and Nanda, 1992). However, the

per capita annual consumption of dry wood in various parts of the Himalayas is reported to be much higher, ranging between 500 and 1200 kg (Campbell and Bhattarai, 1984; Singh, 1989; Metz, 1990).

In Garhwal Himalayas, about 77.4% of the total population is rural (Anonymous, 1991). Due to low connectivity with the urban areas of the country, the alternative sources of fuelwood are not easily accessible hence making the population to totally depend on wood resources (Bhatt *et al*., 2004). According to one estimate, firewood accounts for 54% of all global harvests per annum, suggesting a significant forest loss (Osei, 1993; Wahab *et al*., 2008).

In Garhwal Himalayas, with increasing altitude, forests of different compositions are found, and so different plant species are used at different altitudes as fuel cooking, lighting, boiling of water, and space heating, (Bhatt and Todaria, 1990). Demand for fuelwood from forests and commons causes resource degradation to the extent that collection exceeds sustainable yield.

The increasing human population resulted in increasing demand for utilization of natural resources leading to severe depletion, especially deforestation. People of the Himalayas had traditional rights to collect limited amount of fuel wood and fodder from forest areas. However new environmental laws by Government agencies have restricted fuel wood collection without providing the alternative source of energy, thus local people are facing problem. Illegal fuel wood collection is still going on and if current pace of deforestation continues, the existing forest resources in the Himalaya will vanish shortly.

The livestock population is expected to grow at the rate 0.55% in the coming years, and the population is likely to be around 781 million by 2050. At present, the country faces a net deficit of 35.6% of green fodder, 26% of dry-crop residues and 41% of concentrate feed ingredients. India has nearly 4.9% of the total cropped area under cultivated forages. In India, the majority of the population lives in rural areas where fuel wood, crop residues, twigs and branches, dry leaves and animal wastes provide most of the energy requirement. The total livestock population in the country was 512.05 million in numbers in 2012. This sector alone

contributes nearly 25.6% and overall contribution of livestock sector is nearly 4.11% in total GDP during 2012-2013 (Anonymous, 2012).

In India, the shortage of feed is one of the major limiting factors for better productivity of livestock sector (Pratab, 2002). This situation is very critical for the livestock of hilly region (Panday and Mishra, 2008). Feed resources production in term of crop residue with increase in area under fodder cultivation up to 4.60% in recent year (Planning Commission, 2006). On average, 58% of total fodder biomass was extracted and 42% was cultivated on private cropland in India for livestock consumption (Tulachan *et al.,* 2002). The annual requirement of dry and green fodder is estimated to be 569 MT and 1025 MT respectively against the availability of 385 MT (Roy and Singh, 2008).

The livelihoods of the hill people are mainly dependent on marginal agriculture on the one hand and rearing livestock on the other. In hills, fodder trees, shrubs and grazing in the forests are the main sources for the livestock feed including use of agricultural residue (Singh and Sundriyal, 2009). The villagers collect grasses from these lands after rainy season and feed them to their cattle's in winter. The rural poor are the key beneficiaries of agroforestry; subsequently, agroforestry technologies are expected to be specially relevant and applicable to small scale landuse, with low capital and energy requirements, and to yield products and benefits directed to immediate human needs rather than commercial advantages (Nair, 1993).

A significant portion of fodder needs are met by dry fodder which comes from the personally managed grasslands. In India, forests meet nearly 40% of the energy needs of the country of which more than 80% is utilized in rural areas, and about 30% of fodder needs of the cattle (Verma, 2009). Agriculture along with animal husbandry is the principal occupation and source of livelihood for over 70% of the population of Uttarakhand state, India. Uttarakhand is well endowed with a variety of livestock. Livestock convert fodder shrubs and grasses from forest, crop residues and other fodder into manure through digestion.

People living in hilly area used to travel several kilometers daily for harvesting fodder from nearby forest area for satisfying the livestock requirement. At the same time, in hilly areas, due to rainfed conditions and small land holding of the farmers, they have limited scope of producing green fodder on their land. Therefore, there is a vital need to have fast growing

fodder tree species with maximum nutritive value. Fodder and fuelwood is collected by lopping the vegetative biomass. A significant part of the fodder and fuel needs are met by forests encroached by the villagers. Fuel wood is also stored during winter months for the use in the remaining part of the year. Moreover in Uttarakhand hills, it is well known that women are mainly responsible for the collection of fuelwood and fodder.

The hill agriculture in Uttarakhand is categorized by small and scattered holding. Lack of irrigation in the traditional agriculture practices results in low yield of crop. The agricultural production is not enough to meet even half of the demands of the region. Therefore people migrate from this area in search of job and the remittances received from migrated family members are an important source of their sustenance (Sharma *et al*., 1999). With increase in population and changing socio-economic conditions, fuelwood and fodder are becoming more scarce and expensive. Some of the socio-economic factors influencing fuelwood consumption are family size, livestock holding, land holding and annual income (Sharma and Laxmi, 1987). Therefore we carried out our study in six different villages in Tehri Garhwal in Uttarakhand *viz.* Maun, Dargi, Jagdhar, Guldi, Dikhol, and Manjyur to find out fodder and fuelwood consumption by the villagers and thereby assessing their socio economic status. Thus our study investigates various factors under the following objectives:

Fodder consumption pattern in study villages under different seasons.

Fuel wood consumption pattern in study villages under different season.

Evaluation of socio-economic status of the villagers.

Determination of moisture content, specific gravity and ash content of different fuel woods species in study areas.

CHAPTER 2 REVIEW OF LITERATURE

The literature pertaining to the present investigation entitled "Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand" is reviewed in this chapter. The available literatures regarding present study have been reviewed under the following heads.

2.1 Fodder consumption pattern in study villages under different seasons.

2.2 Fuel wood consumption pattern in study villages under different seasons.

2.3 Socio-economic status of the villagers.

2.4 Physical properties of fuelwood species of study area.

2.1 Fodder consumption pattern in the selected villages under different seasons

Toky *et al*. (1989) reported that the total above ground biomass in agrihorti silvicultural or agri-horticultural system was around 48 t/ha. In fodder tress, significant percentage of annual production up to 48% was allocated in current twigs, while in horticultural trees, a major portion, up to 63% was partitioned in fruits. Trees and shrubs are found ubiquitously, but fodder availability for livestock production is limited.

Khanduri *et al.* (2002) conducted a study at three different high altitudinal villages of Garhwal Himalayas. The study revealed that the average fodder requirement of the area surveyed was 4758.65 kg/day/village. It was recorded that the fodder extracted from the forest was maximum 1211.14 kg/day/village at Sari village and minimum 838.24 kg/day at Makkumath village.

Awasthi *et al.* (2003) quantified standing biomass, regeneration and population of highly preferred species and their consumption pattern. The standing biomass of preferred woody species at low altitude villages and high altitude summer camping site (Kharaks) were 140.68±26.91 t/ha and 477.46±31.8 t/ha, respectively.

Rajan (2009) analyzed the utilization of tree foliage as an alternative or supplementary feed to the available grass fodder. Use of tree foliage is one of the useful method to solve the scarcity of quality feed for the livestock. The foliages have high digestibility, good vitamin and mineral content and they enhance the microbial growth and digestion of cellulosic biomass in the rumen of livestock.

Sharma *et al.* (2009) conducted a study in the Rudraprayag and Tehri district of Garhwal Himalayas on five mid altitudinal villages to examine the utilization of resources by the inhabitants and their effect on these village ecosystems. The investigation revealed that the average fodder consumption in these villages was 6736.6 kg\day\village.

Singh and Sundriyal (2009) conducted a study of traditional agroecosystem to understand the status of fodder in Central Himalayan village. Total available fodder was found to be 281.76 MT but the total consumption was 402.72 MT with a deficit of 207.83 MT.

Dikshita and Birthal (2010) estimated the feed consumption rates for different livestock species by age group, sex and function at the national level, and based on that, the study has generated demand for different types of feed by the year 2020. According to this study, by 2020 India would require a total 526 million tonnes (Mt) of dry matter, 855 Mt of green fodder, and 56 Mt of concentrated feed (comprising 27.4 Mt of cereals, 4.0 Mt of pulses, 20.6 Mt of oilseeds, oilcakes and meals, and 3.6 Mt of manufactured feed).

Bijalwan *et al.* (2011) studied the fodder consumption pattern in six villages in Garhwal Himalayas. It was revealed that the utilization of tree fodder varied from 305.02 to 1015.17 kg/day/village in the summer and 659.53 to 2015.52 kg/day/village in the winter season, which was supplemented by traditional agroforestry tree species.

Dhyani *et al.* (2011) studied energy fodder harvesting pattern along the altitudinal gradient in Garhwal Himalayas to understand the fodder utilization pattern and fodder biomass removal in existing traditional hill agroecosystems prevalent at different altitudes. The total fodder collection at different altitudes varied for green and dry fodder. The total green fodder collection ranged from 64.4 ± 3.60 to 84.0 ± 6.23 kg/ household/day. Whereas, total dry fodder collection ranged from 62.4 ± 1.66 to 80.4 ± 5.11 kg/household/day. Study

was found that fodder collection varied in summer (March-October) and winter months (November-February) of the year.

Sati and Song (2012) carried out a study in eight villages of Kewer Gadhera Sub-Watershed, which revealed that variation in forest biomass consumption varies from 12 kg/day/house hold (fodder) in the lower elevation (1150m) to 34 kg/day/household (fodder) in the higher elevation (1900 m).

Maikhuri *et al.* (2013) aimed at understanding the fodder utilization pattern, energy budget, and problem related to fodder biomass harvesting in six villages located at an altitudinal gradient in Govind Wildlife Sanctuary. The highest average fodder consumption was observed in the village Osla (38.8±3.7 kg/household/day) and lowest in Gainchwangon (31.3±2.3 kg/household/day).

Akhter and Malaviya (2014) conducted a study to understand status of resources utilization pattern with special reference to fodder in village Chak Chua, Jammu, J&K. The common fodder type used were green fodder, top feeds, crop residues and tree leaves. The crop residues consumption was found to be highest i.e., 14.50 kg/day/family while top feed was least consumed i.e., 1.74 kg/day/family.

Dhanai *et al.* (2014) quantified the dynamics of seasonal fodder consumption in Takoligad watershed, Tehri Garhwal, Uttarakhand. Data was recorded for three altitudinal range during three seasons by randomly selecting 120 households of different villages. The total annual consumption of fodder was highest (7946.05 kg) in high altitude and lowest (6077.25 kg) in the lower altitude villages.

Malik *et al.* (2014) conducted a study to understand the fodder consumption pattern at three different altitudes of Kedarnath Wildlife Sanctuary. The average fodder consumption was found to be 43.96 kg/day/household.

Qureshi *et al.* (2015) conducted a study to understand fodder and fuel utilization pattern in village Shahdarah Sharief, Rajouri, India. The common fodder types used were green fodder, top feeds, crop residues and tree leaves. The green fodder consumption was

found to be highest (16.83 kg/day/family) while top feed was least utilized (1.10 kg/day/family).

2.2 Fuel wood consumption pattern in the selected villages under different season

Bhatt *et al.* (1994) analyzed firewood consumption along altitudinal gradient by households according to their socio-economic condition in Garhwal Himalayas. Consumption of fuelwood (kg/capita) was 789, 664, 518, and 544 kg/capita, respectively, above 2000 m, for 1500 m-2000 m, 1000 m-1500 m, and 500 m-1000 m elevations.

Kituyi *et al.* (2001) conducted survey in rural and urban Kenya to establish biofuel consumption rate and patterns. Average consumption rates ranged from 0.8-2.7 kg/capita/day.

Khanduri *et al.* (2002) conducted study in the Kedarnath Forest Division, involving three high altitude villages to study the involvement of local villagers with the forest and their effect on forest composition and regeneration status. Investigation revealed that the average fuelwood consumption was 1093.35 kg/day/village.

Awasthi *et al.* (2003) conducted a study of forest resources availability and its use by the migratory villages of Uttarkashi, Gahwal Himalayas. Average firewood consumption per household was 14.65±0.78 kg/day.

Bhatt and Sachan (2003) studied the fuelwood consumption pattern for households along an altitudinal gradient in Garhwal Himalayas, Uttaranchal. Firewood consumption was 2.80, 2.00, 1.42, 1.10 and 1.07 kg/capita/day, respectively, above 2000m, 1500m–2000m, 1000m–1500m, 500m–1000m and below 500 m altitude. The energy expenditure for fuelwood collection was 60.77, 62.57, 76.70, 87.23 and 85.14 MJ/capita/year, accordingly. Firewood consumption was influenced by climate and season of the year.

Bhatt and Sachan (2004) conducted a study of firewood consumption pattern of three tribal communities of Meghalaya, India-Garo, Khasi and Jaintia in Northeast India. Fuelwood consumption was highest for Khasi community (5.81 kg/capita/day), followed by the Garo (5.32 kg/capita/day) and Jaintia (3.90 kg/capita/day).

Munesh and Sharma (2009) studied the use of fuelwood as a primary source of energy for domestic use in causing severe deforestation in Garhwal Himalayas. The total average fuelwood consumption in the study was observed to be highest for Ganga Bhogpur (2.52 kg/capita/day) and lowest for Ghargoun (1.63 kg/capita/day). The fuelwood consumption rate oscillated considerably across the different seasons.

Sharma *et al.* (2009) conducted a study in the Rudraprayag and Tehri district of Garhwal Himalayas on five mid altitudinal villages to examine the utilization of resources by the inhabitants and their effect on these village ecosystems. Investigations have revealed that the average fuelwood consumption in these villages was 2636 Qt/year/village.

Singh and Sundriyal (2009) conducted a study of traditional agroecosystem to understand status of fuelwood in Central Himalayan village. The fuel consumption was 418.86 MT and the annual fuel availability was 211.03MT, there was a deficit of 207.83MT.

Rawat *et al.* (2009) conducted a study on fuelwood consumption pattern in cold desert of the Lahaul valley. Fuelwood consumption was highest in high altitude villages as compared to low altitude. Fuelwood consumption of 4.32±0.99 kg/capita/day was observed at Khoksar during winter season followed by the autumn (2.25±0.15 kg/capita/day) and summer (1.38±0.13 kg/capita/day). The labour energy expenditure for fuelwood collection was also highest for Khoksar (91.91 MJ/capita/year) followed by Hinsa (61.29 MJ/capita/year), Kuthar (52.01 MJ/capita/year) and Jahlma (51.89 MJ/capita/year), respectively.

Singh *et al.* (2010) estimates reflect that a total of 88 species are consumed as fuelwood (54 trees and 34 shrubs) by the local people. Fuelwood consumption by 'dhaba' (roadside refreshment establishments) owners (90–120 kg/household/day) was much higher over the common villagers (20–22 kg/household/day). The fuelwood is mainly burnt for cooking, water heating, space heating and lighting, etc. Among these, cooking consumes fuelwood the most.

Bijalwan *et al.* (2011) studied fuelwood consumption pattern in six villages in Garhwal Himalayas. It was found that the average daily fuelwood consumption during summer and winter in different villages varied from 84.41 to 538.45 kg/day/village and

156.75 to 701.01 kg/day/village which was supplemented by existing agroforestry upto considerable extent.

According to Khuman *et al*. (2011) rural India constributes 75% of the total energy consumption. The present study was conducted at Fakot micro-watershed in Garhwal district of Uttarakhand, India. The fuelwood consumption in the watershed ranged from 455 to 2388 gm/person/day.

Sati and Song (2011) conducted a study of eight villages of Kewer Gadhera Sub Watershed into the Pindar River at Narain Bagar town Uttarakhand. Forest biomass consumption varied from 13 kg/day/households (fuelwood) in the lower elevation (1150 m) to 28 kg/day/household (Fuelwood) in the higher elevation (1900 m). Its consumption varied in different locations and seasons. It is also influenced by the aspect of slope.

Vibol *et al.* (2012) carried out a study of fuelwood consumption rate for different activities, such as coocking, boiling water, preparing animal feed and examined the characteristics of cook stoves. Approximately 96% of sampled households depend on fuelwood. Overall average fuelwood consumption for cooking and boiling water per family per day was 5.21±0.11 kg and 2.82±0.11 kg. The average fuelwood consumption rate is approximately 5.60±0.11 kg/day/family.

Akhter and Malaviya (2014) studied the traditional agro-ecosystem conducted to understand status of resources utilization pattern with special reference to fuel and fodder in village Chak Chua, Jammu, J&K. The major fuel types fulfilling the energy demand of local people in study area were wood, kerosene, LPG and dung cake. LPG constituted the major share of consumption which is 7.6x10 kcal/month while dung cake consumption was found least. The total fuel consumption in study area was found to be 18.2 x10 kcal/month.

Dhanai *et al.* (2014) quantified the dynamics of seasonal fuel and fodder consumption in Takoligad watershed, Tehri Garhwal, Uttarakhand. Data was recorded at three altitudinal ranges during three seasons by randomly selecting 120 households of different villages. Domestic cooking is the major use of fuel wood in the entire watershed. Fuel wood consumption was highest 1091.35 kg/capita/year at higher altitudes and lowest 646.05 kg/capita/year in the middle altitudinal zone.

Malik *et al.* (2014) carried out a study at three different altitudes of Kadarnath Wildlife Sanctuary to understand rural peoples dependency on the adjacent forests. Average fuelwood consumption were found to be 2.42 kg/capita/day.

Qureshi *et al.* (2015) conducted a study to understand fodder and fuel utilization pattern in village Shahdarah Sharief, Rajouri, India. The major fuel types fulfilling the energy demand of local people in study area were wood, LPG and dung cake. LPG constituted the major share of consumption (10.7x10 kcal/month) while dung cake consumption was least (3.1x105 kcal/month). The total fuel consumption in study area was 17.2x10 kcal/month.

Singh *et al*. (2015) studied the biomass utilization by villagers along different altitudinal gradient during three seasons in Takoligad Watershed of Garhwal Himalaya, India. Fuelwood used in watershed for different purposes such as cooking, boiling water and space heating. 69.33 % LPG (Liquid Petroleum Gas) was estimated in the study area. Overall average fuelwood consumption (Kg/household/day) at three altitudinal zones in three different season was 6.58 in summer, 10.80 in winter and 6.52 in monsoon (Low 500-1000 m amsl), 7.34 in summer, 12.72 in winter, 7.28 in monsoon (Middle 1000-1500 m amsl) and 9.66 in summer, 14.42 in winter and 9.28 in monsoon (High 1500-2000 m amsl), respectively.

2.3 Socio-economic status of the villagers

John and Nair (1999) studied the socio-economic factors and constraints that affect farming in 400 homesteads of Southern Kerala, India. The study revealed that 17.5 % and 30.25% of the homesteads raised cattle and poultry, respectively as a complementary enterprise. The major constraints identified were cultivation cost, labour availability, credit availability and technical information availability, availability of manures and fertilizers, availability of plant protection chemicals, marketing facilities, and storage facilities. An average of 14-15 species and 397 plants per homestead was observed. The major crops grown were tuber crops, fruits, coconut, rubber, spices, vegetable, timber and fuel trees and fodder.

Salam *et al*. (2000) carried out an investigation in Bangladesh and concluded that farmer's decisions of whether to plant trees or not was based primarily on economic factors than ecological factors. They surveyed that 51% of the households had less than 0.08 ha of homestead land and only 17% of the remaining households had 0.16 ha or more of homestead

land and considerable number of farmers possessed a very limited amount of homestead land. They found about 48% of the households had bamboo clumps on their homesteads. 11% of the households had no trees on the homestead, and 19% of the households had 50 % or more trees on the homestead. The average number of trees per household was noted to be 19 %.

Maikhuri *et al.* (2001) conducted a study in 150 different villages located along and elevate transect of the Alaknanda catchment of Central Himalayas over a period of two decades (1970-74 and 1990-94). It was observed that the cultivated area under many traditional crops had declined significantly.

Khanduri *et al.* (2002) conducted a study to evaluate socio-economic status in three villages of the Kedarnath Wildlife Sanctuary, India. Whole the fuel wood is extracted from the adjacent forest. However, the fodder extracted from the forest was maximum 1211.14 kg/day at Sari village and minimum 838.24 kg/day at Mukkumath village.

Bhatt and Sachan (2004) conducted a study of varying ecological, socio-economic and socio- cultural condition of three tribal communities of Meghalaya, India-Garo, Khasi and Jaintia in Northeast India. The labour energy expenditure for fuelwood collection was highest for the Jaintia (888.56 MJ/capita/year) and minimum for Garo (70.64 MJ/capita/year).

Arulprakash and Hirevenkanagoudar (2005) surveyed that middle aged persons especially women have more entrepreneurial orientation and innovative ideas and they take up more income generating activities. On the other hand, young group is busy with their studies and household activities and old age respondent are not very much involved in planting, collection of fuel wood and fodder activities.

Bijalwan *et al.* (2009) studied the structure and composition of tree species under existing Agroforestry system *viz.,* agri-horti-silviculture and agri-horti-culture system in mid hill situation of Garhwal himalaya between 1000 m to 2000 m in the year 2004-2006. In northern aspect 21 tree species were recorded in agri-horti-silviculture system compared to 13 in southern, whereas in agri-horticulture system the reported tree species were 11 and 9 in northern and southern aspects, respectively. In the northern aspect of agri-horti-silviculture system, *Quercus leucotrichophora* was observed as dominant tree species followed by *Celtis australis* and *Grewia optiva* while in southern aspect *Grewia optiva* was reported as dominant

species. In agri-horticulture system *Malus domestica* and *Prunus armeniaca* were dominant fruit trees in northern and southern aspect, respectively.

Joon *et al*. (2009) carried out a study of household energy consumption pattern in a villages of Jhajjhar district of Haryana, India. The households surveyed covered heterogeneous population belonging to different income, educational and social groups.

Sharma *et al.* (2009) conducted a study at two forested sites in Garhwal Himalayan: Mandal and Khalla in Chamoli district, and Chaundiyar and Dikholi in the Uttarakashi district. In all the study villages more than 75% of fodder and fuelwood were extracted from the forest. The study revealed a positive relationship between income and livestock population (0.995).

Gupta *et al.* (2009) evaluated socio-economic factor affecting fuel wood consumption in Jammu & Kashmir. The result showed that average family size, livestock holding, land holding (in ha), annual income.

Akhter *et al.* (2010) revealed that 52% of the women participated in decision-making in selecting species for home gardens. They mainly preferred timber species, fruit-bearing species and vegetables. They also grew medicinal plants (*Emblica officinalis, Aegle marmelos, Azadirachta indica, Ocimum sanctum*) in their home gardens and used these plants for treating dysentery, cough, fever, and other diseases.

Kumar *et al.* (2010) describes the socio-economic condition in Henwal Watershed in Tehri Garhwal. The study reveals that the ratio of female to male population is more due to migration of males in search of livelihood to the other places. The average livestock varies from 4.43 to 5.40 per family and average land holding from 0.26 ha (Manjyar) to 1.51 ha (Jaul).

Bhatnagar *et al.* (2011) conducted a study regarding the socio-economic status in rural areas of Indo-Gangetic plain, India to determine the emission of trace grasses and aerosols from domestic fuels. Dung cake is the major domestic fuel (80-90%) in the rural areas of Delhi, Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal, whereas, 99% of rural households in Uttarakhand use wood as the main energy source.

Bijalwan *et al.* (2011) deals with the socio-economic status and livelihood support through traditional agroforestry system in Garhwal Himalaya, India. A total of 443 households were studied from the six selected villages with a family size of about 5.5 members/family. The adult literacy rate was 43% in marginal, 54% in small and 73% in medium-large land holding families while the child education rate was 86%, 98%, and 100%, respectively. The livestock were kept by 37% to 56% families in different villages.

Rawat *et al.* (2011) aimed to document detailed information of some of the selected wild edibles having enormous potential for livelihood enhancement and socio-economic development by making variety of value added products

Sharma *et al.* (2011) study focused on the relationship between the socio-economic status of the inhabitants, the forest utilization pattern in the Dudhatoli area of Garhwal Himalaya. Agricultural production and labour employment were the main occupation of the villagers in the study area. Approximately 82% of total fuelwood and 78% of the total fodder were consumed from the forest.

Gairola *et al.* (2012) conducted a study on the Van Gujjar tribe inhabiting a sub-Himalaya tract in North Western Himalayas of Uttarakhand state, India. A total of 176 households were interviewed by using pre-structured questionnaires. The major source of income was dairy production (80.6%) followed by labour employment (13.9%), NTFPs (4.2%) and agricultural production (1.4%).

Roy *et al.* (2013) conducted a study to assess the status, ecological diversity, and importance of homestead garden for biodiversity, conservation of the urban and rural households in Kishoreganj Sadar of northern Bangladesh. Assessment was done by means of multistage random sampling from a total of 80 households using a questionnaire. A total of 62 plant species including 5 threatened species were identified. The majority of plant species were used as fruit, as fodder (45%) followed by medicinal plants (38.71%), firewood (32.26%) and timber (29 %).

Panday and Yadav (2016) carried out a study in two villages, one in the Farika Village at Masi-Chaukhutia, in Almora district, and another one in the Ramara village at Ghaniyal area in the Chamoli district of Uttarakhand. The average family size varied between 7.9

people per households in Ramara and 7.3 people per households in Farika village and similarly sex ratio ranged between 933 and 1036, respectively. Although the literacy rate in both villages was above 65%, due to lack of employment opportunities people still invariably depend on forests for their livelihood. In those villages more than 75% of fodder and fuelwood were extracted from the forest.

2.4 Physical properties of fuelwood species of study areas

Krishna and Ramaswamy (1932) reported higher ash-free sapwood calorific values for nine species studied by them (*Anogeissus pendula, Bischofia javanica, Dalbergia latifolia, Dipterocarpus turbinatus, Dodonaea viscosa, Grewia tiliifolia, Melia azedarach, Meliosma simplicifolia* and *Talauma hodgsonii*).

Bhatt and Todaria (1990) conducted qualitative analysis of 33 mountain tree and shrub species growing in the Garhwal Himalayas. The study indicated that temperate species are better suited as fuelwood species as they contain high density wood, low ash content and low N-percentage.

Bhatt and Todaria (1992) analyzed 20 indigenous mountain taxa of Garhwal Himalayas and proved that temperate species are best suited as firewood as they contain high density wood , low ash and moisture content, high biomass to ash ratio and low nitrogen percentage. Results showed that *Anogeissus latifolia* had an average calorific value density and comparatively low ash content and thus has the highest Fuelwood Value Index.

Jain and Singh (1999) analyzed 30 tree species indigenously growing in their natural habitat in sub-tropical forest of central India and identified the fuelwood properties *viz.* moisture content, ash content, density, calorific value and fuel value index. The study revealed *Acer oblongum, Betula alonoides, Grevillia robusta, Limonia acidissima, Lyonia ovalifolia, Madhuca indica, Melia azedarch, Morinda tinctoria, Myrica sapida, Prunus cornata, Pyrus pashia and Quercus langinosa.*

Bhatt and Tomar (2002) analyzed 26 indigenous mountain fuelwood species of North –Eastern Himalayan region and identified trees with potential for fuelwood production.

Kataki and Konwer (2002) studied the fuelwood characteristics viz. moisture content, ash, silica, carbon, nitrogen, density and calorific value of 35 indigenous tree species of the age group of 10-15 years growing in their natural habitat in North-eastern region of India.

Shanavas and Kumar (2003) studied the fuel wood characteristic of tree species in home garden of Kerala, India. Consumption of phytofules, such as ash content, specific gravity and moisture content was also determined ash content had a negative correlation with heat of combustion, but specific gravity exerted a positive influence.

Bhatt *et al.* (2004) evaluated the characteristic study of 25 indigenous trees and shrubs of the North Eastern Himalayan Region to identify tress with potential for firewood production. A fuelwood value index was defined as the calorific value, density and ash content. The results showed that *Gaultheria fragrantissima, Litsea citrate, Myrica esculenta, Aesculus assamica, Daphniphyllum himalense, Mesua ferrea,* and *Wendlandia trnctoria* had the most promising firewood properties.

Chettri and Sharma (2009) evaluated the wood properties (calorific value, wood density, moisture and ash content) based on the firewood value index.

Kumar *et al*. (2009) analyzed the trees commonly used for fuelwood in India are *Acacia nilotica, Acacia leucophloea, Prosopis cineraria, Tectona grandis, Cassia fistula, Butea monosperma,* and *Sterculia urens*. Properties, such as wood density, ash content and elemental composition of plants were determined and correlated with the calorific value and evaluated in relation to their properties and environmental impact when burned. It was revealed that the wood with the highest calorific value does not necessarily constitute the best option as fuelwood.

Kumar *et al*. (2011) conducted a study of fuelwood characteristic of 26 trees including shrub species from the dry deciduous forest in Aravally Region, Rajasthan. Western India. Fuelwood value index was based on the properties of calorific value, wood density and ash content. Wood density varied from 0.538±0.01 to 0.966±0.07 g/cm in *Jatropha curcus* and *Acacia nilotica.*

Sheikh *et al.* (2011) estimated specific gravity of wood samples collected from a total of 34 tree species, 30 from lower elevations and 4 from upper elevations in the Garhwal

Himalayas, India. The resu1ts show that the average wood specific gravity was 0.631 (ranging between 0.275±0.01 and 0.845±0.03) for the species at lower elevations and 0.727 (ranging between 0.628±0.02 and 0.865±0.02) for the upper elevations.

Kanawjia *et al.* (2013) estimated specific gravity of wood samples collected from a total of 34 tree species, 30 from lower elevations and 4 from upper elevations in the Garhwal Himalayas, India. The resu1ts show that the average wood specific gravity was 0.631 (ranging between 0.275±0.01 and 0.845±0.03) for the species at lower elevations and 0.727 (ranging between 0.628±0.02 and 0.865±0.02) for the upper elevations.

Wani *et al.* (2014) conducted a study of wood specific gravity variation among five important hardwood species of Kashmir Himalayas. Among the three different sites, specific gravity varied from 0.73 to 0.80 in *Parroptiosis jacquemontiana,* in *Robinia pseudoacacia* it varied from 0.71 to 0.79, in *Salix alba,* it varied from 0.42 to 0.48. In *Populus nigra* it varied from 0.40 to 0.48, and in *Juglans regia* it varied from 0.59 to 0.66.

Niemz *et al.* (2014) analyzed the common ash (*Fraxinus excelsior* L.) under varying equilibrium wood moisture conditions. Result determined a dataset of selected moisture dependent elastic and strength parameters for different load types and orientations. Furthermore, important physical properties of ash, such as differential swelling ratio, water absorption coefficient, water vapor resistance and thermal conductivity, were obtained within this study.

Hytonen and Nurmi (2015) analyzed the heating value and ash content of bark and wood components of *Betula pubescens, Betula pendula, Alnus incana, Salix triandra* and *Salix phylicifolia.* The ash content in bark was highest in short-rotation willows (2.7-3.6 %), followed by alder (2.5 %) and lowest in birch (1.5-1.6 %). The ash content of short-rotation willow shoots decreased with an increase in age from one (2.1-2.2 %) to two and three (1.8-1.9 %) years. Downy birch, silver birch and grey alder had 8-9 %, 11-12 %, 9-10 % and 5 % higher heating value in bark than in wood.

CHAPTER 3 MATERIALS AND METHODS

The present investigation entitled "Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand" was carried out during the period June 2015 to March 2016. The study was based on the primary survey and data collection through the Participatory Rural Appraisal (PRA) method by approaching the villagers representing different age groups and gender also. The survey has been conducted in 25 households on random basis from centre of the village to obtain the real pattern of information. A common questionnaire containing all the information was drawn in close consultation with each household, mostly head or the elder person of the family. House to house visit was followed by field survey as well. The study was based on the primary data collected from the respondents on different aspects *viz.* family size, family type, livestock holding, land holding, land use pattern, cropping pattern, number of trees in the field, distance covered by farmers to collect fuel wood and fodder. The material and method used during the course of present investigation have been detailed under the following headings.

3.1 Location map

3.1.1 The study area

3.1.2 Geographical location and physiography

3.1.3 Climate and Rainfall

3.2 Physical properties of fuel wood species

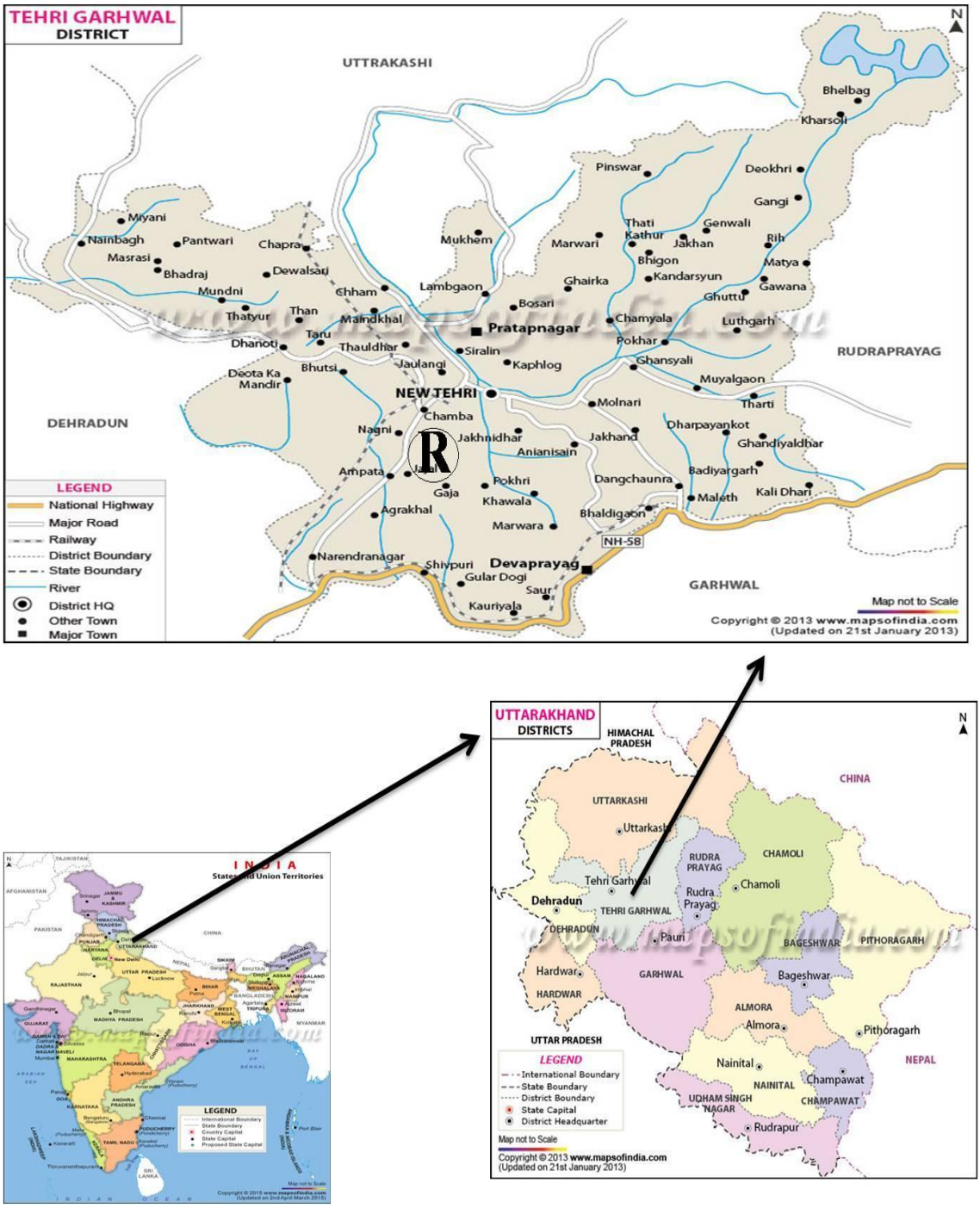
3.3 Socio-economic feasibility

3.3.1 Fodder consumption pattern in selected villages

3.3.2 Fuel wood consumption pattern in the selected villages

3.4 Statistical analysis

3.1 Location map



3.1.1 The study area

The study was conducted in six different villages of Tehri Garhwal, Uttarakhand *viz.* Dikhol, Manjyur, Guldi, Dargi, Jagdhar, and Maun, including sub-tropical to temperate zone of Garhwal. The district Tehri Garhwal lies in the hilly areas of the state and agriculture is the major occupation of its inhabitants. This district consists of 182 villages with 61,569 ha. Area under cultivation of which irrigated land, is only 7.4% (Srivastava, 2007).

3.1.2 Geographical location and physiography

The area falls between sub-tropical and temperate zone. The study was carried out in the agricultural fields, mostly dominated by trees on the field. The elevations of the area were measured using GPS. The location map showing the details of the study area has been presented in Figure 1.

Table 1. Table showing general information of the study site

Sl. No.	Villages Name	Altitude(m)
1.	Dikhol	1320-1375
2.	Manjyur	1369-1300
3.	Guldi	1441-1475
4.	Dargi	1637-1698
5.	Jagdhar	1600-1656
6.	Maun	1873-1981

3.1.3 Climate and Rainfall

The climate in Tehri Garhwal district varies from cold temperate to sub-tropical. The weather is very cold in winter and pleasant in summer. Snowfall is quite common during the winter in these areas. Rainfall, in the study area, occurs almost throughout the year. Maximum rainfall is recorded during the monsoon period i.e. from July to August. The mean temperature ranges between 11.4ºC to 25.9ºC and annual relative humidity between 48% to

95%. The annual total rainfall is 1287.8 mm. (V.C.S.G.U.U.H.F, Ranichauri meteorology data, 2015).

3.2 Physical properties of fuel wood species

3.2.1 Samples

All the nine fuel wood species *Dalbergia sissoo, Grewia optiva, Melia azedarach, Morus alba, Myrica esculenta, Pinus roxburghii, Prunus cerasoides, Pyrus pashia, Quercus leucotrichophora, i*nvestigated in the study areas. All of them are equally available in the selected villages. The wood samples are collected from one representative tree with a clean bole which is free from damages. For each tree species, three samples were taken from mature trees of different girth classes (1-3 cm) and the mean of the three samples was considered as the specific gravity of that species. In the present study, the samples were collected for analysis of wood moisture content, specific gravity and ash content of given species.

3.2.2 Moisture content

Moisture content is an important characteristic which is responsible for the case of combustion of fuel wood, the amount of smoke it emits, and its usable heat content. As reported moisture content does not contribute to the heating value but reduces the heat available from the fuel by lowering the initial gross calorific value of wood. The moisture content varies from species to species and also from one tree part to another. Seasons are also known to effect moisture content.

The oven-dry method is the most accurate and reliable method of determining the moisture content (MC) of the wood at any moisture content. Wood samples were placed in the oven at 105º C for 24 hours. After 24 hours weighing the oven dry weight of wood of each sample after 3 hours when the weight of the sample remains constant it can considered to be oven dry. The weight of moisture content in a piece of wood expressed as the percentage of its oven dry weight is almost universally referred to as its moisture content. It is define by Siau in 1984 as the following formula.

$$Moisture\ \% = \frac{Fresh\ weight - Oven\ dry\ weight}{Oven\ dry\ weight} \times 100$$

3.2.3 Specific gravity

Density means concentration of matter, measured as a mass per unit volume (Hodgman, 1950). Specific gravity (SG) is the ratio of the density of a material to the density of water. Both the terms bear the same characteristic and they are different only in the fundamental sense. Specific gravity is a pure number and density is not. The specific gravity was calculated using the maximum moisture content method (Smith, 1954).

$$Specific\ gravity = \frac{Oven\ dry\ mass/Volume}{Density\ of\ water}$$

3.2.4 Ash %

Total ash content estimated by procedure given by AOAC (1995) and Sankaram (1966).

The crucible and lid was placed in the muffle furnace at 600ºC overnight to ensure that impurities on the crucible are burned off. Then the crucible cooled in the desiccator for 30 minutes and weighed crucible and lid up to 3 decimal places. 10 gm. oven dried powered sample was taken in crucible and ignited on muffle furnace till smoke ended up. Then crucibles were placed into muffle furnace at the temperature of 600ºC for two hours. The crucible was removed from furnace and cooled in desiccator and weighed. Subtract the weight of crucible previously recorded gives the weight of ash.

$$Total\ ash\ \% = \frac{Weight\ of\ ash}{Weight\ of\ sample} \times 100$$

3.3 Socio-economic feasibility

The socio-economic survey was performed in all the selected villages. The gradual socio-economic survey of selected areas was conducted during June 2015 to March 2016. Population of the study area was classified into different land holding categories *viz*. marginal, small, medium and large. The study was conducted in terms of percentage representation of families, their share in total land holdings and pattern of land use. Livestock population of the study area comprised mainly of cow, bullock and buffalo with very few sheeps and goats. Their percentage share in total population and total dung produced in terms of kg/family/day was calculated on the basis of procedure given by Rao (2000). The object of the socio-

economic survey was to gain information about the fuel wood and fodder consumption pattern and their resources used by the local peoples of the area. Socio-economic indicators were obtained from the state/district revenue recorders; through Patwari (revenue record keeper) or village head i.e., Gram Pradhan of the concerned area. The total collection information was recorded.

3.3.1 Fodder consumption patterns in the selected villages

The fodder consumption of the selected villages in the study area was carried out with the help of data collected from the villages using questionnaires. The fodder requirement was based on the daily use of fodder in the village, which was calculated on cattle equivalent unit (CEU) basis. The cattle equivalent unit refers to: 1 adult cow/bullock/ buffalo= 1CEU, 1 young stock of cattle, buffalo and other animals = 0.5, 1 goat/sheep =0.2 CEU (According to Singh *et al,* 2004). The fodder consumption (tree fodder, grass, agricultural residue and forest grass) was calculated separately for the summer and winter seasons. The fodder consumption was based on the habit of the animals and season. The fodder collected from the adjoining forest area, wasteland and fodder from the trees of the existing agroforestry system, residues of agricultural crops and grasses in agricultural fields and forest areas were calculated using feedback from the questionnaires and weighing of green and dry grasses feed to livestock in different season. Consumption of green and dry fodder on per day basis by different categories of livestock was recorded by weighing the green and dry fodder feed to the livestock in different seasons. Through this data per household and per village consumption in different season was calculated. (According to Khanduri *et al.* 2002 and Bijalwan *et al,* 2011).

Fodder Consumption

$$Daily\ per\ cattle\ consumption\ of\ fodder = \frac{Quantity\ consumed\ per\ day\ per\ household}{No.of\ cattles\ per\ household}$$

$$Daily\ per\ village\ consumption = Per\ cattle\ consumption\ of\ fodder \times No.of\ cattles\ per\ village$$

3.3.2 Fuel wood consumption pattern in the selected villages

The fuel wood consumption of the selected villages in the study area was carried out with the help of data collected from the villages using questionnaires. The fuel wood requirement was based on the daily consumption rate on per capita basis, which was later multiplied by the number of individuals in the village. Fuel wood is use by the villages for various purposes such as cooking is the major activity in household and account for maximum firewood demands in all communities, as primary source of energy, used for food preparation, water heating during winter.

Fuel wood Consumption

$$Daily\ per\ head\ consumption\ of\ fuel\ wood = \frac{Quantity\ consumed\ daily\ per\ household}{No.of\ persons\ in\ that\ household}$$

$$Total\ consumption\ of\ the\ village = Daily\ per\ head\ consumption \times No.of\ persons\ in\ the\ village$$

3.4 Statistical analysis

The stratified random sampling will be adopted for the consumption of fuel wood and fodder in different villages. Mean, standard deviation and percentage for different quantitative parameters in each agroforestry system will be calculating using MS Excel 2007.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Fodder consumption pattern in study villages in different seasons

For assessing the fodder consumption, pattern in selected villages first we have documented livestock breeds *viz*. buffalo, cow, calf, goat and sheep in different villages. There after we calculated the CEU (Cattle Equivalent Unit) on the basis of livestock breeds. Further total numbers of CEU were divided by number of household for the calculation of the average CEU in each village. The description of CEU and avg. CEU are described according to villages in following Table 2. Table 2 showing the maximum household for Maun village (159) and minimum household for Dargi village (64). The highest CEU (Cattle Equivalent Unit) present in Maun village (135.2) and lowest CEU present in Dargi village (62.5).

Table 2: Table showing general description of villages on the basis of livestock

Village	Household	CEU	Avg.CEU
Dikhol	150	114	0.76
Manjyur	81	72.4	0.89
Guldi	101	88.9	0.88
Dargi	64	62.5	0.97
Jagdhar	135	128.4	0.95
Maun	159	135.2	0.85

*Abbreviation used: CEU= Cattle Equivalent Unit

1Adult cow/bullock/buffalo = 1CEU, 1 Young stock of cattle, buffalo and other animals = 0.5, 1 Goat/sheep = 0.2 CEU. According to **Singh *et al.* (2004)**

4.1.1 Fodder consumption in different seasons

The maximum fodder consumption varied from 8.41 kg/day/cattle head to 18.76 kg/day/cattle head in winter and 9.35 kg/day/cattle head to 20.63 kg/day/cattle head in summer season. The maximum fodder consumption (kg/day/cattle head) was recorded for

Dargi village in both season and minimum fodder consumption was for Dikhol village in both summer and winter season (Table 3). The variation of fodder collection due to high altitude villages are in close vicinity of the forest and thus collect more fodder as compared to lower and middle altitude villages. The peoples of middle and lower altitude collect maximum fodder from their farmland and on farm trees.

The season also played a major role in the availability of fodder. The Table 4 shows that the per village consumption of fodder varied from 960 kg/day/village to 2263.48 kg/day/village for Dikhol and Maun villages, respectively in the winter season and 1066 kg/day/village to 2527.44 kg/day/village for Dikhol and Maun villages, respectively in summer season.

In winter season, tree leaves are used as a green fodder viz. *Grewia optiva, Ficus roxburghii, Quercus leucotrichophora, Bauhinia variegata, Morus serrata, Ficus palmata, Melia azedarach* etc. Because in this season green grass is not available and tree leaves are used as a green fodder. In case of dry fodder, stored agriculture residues, dry grass of forest, waste lands and fields are used for livestock feeding. Green fodder consumption is directly proportional to number of cattle equivalent unit.

A similar study was done by Khanduri *et al.* (2002) 5.74 kg/day/cattle head to 6.76 kg/day/cattle head forest fodder and 2.68 to 3.17 kg/day/cattle head agriculture fodder consumption had been reported. In case of forest fodder and agricultural fodder in respect of per village basis, the value varied from 838.24 to 1211.14 kg/day/village and 393.08 to 565.48 kg/day/village respectively for Kedarnath forest division in Rudraprayag district of Garhwal Himalayas. Bijalwan *et al.* (2011) also reported the consumption of tree fodder (green) and dry fodder in winter season was 5.28 to 8.16 kg/day/cattle head and 1.88 to 3.72 kg/day/cattle head respectively under six different villages of Garhwal Himalayas. And utilization of tree fodder varied from 659.53 to 2015.52 kg/day/village in the winter season. Dhanai *et al.* (2014) reported 19.25 to 28.08 kg green fodder collection per household per day and 20.95 to 22.45 kg dry fodder collection per household per day in winter season. And average fodder consumption was 12.37 to 18.33 kg animal per day in different altitudinal zones in TakoliGad watershed. Sharma *et al.* (2009) conducted a study in the Rudraprayag and Tehri district of Garhwal Himalayas on five mid altitudinal villages. The investigation revealed that the

average fodder consumption in these villages was 6736.6 kg\day\village. Maikhuri *et al.* (2013) reported the highest average fodder consumption was observed in the village Osla (38.8±3.7 kg/household/day) and lowest in Gainchwangon (31.3±2.3 kg/household/day). Dhanai *et al.* (2014) quantified the dynamics of seasonal fodder consumption in Takoligad watershed, Tehri Garhwal, Uttarakhand. The total annual consumption of fodder was highest (7946.05 kg) in high altitude and lowest (6077.25 kg) in the lower altitude villages. Malik *et al.* (2014) conducted a study to understand the fodder consumption pattern at three different altitudes of Kedarnath Wildlife Sanctuary. The average fodder consumption was found to be 43.96 kg/day/household. Sati and Song (2012) carried out a study in eight villages of Kewer Gadhera Sub- Watershed, which revealed that variation in forest biomass consumption varies from 12 kg/day/house hold (fodder) in the lower elevation (1150m) to 34 kg/day/household (fodder) in the higher elevation (1900 m).

Table 3: Table showing preferred fodder tree species in study area

Sl. No	Local Name	Botanical Name	Family
Tree			
1	Bhimal	*Grewia optiva*	Tiliaceae
2	Kharik	*Celtis australis*	Ulmaceae
3	Shehtoot	*Morus alba*	Moraceae
4	Banjh	*Quercus leucotrichophora*	Fagaceae
5	Bedu	*Ficus palmata*	Moraceae
6	Timla	*Ficus roxburghii*	Moraceae
7	Daikan	*Melia azedarach*	Meliaceae
8	Painya	*Prunus cerasoides*	Rosaceae
9	Toon	*Toona ciliata*	Meliaceae
Shrub			
10	Tungla	*Rhus parviflora*	Anacardiaceae
Grasses			
11	Kumaya	*Andropogon contortus*	Poaceae
12	Musliya	*Andropogon munrio*	Poaceae
13	Tuchulla	*Apluda mutica*	Poaceae

Table 4: Table showing fodder consumption pattern in the selected village of study area

Villages	Fodder consumption kg/day			
	kg/day/cattle head		kg/day/village	
	Winter	Summer	Winter	Summer
Dikhol	8.41	9.35	960	1066
Manjyur	14.17	15.75	1026.61	1140.50
Guldi	15.12	16.01	1344.61	1423.41
Dargi	18.76	20.63	1172.68	1289.94
Jagdhar	14.27	15.27	1832.74	1961.14
Maun	16.74	18.69	2263.48	2527.44
Mean	**14.58**	**15.95**	**1433**	**1568**
SD	**3.49**	**3.83**	**512.63**	**567.11**

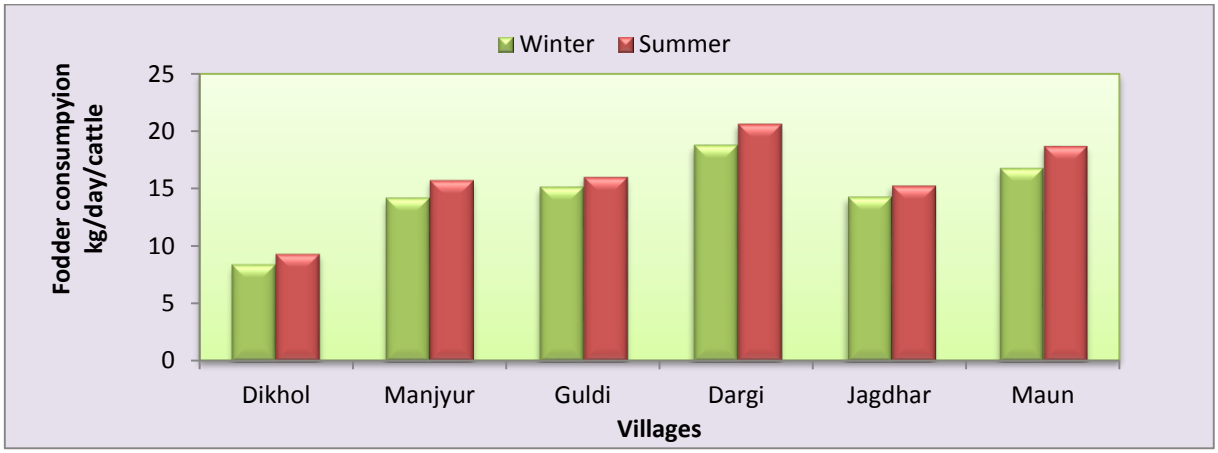


Fig 2: Figure showing Fodder consumption kg/day/cattle head in different villages of study area

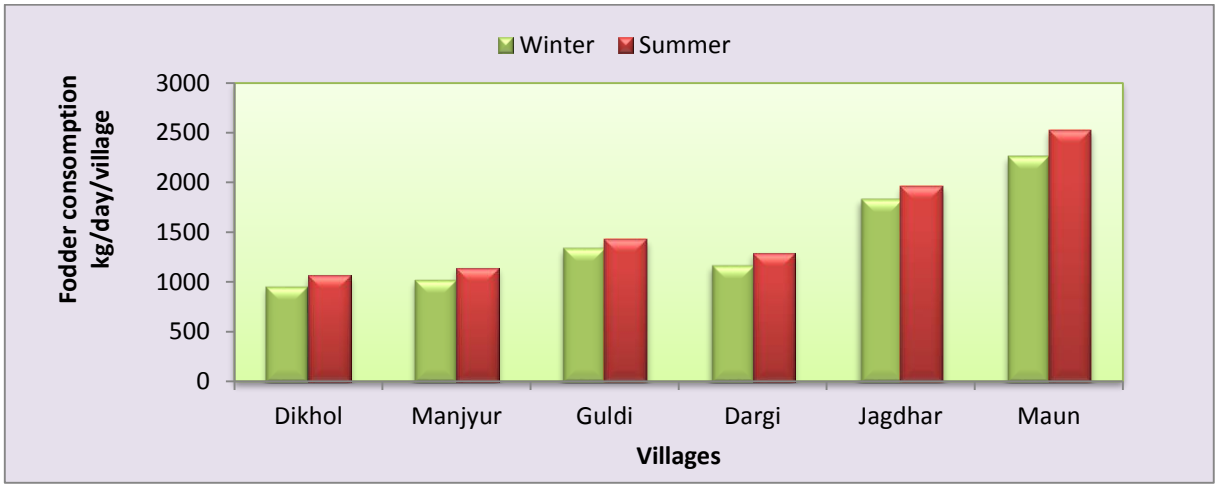


Fig 3: Figure sowing fodder consumption kg/day/village in different villages of study area

4.1.2 Amount of fodder used by different livestock in kg/day

The farmer used green as well as dry fodder for their animals. The dependency on dry fodder was more during winter and summer season as there was a scarcity of green fodder during winter and summer. For dry fodder the farmers either collected it from grass and pasture lands or forest lands or crop residues. The amount of fodder used to feed the animal also varied with economic status of the farmer. The farmer does not purchase the fodder from market society. The dependency on dry fodder was more during winter.

Livestock population of study area comprised mainly of cow, bullock and buffalo with very few goats. The Maun village has highest number of livestock it is 51, and the least number of livestock in Manjyur village (29) according to Table 5. The study also shows the grazing pattern in these villages which is indication about grazing that being persuaded.

Table 6 showing the quantity of fodder used by livestock. All the study villages the highest quantity of fodder used by Buffalo 35.4 kg/day, than Cow 18.2 kg/day. Lowest quantity of fodder used by Goat 6.5 kg/day

Qureshi *et al.* (2015) reported that the highest share among total bovine population was shown by buffaloes (43.38%) and lowest by he-buffaloes (4.42%). The reason behind the largest population of buffaloes was the dependency of villagers on buffalos for milk and milk products which help them to generate income. A similar study was done in Bangladesh where it was found that in the household having home gardens, poultry (64%) was the major livestock component of each household followed by goat (12%), cattle (10%), buffalo (18%), and 6% sheep (Alam and Masum, 2005). Akhter and Malaviya (2014) estimated the highest percentage share among total bovine population was shown by cow (50.79%) and lowest by sheep and goats (7.93%). Toky *et al*. (1989) reported that the total above ground biomass in agri-horti-silvicultural or agri horticultural system was around 48 t/ha and it was about two fold higher than, agrisilviculturtal systems. In fodder tress, significant percentage of annual production up to 48% was allocated in current twigs, while in horticultural trees, a major portion, up to 63% was partitioned in fruits. Trees and shrubs are found ubiquitously, but fodder availability for livestock production is limit. Rajan (2009) analyzed the utilization of

tree foliage as an alternative or supplementary feed to the available grass. The foliages have high digestibility, good vitamin and mineral content and they enhance the microbial growth and digestion of cellulosic biomass in the rumen of livestock.

Table 5: Table showing fodder consumption (animal/kg) and form of feed in selected villages of study area

Village	Type of livestock and number	Average fodder consumption (animal/kg)	Rearing or grazing	Stall feeding	Cooked food
Dikhol	Buffalo (19)	37	No	Yes	Yes
	Cow (4)	20	No	Yes	Yes
	Goat (12)	Browsing	Yes	No	Yes
Manjyur	Buffalo (18)	35	No	Yes	Yes
	Bullock (6)	12	Yes	Yes	No
	Cow (5)	19	No	Yes	Yes
Guldi	Buffalo (23)	36	No	Yes	Yes
	Cow (5)	20	No	Yes	Yes
	Goat (8)	Browsing	Yes	No	Yes
Dargi	Buffalo (21)	35	No	Yes	Yes
	Bullock (6)	13	Yes	Yes	No
	Cow (6)	17	No	Yes	Yes
Jagdhar	Buffalo (27)	36	No	Yes	Yes
	Cow (6)	20	No	Yes	Yes
	Goat (10)	Browsing	Yes	No	Yes
Maun	Buffalo (36)	36	No	Yes	Yes
	Bullock (8)	13	Yes	Yes	No
	Cow (7)	18	No	Yes	Yes

Table 6: Table showing quantity of fodder used by the livestock in kg/day in different villages of study area

Sl. No	Name of livestock	Quantity of fodder used by kg/day/animal
1	Buffalo	35.4
2	Bullock	14.21
3	Cow	18.2
4	Goat	6.5

4.2 Fuel wood consumption pattern in study villages

4.2.1 Preferred fuelwood species and their availability in the different study areas

Study of fuelwood consumption pattern was conducted among different land holding categories. Firewood is also used for cooking food and for warming houses in winter season. At higher elevations people collected firewood during winter months only and store it for the whole year whereas, at lower elevations collection is made throughout the year. Fuelwood consumption is also not similar for all the season (Table 9, Fig 4 and Fig 5).

On the field work that included personal interview, discussions with villagers and personal observation, a total of nine tree species were identified as the preferred fuelwood species (Table 7). Some woody species like *Quercus leucotrichophora, Pinus roxburghii* and *Rhododendron arboretum.* These preferred fuelwood species having good fuel characteristics like high calorific value, burn well with good and gradual flame, and produce less smoke. Villagers also use many other agro-forestry species as fuelwood but they preferred to use these species more likely as fodder viz. Kharik (*Celtis australis),* Bhimal *(Grewia optiva),* Dainkan *(Melia azedarach)* etc. The major tree species used for fuelwood at different altitudes are presented in Table 7.

Singh *et al.* (2010) estimated that a total of 88 species are consumed as fuelwood (54 trees and 34 shrubs) by the local people in "Dhaba owner" in Garhwal Himalayas, India. Similarly, as Dhanai *et al.* (2015) recorded 10 trees and 4 shrub species as the preferred fuelwood species at Takoligad Watershed Garhwal Himalayas, India. Bhatt and Sachan (2014) found that 32 tree species are used as fuelwood by the villagers at Garhwal Himalayas. According to Sharma *et al.* (2012) 35 species of cultivated plants and 89 species of wild plants were found to be utilized as food sources. Selectively 25 wild tree species are used by the Van Gujjars as fodder, fuelwood, agricultural implements, medicine and other products.

Villagers travel considerable distances (1-3 Km.) to collect the fuelwood species and spent large part of day ranging from few hours to half a day to collect fuelwood (Table 8). Villagers of lower altitude travel more distance and spent more time in search of preferred fuelwood species as compared to higher and middle altitudes. The maximum fuelwood is

collected during winter season (October to March). Fuelwood collection is carried out mainly by women and children, but sometimes men also take.

Table 7: Table showing preferred fodder tree species in study area

Sl. No.	Local Name	Botanical Name	Family
1	Banjh	*Qurecus leucotrichophora*	Fagaceae
2	Mellu	*Pyrus pashia*	Rosaceae
3	Chir	*Pinus roxburghii*	Pinaceae
4	Dainkan	*Melia azedarach*	Meliaceae
5	Sissoo	*Dalbergia sissoo*	Fabaceae
6	Shehtoot	*Morus alba*	Moraceae
7	Bhimal	*Grewia optiva*	Tiliaceae
8	Painya	*Prunus cerasoides*	Rosaceae
9	Kaphal	*Myrica esculenta*	Myriacaceae

Table 8: Table showing source of fodder and fuel wood collection in different villages of study area

Village	Distance travelled by villager (km/day)	Distance travelled by animal/browsing (km/day)	Main sources of fodder and fuelwood collection
Dikhol	1.25	1-3	Forest, Agroforestry trees, Agricultural land
Manjyur	1.15	1-2	Forest, Agroforestry trees, Agricultural land
Guldi	1.25	1-4	Forest, Agroforestry trees, Agricultural land
Dargi	1	1-3	Forest, Agroforestry trees, Agricultural land
Jagdhar	1	1-3	Forest, Agroforestry trees, Agricultural land
Maun	1.5	1-5	Forest, Agroforestry trees, Agricultural land

4.2.2 Altitudinal and Seasonal variations in fuelwood consumption

The fuel wood was used by all the families in different villages besides the other alternatives. The average daily fuel wood consumption in different villages varied from 253.43 kg/day/village to 1202.05 kg/day/family in summer and 928.52 kg/day/village to 3712.28 kg/day/village in winter (Table 9). The minimum consumption of fuel wood was recorded in Dargi village in both summer and winter season and the maximum consumption of fuel wood was recorded in Maun village in both summer and winter season. Fuelwood consumption (kg/household/day) varied from one household to another which was depending on size of the family. Majority of fuel wood demand was met out from forest area. The minimum and maximum per capita consumption of fuel wood was recorded for Dikhol and Maun village in both summer and winter season which was from 0.57 kg/capita/day to 1.68 kg/capita/day and 2.11 kg/capita/day to 5.18 kg/capita/day.

On the basis of above mentioned result it is observed that in winter season the consumption of fuelwood is much higher than summer season. During winter season, temperatures fall under 0ºC, especially during the night. So most of peoples use fuelwood as room or water heating during winter. Khanduri *et al.* (2002) reported the consumption of fuelwood in summer season was 164.16 kg/day/village to 389.91 kg/day/village and in winter season it was 277.92 kg/day/village to 662.53 kg/day/village. The average per capita fuelwood consumption varied from 1.14 kg/capita/day to 1.23 kg/capita/day in summer and in winter season from 1.93 kg/capita/day to 2.09 kg/capita/day respectively for Kedarnath forest division in Rudraprayag district of Garhwal Himalayas. In the same way a study was done Bijalwan *et al.* (2011) in six villages in Garhwal Himalayas. The average daily fuelwood consumption during summer and winter in different villages varied from 84.41 to 538.45 kg/day/village and 156.75 to 701.01 kg/day/village. Todaria *et al.* (2009) reported fuelwood consumption was highest in high altitude villages as compared to low altitude. Fuelwood consumption of 4.32 kg/capita/day was highest at Khoksar during winter season followed by the autumn (2.25 kg/capita/day) and summer (1.38kg/capita/day) in cold desert of the Lahaul valley. In comparison to earlier studies Singh *et al*. (2015) noted average fuelwood consumption (kg/day/household) at three altitudinal zones in different season was 6.58 in summer, 10.80 in winter (Low 500-1000 m amsl), 7.34 in summer, 12.72 in winter (Middle

1000-1500 m amsl) and 9.66 in summer, 14.42 in winter (High 1500-2000 m amsl) in Takoligad Watershed of Garhwal Himalayas, India. Awasthi *et al.* (2003) conducted a study of Forest resources availability and its use by the migratory villages of Uttarkashi, Gahwal Himalayas. Average firewood consumption per household was 14.65±0.78 kg/day. Bhatt and Sachan (2004) conducted a study of firewood consumption pattern of three tribal communities of Meghalaya, India-Garo, Khasi and Jaintia in Northeast India. Fuelwood consumption was highest for Khasi community (5.81 kg/capita/day), followed by the Garo (5.32 kg/capita/day) and Jaintia (3.90 kg/capita/day). Sati and Song (2011) conducted a study of eight villages of Kewer Gadhera Sub Watershed into the Pindar River at Narain Bagar town Uttarakhand. Forest biomass consumption varied from 13 kg/day/households (fuelwood) in the lower elevation (1150 m) to 28 kg/day/household (Fuelwood) in the higher elevation (1900 m). Its consumption varied in different locations and seasons. It is also influenced by the aspect of slope. Bhatt *et al.* (1994) analyzed firewood consumption along altitude gradient by households according to their socio-economic condition in Garhwal Himalayas. Consumption of fuelwood (kg/capita) was 789, 664, 518, and 544 kg/capita, respectively, above 2000 m, for 1500 m-2000 m, 1000 m-1500 m, and 500 m-1000 m elevations. Munesh and Sharma (2009) studied the use of fuelwood as a primary source of energy for domestic use in causing severe deforestation in Garhwal Himalayas. The total average fuelwood consumption in the study was observed to be highest for Ganga Bhogpur (2.52 kg/capita/day) and lowest for Ghargoun (1.63 kg/capita/day). The fuelwood consumption rate oscillated considerably across the different seasons. Vibol *et al.* (2012) Analyzed approximately 96% of sampled households depend on fuelwood. Overall average fuelwood consumption for cooking and boiling water per family per day was 5.21±0.11 kg and 2.82±0.11 kg. the average fuelwood consumption rate is approximately 5.60±0.11 kg/day/family.

Table 9: Table showing fuel wood consumption pattern in the selected villages of study area

Village	Fuel wood consumption (kg)					
	Kg/day/head		Kg/day/family		Kg/day/village	
	Summer	Winter	Summer	Winter	Summer	Winter
Dikhol	0.57±0.38	2.11±1.10	3±0.12	10.57±0.3	370.94	1375.02
Manjyur	0.68±0.62	2.53±0.95	4.26±0.21	13.73±0.37	254.30	948.10
Guldi	1.08±0.98	2.68±1.03	4.16±0.96	13.94±0.36	497.72	1234.03
Jagdhar	0.93±0.48	2.71±0.71	3.33±0.24	9.01±0.51	526.80	1537.99
Dargi	0.83±0.68	3.05±0.67	2.456±0.05	8.29±0.88	253.43	928.52
Maun	1.68±0.29	5.18±0.44	6.74±0.35	20.27±0.42	1202.05	3712.28

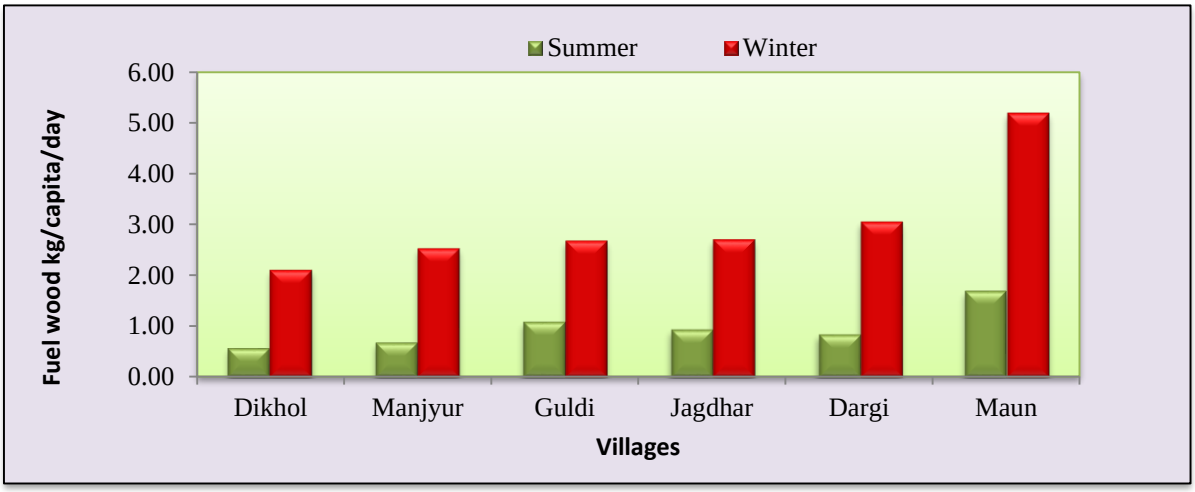


Fig 4: Figure showing fuel wood consumption kg/capita/day in different villages of study area

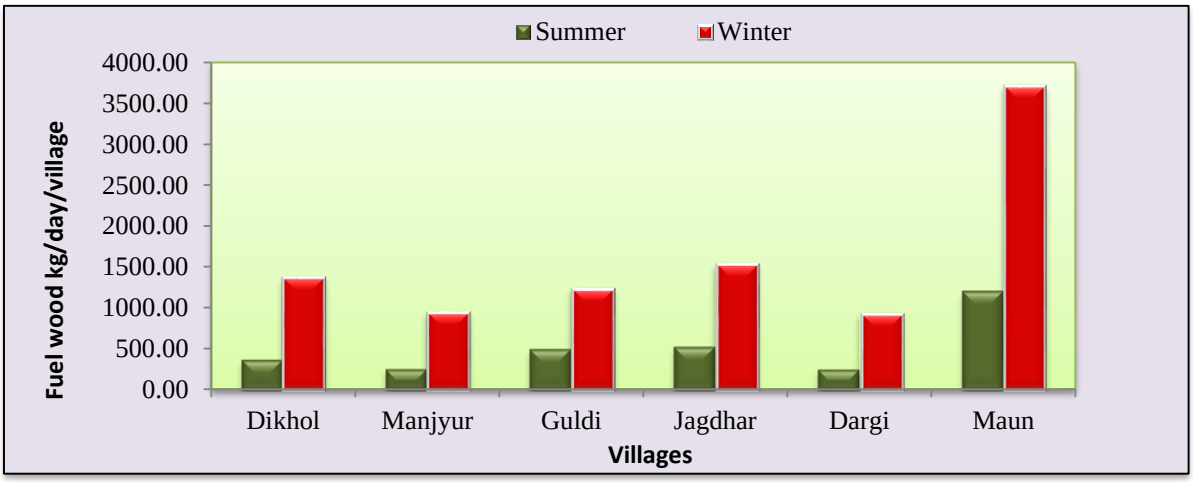


Fig 5: Figure showing fuel wood consumption kg/day/village in different villages of study area

4.3 Socio-economic status of different villages in the study area

The study was based on the primary survey and data collection through the Participatory Rural Appraisal (PRA) method by approaching the villagers representing different age groups and gender also. The survey has been conducted in 25 household on random basis from centre of the village to obtain the real pattern of information.

4.3.1 General information about the selected villages: The nearest local market is Chamba and the main business centre is Rishikesh (Table 10). All the six villages are connected by telephone, and school for primary education. Medical facilities are not available in the study villages. All the surveyed villages have cemented houses and supply of electricity. The major crops are *Oryza sativa* (Rice), *Triticum estivum* (Wheat), *Zea mays* (Maize), *Cynosurus coracana* (Koda), *Panicum crusgalli* (Jhangora) and various vegetables, pulses, banana and other fruit trees are grown for household consumption.

Age distribution of respondents is given in the Fig 6. The age of respondents was categorized as young, middle and old. Majority of the respondents in middle age 220 (49%) followed by 146 (32.30%) in young age.

The earlier studies by (Hisrich and Brush, 1984; Arulprakash *et al.* 2005 and Mehram *et al.* 2006) also supported the present study which indicates that middle aged persons especially women have more entrepreneurial orientation and innovative ideas and they take up more income generating activities. On the other hand, young group is busy with their studies and household activities and old age respondent are not very much involved in planting, collection of fuel wood and fodder activities.

Data regarding family size has been presented in Fig 7. It was revealed that majority of respondents 81% belonged to small family, followed by 14% respondent who had medium sized families and only 5% respondent had large family. In Table 10 it is clear at the majority of the family belonged to the nuclear family 23 (92%) in Manjyur and Dargi. Data represented in Fig. 8, show the type of family of the respondents. It is clear from the data that majority of the family belonged to the nuclear family 130 (86.7%) while only 20 (13.33%) respondent belonged to joint family. It is indicated that nuclear family system was gradually replacing joint family system in rural areas also.

According Pandeya and Yadava (2016) average family size varied between 7.9 person perhouseholds in Ramara and 7.3 per household in Farika village. According Akhter and Malaviya, (2014) highest representation of families was from large (60%) followed by small (26.66%) and medium (13.33%). According to family size classes, nearly 25.83% belonged to the small household category, while 8.33% were in the very large category (Dhanai *et al*. 2014). Arulprakash and Hirevenkanagoudar (2005) surveyed that middle aged persons especially women have more entrepreneurial orientation and innovative ideas and they take up more income generating activities. On the other hand, young group is busy with their studies and household activities and old age respondent are not very much involved in planting, collection of fuel wood and fodder activities.

Table 10: Table showing the description and general information of the villages

Parameter	**Villages**					
	Dikhol	**Manjyur**	**Guldi**	**Dargi**	**Jagdhar**	**Maun**
Altitude (m)	1350	1300	1475	1698	1656	1981
Existing Agroforestry system	AS,AHS, AH, ASP	AS,AHS, AH, ASP	AS,AHS, AH,	AS,AHS, AH	AS,AHS, AH	AS,AHS, AH,ASP
Distance (km) from (a) local market (Chamba)	1	1	3	5	6	10
(b) Main market (Rishikesh)	94	94	97	99	100	110
Electrification (%)	100	100	100	100	100	90
Primary School	Y	Y	Y	Y	Y	Y
Primary Health Centre	N	N	N	N	N	N
Post Office	N	N	N	N	N	N
Telephone	Y	Y	Y	Y	Y	Y

*Abbreviation used: N= Not available, Y= Yes available

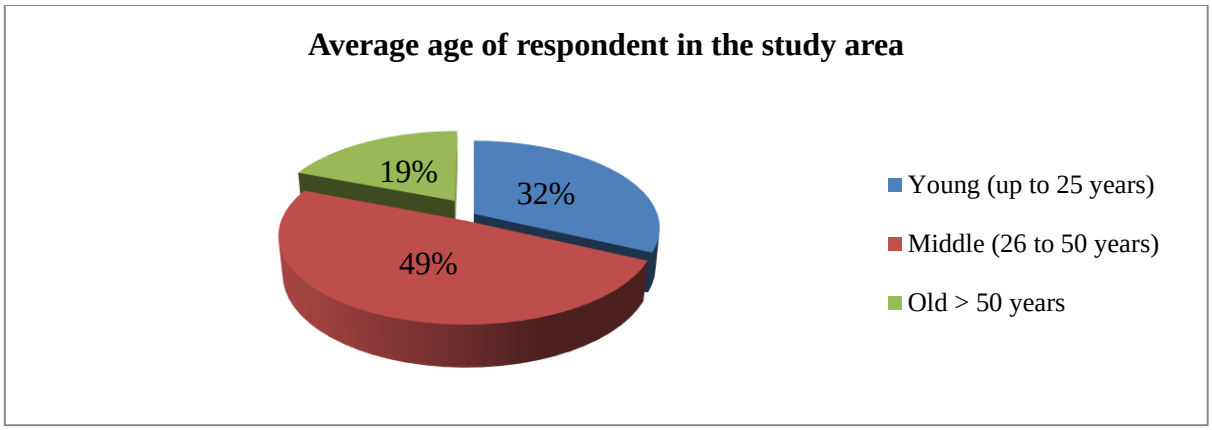


Fig 6: Figure showing distribution of respondent on the basis of age (N=452)

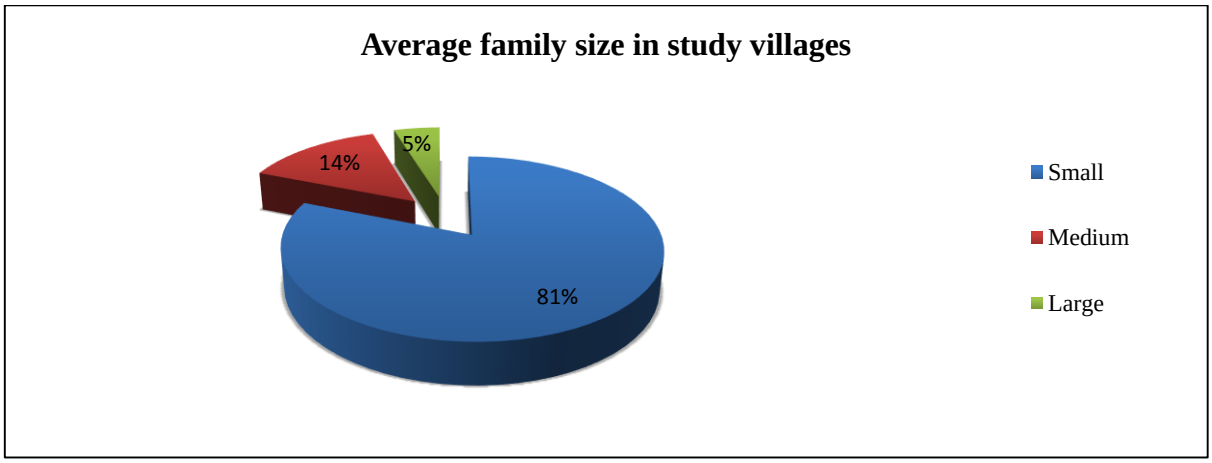


Fig 7: Figure showing distribution of respondent on the basis of size of family (N= 150)

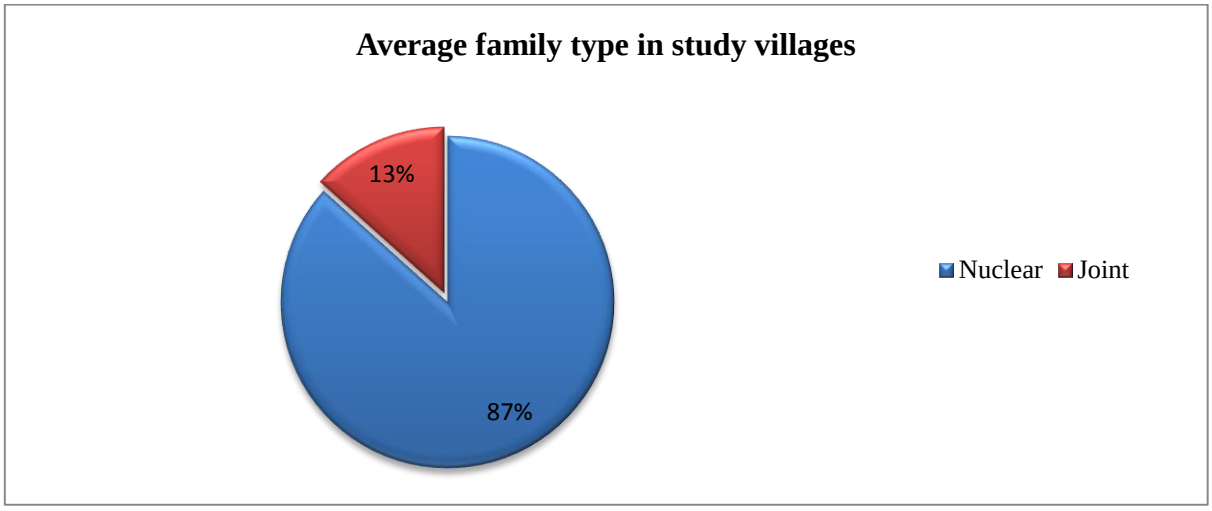


Fig 8: Figure showing distribution of respondents on the basis of Family Type (N=150)

Data given in (Table 11) shows education distribution in different villages. It was revealed from the interview that maximum number of respondents 51.47 % male had educated in Manjyur followed by 47.05% man in Maun village. The maximum educated female 35.93% in Dikhol, which is followed by 34. 93% in Jagdhar village. The data in the Fig 9 gives education level of the respondents. Out of 150 families, 24% peoples are illiterate, 30 % female are educated and 46% male are educated.

It was observed that maximum number of household families *i.e.* 57 (38%) belonged to service class which was source of income followed by 50 (33.33%) belonged to farming followed by 43 (26.66%) families that were dependent in the business for their livelihood. In addition to primary occupation, information was collected on secondary source of income (Fig 10). According to (Statistical bulletin, Nainital district, Uttarakhand, 2011-12), 30.36% of persons are farmers, 4.43% agricultural labourers, 1.40% in family business, 3.26% in plantation, 2.97% in transportation and communication, 7.14% in trading and 5.06% in others. The results indicated that selected families earn their income from business, service, self-employment and agriculture. During informal discussion it was found that education facility was well in the village & nearby area. But the education level of women till the day was less than the man because the women were fully involved in the agriculture as well as household activities. The earlier studies by (Bijalwan *et al.* 2011) also support present study which indicates that the adult literacy rate was 43% in marginal, 54% in small and 73% in medium-large land holding families while the child education rate was 86, 98, and 100%, respectively. The livestock were kept by 37 to 56% families in different villages in Garhwal Himalayas, India. Panday and Yadav, (2016) recorded the average family size varied between 7.9 people per households in Ramara and 7.3 people per households in Farika village and Similarly sex ratio ranged between 933 and 1036, respectively. The literacy rate in both villages above 65%, due to lack of employment opportunities people still invariably depend on forests for their livelihood in Chamoli district, Uttarakhand. Gairola *et al.* (2012) conducted a study on the Van Gujjar tribe inhabiting a sub- Himalaya tract in North Western Himalayas of Uttarakhand state, India. A total of 176 households were interviewed by using pre-structured questionnaires. The major source of income was dairy production (80.6%) followed by labour employment (13.9%), NTFPs (4.2%) and agricultural production (1.4%).

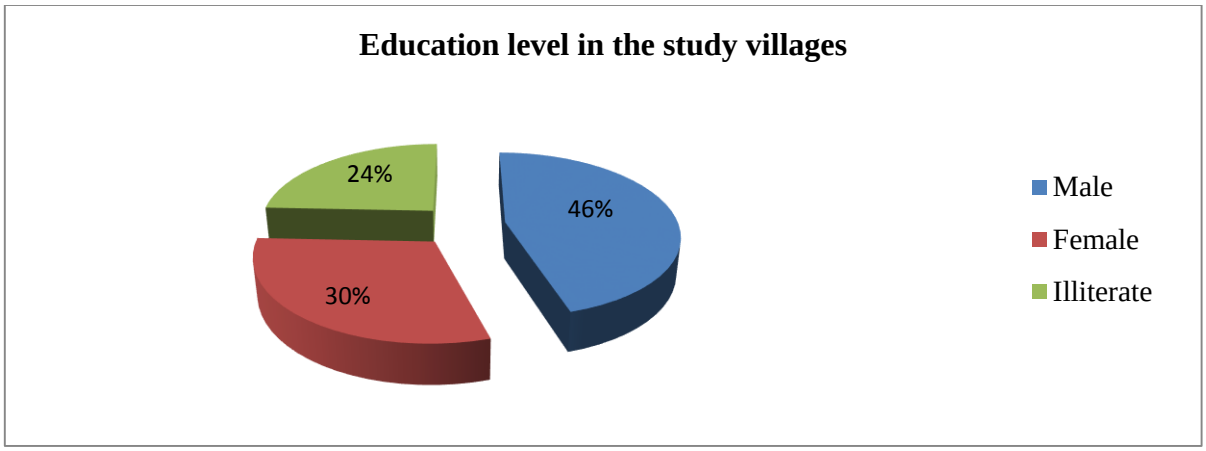


Fig 9: Figure showing distribution of respondents on the basis of education (N=452)

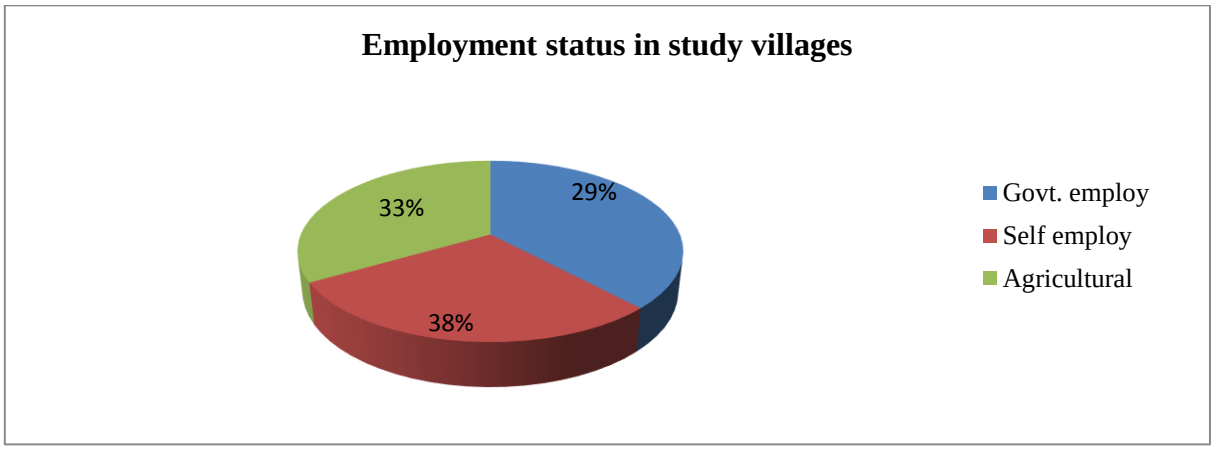


Fig 10: Figure showing distribution of respondents on the basis of primary occupation (N= 150)

Table 11: Table showing Socio-economic status of different villages of study area

Parameter	Villages												Total
	Dikhol		Manjyur		Guldi		Dargi		Jagdhar		Maun		
Existing Agroforestry system	AS,AHS, AH,ASP		AS,AHS,A H		AS,AHS, AH,ASP		AS,AHS, AH,ASP		AS,AHS,AH, ASP		AS,AHS, AH,ASP		
Total Household	150		81		101		64		135		159		690
Total Population	652		375		460		568		304		716		3085
Average household size	4.34 %		4.62 %		4.55%		8.87%		2.25%		4.50%		4.5%
Sample household	25		25		25		25		25		25		150
Total Population	64		68		68		67		83		102		452
Male	26		22		27		28		32		34		169
Female	38		46		41		39		51		68		283
		%		%		%		%		%		%	
Literate male	29	45.31	35	51.47	31	45.59	28	41.79	34	40.96	48	47.05	205
Literate female	23	35.93	19	27.94	17	25	22	32.83	29	34.93	27		137
Family size													
Small (Up to 4)	23	108.7	21		20		18		22		16		120
Medium (4 to 8)	2		4		3		4		3		5		21
Large > 8	0		0		2		2		0		3		7
Family type													
Nuclear	21	84	23	92	21	84	23	92	20	80	22	88	130
Joint	4	16	2	8	4	16	2	8	5	20	3	12	20
Age													
Young (Up to 25 year)	23	35.93	21	30.88	22	32.35	21	31.34	25	30.12	34	33.33	146
Middle (26 to 50 year)	31	48.43	36	52.94	32	47.05	34	50.74	41	49.39	46	45.09	220
Old (50 onward)	10	15.62	11	16.17	14	20.58	12	17.91	17	20.48	22	21.56	86
Employment status													
Govt. employ	8		6		10		12		14		7		57
Self employ	6		9		5		7		4		10		41
Depend on Agricultural	11		10		5		6		7		8		47
Domestic animal population													
Buffalo	18		15		17		21		25		34		130
Cow	2		3		1		2		3		3		14
Bullock	0		2		0		4		0		4		10
Goat	9		0		5		0		8		0		22

AS=Agrisilvicultural, AHS= Agrihortisilvicultural, AH= Agrihorticultural, ASP=Agrisilvipastoral (system)

4.4 Physical properties of fuelwood species

The wood moisture content, specific gravity and ash content of eleven fuelwood species are represented in Table 12. The moisture content and specific gravity of eleven wood species ranges from 48.42% (*Pyrus pashia)* to 109.85% (*Toona ciliata)*, and 0.568 (*Ficus palmata*) to 0.860 *(Quercus leucotrichophora)*, respectively. *Pyrus pashia* has poorest ash content (2.3%), followed by *Toona ciliata* (5.3%). The ash content is the remaining inorganic part of wood matter that cannot be combusted. A high ash content of a plant part makes it less desirable as fuel, because a considerable part of the volume cannot be converted into energy.

Puri *et al.* (1994) suggested that indigenous species are better suited for fuel purposes as they manifest lower ash content and higher wood density than exotics. Bhatt and Todaria (1992) and Kataki and Konwer (2001) too recorded decreasing heat of combustion with increasing ash percentage. According to, Hashmi and Waqar (2014), ash content ranged from 8.93 % to 14.23 % in *G. optiva,* which supports present study. Bhatt and Tomar (2002) analysed 26 indigenous mountain fuelwood species of North-Eastern Himalayan region to identify trees with potential for fuelwood production. A fuelwood value index (FVI) was defined as calorifc value density/ash content. *Betula nitida, Machilus bombycina, Itea macrophylla, Cryptomeria japonica, Gmelina arborea, Simingtonia populnea, Macaranga denticulata and Schima wallichii* were shown to have promising firewood production. Krishna and Ramaswamy (1932) also reported higher ash-free sapwood calorific values for nine species studied by them (*Anogeissus pendula, Bischofia javanica, Dalbergia latifolia, Dipterocarpus turbinatus, Dodonaea viscosa, Grewia tiliifolia, Melia azedarach, Meliosma simplicifolia* and *Talauma hodgsonii*). Sheikh *et al.* (2011) estimated specific gravity of wood samples collected from a total of 34 tree species, 30 from lower elevations and 4 from upper elevations in the Garhwal Himalayas, India. The resu1ts shows that the average wood specific gravity was 0.631 (ranging between 0.275±0.01 and 0.845±0.03) for the species at lower elevations and 0.727 (ranging between 0.628±0.02 and 0.865±0.02) for the upper elevations. Ghosh *et al.* (1963) reported the highest specific gravity (0.845), in *Aegle marmelos.* Wani *et al.* (2014) conducted a study of wood specific gravity variation among five important hardwood species of Kashmir Himalayas. Among the three different sites, specific gravity varied from 0.73 to 0.80 in *Parroptiosis jacquemontiana,* in *Robinia pseudoacacia* it varied

from 0.71 to 0.79, in *Salix alba*, it varied from 0.42 to 0.48. In *Populus nigra* it varied from 0.40 to 0.48, and in *Juglans regia* it varied from 0.59 to 0.66.

Table 12: Table showing moisture content, specific gravity and ash content of evaluated fuelwood species

Sl. No.	Fuel wood Species	Moisture Content %	Specific Gravity	Ash content %
1.	*Celtis australis*	54.19	0.716	8.4
2.	*Dalbergia sissoo*	56.92	0.679	8.1
3.	*Ficus palmata*	70.73	0.568	8.6
4.	*Grewia optiva*	50.61	0.706	9.7
5.	*Melia azedarach*	69.08	0.685	7.2
6.	*Morus alba*	65.96	0.716	6.9
7.	*Myrica esculenta*	71.77	0.737	7.5
8.	*Prunus cerasoides*	72.85	0.634	8.4
9.	*Pyrus pashia*	48.42	0.680	2.3
10.	*Quercus leucotrichophora*	73.06	0.860	5.7
11.	*Toona ciliata*	109.85	0.571	5.3

CHAPTER 5 SUMMARY AND CONCLUSION

The present investigation entitled "Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand was conducted in six different villages lying between 1300 and 2000 m elevation in Garhwal Himalayas. The survey was done for assessment of fuelwood and fodder consumption pattern based on the basis of questionnaire, interview of family and visual basis. 25 households from each village were selected and a total 150 households were surveyed. The study was proposed to identify the consumption pattern of fuelwood and fodder in the study sites and socio-economic status of farmer's in the hilly areas with the following objectives:

1. Fodder consumption pattern in study villages under different seasons.
2. Fuel wood consumption pattern in study villages.
3. Evaluation of socio-economic status of the villagers.
4. Determination of moisture content, specific gravity and ash content of different fuel woods species of study areas.

MAJOR FINDINGS:

5.1 Fodder consumption pattern in study villages under different seasons

5.1.1 Maximum fodder consumption was recorded in summer season all the study villages. The maximum fodder consumption varied from 8.41 kg/day/cattle head to 18.76 kg/day/cattle head for winter season and 9.35 kg/day/cattle head to 20.63 kg/day/cattle head for summer season.

5.1.2 The maximum fodder consumption (kg/day/cattle head) was recorded for Dargi village and minimum fodder consumption for Dikhol village in both summer and winter season.

5.1.3 Per village fodder consumption was noted as 960 kg/day/village (Dikhol) to 2263.48 kg/day/village (Maun) for winter season and from 1066 kg/day/village (Dikhol) to 2527.44 kg/day/village (Maun) for summer season.

5.2 Fuel wood consumption pattern in study villages

5.2.1 The average daily fuel wood consumption in different villages varied from 253.43 kg/day/village (Dargi village) to 1202.05 kg/day/family (Maun village) in summer season and 928.52 kg/day/village (Dargi village) to 3712.28 kg/day/village (Maun village) in winter season. The minimum consumption of fuel wood was recorded for Dargi village in both summer and winter season and the maximum consumption of fuel wood was recorded for Maun village in both summer and winter season.

5.2.2 The highest fuelwood consumption noted for Maun village (6.74 kg/day/family) followed by Manjyur (4.26 kg/day/family) and minimum consumption in Dargi (2.45 kg/day/family) followed by Dikhol (3 kg/day/family) in summer season. In winter season highest consumption of fuelwood recorded Maun (20.27 kg/day/family) and least consumption in Dargi (8.29 kg/day/family).

5.2.3 The average per capita fuel wood consumption during summer and winter in all the villages ranged from 0.57 kg/capita/day (Dikhol) to 1.68 kg/capita/day (Maun) and 2.11 kg/capita/day (Dikhol) to 5.18 kg/capita/day (Maun). The minimum and maximum per capita consumption of fuel wood was recorded for Dikhol village and Maun village in both summer and winter season.

5.3 Evaluation of socio-economic status of the villagers

5.3.1 The nearest local market of all the study villages is Chamba and the main business centre is Rishikesh. All the six villages are connected by telephone, and school for primary education. Medical facilities are not available in the study villages. All the surveyed villages have cemented houses and supply of electricity. The major crops are *Oryza sativa* (Rice), *Triticum estivum* (Wheat), *Zea mays* (Maize), *Cynosurus coracana* (Koda), *Panicum crusgalli* (Jhangora) and various vegetables, pulses, banana and other fruit trees are grown for household consumption.

5.3.2 The age of respondents was categorized as young, middle and old. Majority of the respondents are middle age 220 followed by 146 are young age.

5.3.3 The majority of respondents 81% belonged to small family, followed by 14% respondent who had medium sized families and only 5% respondent had large family.

5.3.4 The majority of the families belonged to the nuclear family 23 (92%) in Manjyur village and Dargi village. Out of 150 families, majority of the family belonged to the nuclear family 130 (87 %) while only 20 (13 %) respondent belonged to joint family. It was reported that nuclear family system was gradually replacing joint family system in rural areas also.

5.3.5 The maximum number of respondents 51.47 % are male had educated in Manjyur village followed by 47.05% are male in Maun village. The maximum educated female are 35.93% in Dikhol, which is followed by 34. 93% in Jagdhar village.

5.4 Determination of moisture content, specific gravity and ash content of different fuel woods species of study areas

5.4.1 Moisture content of species ranged from 48.42 % (*Pyrus pashia)* to 109.85 % (*Toona ciliata*). Highest moisture content present in *Toona ciliata* and lowest in *Pyrus pashia.*

5.4.2 Specific gravity of species ranged from 0.568 (*Ficus palmata*) to 0.860 *(Quercus leucotrichophora),* respectively.

5.4.3 *Pyrus pashia* has poorest ash content (2.3%), which followed by *Toona ciliata* (5.3%).

Conclusion

- Based on survey conducted in the year 2015-2016, fuelwood and fodder consumption was analyzed at six different villages of Tehri Garhwal. It was observed that rural households totally depend on forest for the fulfillment of the demand of energy and fodder requirements. This is so because the rural households are resource constrained and availability of other cheaper alternatives to fuelwood is poor. This situation creates an additional pressure on

the forest. Higher fuel wood consumption in the study area is mainly due to lack of accessibility of alternative energy sources, remoteness and poverty. Families belonging to large Family size was the major consumer of all type of energy resources found in the area while the least consumption of energy resources was found in case of small family size. Due to lack of fodder the number of livestock is very poor in these villages so, there is a wide concept gap between villagers for the marketing of milk and other products. Fuelwood is required for cocking food and warming rooms. The fuel wood need is high, particularly during winter season. Agricultural is the main occupation around which all human activities are centered. The tree species which are abundantly used as the fuelwood and fodder by the villagers are *Celtis australis, Dalbergia sissoo, Ficus palmata, Grewia optiva, Melia azedarach, Morus alba, Myrica esculenta, Prunus cerasoides, Pyrus pashia, Quercus leucotrichophora, Toona ciliata.* Villagers should be made aware of the limited natural resources around them and should be encouraged to plant fuel and fodder trees in forests and their farms, beside these lands, community land in surroundings of the villages can also be used for growing grasses and plantation of fuel and fodder trees. Awareness and adoption of improved fuelwood and fodder production and conservation technologies among farmers will increase the production & availability of green fodder in term of quality and quantity significantly. Awareness programmers and adoption of improved fuelwood and fodder production and conservation technologies among farmers should be conducted which will increase the production & availability of green fodder in terms of quality and quantity significantly.

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Questionnaire

1. General information of the village:

Sl. No	Aspects	Villages					
		V1	V2	V3	V4	V5	V6
1	Altitude						
2	Block						
3	District						
4	Total population of the village						
5	Total no. of household						
6	Distance (km) from						
7	Local Market						
	Main Market						
8	Electrification						
9	Post Office						
10	Telephone						
11	Primary School						
12	Health Centre						

2. General information about Villagers:

Villages	Name of Farmer	Gender	Age	Education	Family size	Family type	Type of house	Occupation
V1								
V2								
V3								
V4								
V5								
V6								

3. No of Livestock per household and form of feed by livestock

S. No	Name of Cattle	Number of Cattle	Rearing	Stall feeding	Cooked food
1	Buffalo				
2	Bullock				
3	Cow				
4	Goat				
Total					

4. Type of agroforestry system:

Villages	Agroforestry System					
	Agri-silviculture	Silvi-pasture	Agri-silvi-pasture	Agri-horticulture	Agri-horti-silviculture	Silvi-horticulture
V1						
V2						
V3						
V4						
V5						
V6						

5. Fodder type:

Fodder type	Available in village	
Green grasses		
Dry grasses		
Tree fodder		
Agricultural residue		

6. Name of fodder species:

Sl. No	Local Name	Botanical Name	Tree species	Grasses
1				
2				
3				
4				
5				

7. Name of fuelwood species:

S. No	Local Name	Botanical Name
1		
2		
3		
4		
5		

8. Source of fodder/fuelwood species:

Source of fodder species	
Homestead	
Agricultural field	
Forest	
Agroforestry system	

9. Distance travelled by village for fodder/fuelwood collection (km/day)

10. Fodder consumption kg/household:

Villages	**Summer season**		**Winter season**	
	Green fodder	**Dry fodder**	**Green fodder**	**Dry fodder**
V1				
V2				
V3				
V4				
V5				
V6				

11. Fuelwood consumption kg/household:

Villages	**Summer season**	**Winter season**
V1		
V2		
V3		
V4		
V5		
V6		

Plate 1: Study areas

1. Jagdhar village, **2.** Dargi village, **3.** Dikhol village, **4.** Manjyur village, **5.** Guldi village, **6.** Maun village

Plate 2: Consumption of fodder and fuelwood


1


2


3

1. Weighing of dry head load, **2.** Weighing of green head load, **3**. Dry fodder, 4. Stock of dry fuelwood

Plate 3: Fodder consumption by different livestock

1. Fodder consumption by buffalo, **2.** Fodder consumption by bullock,
3. Fodder consumption by goats

ABSTRACT

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Thesis Title: Fuel wood and Fodder Consumption Pattern in Different Villages of Tehri Garhwal Region, Uttarakhand

The present investigation was conducted in six different villages of Tehri Garhwal Region which lies between 1300m to 2000m altitude. Fuelwood and fodder consumption was studied through socio-economic survey, which was done with the help of a common questionnaire, semi structured inter-views with head or the old person of the family and field observations. In order to ensure the correct answers to the questionnaire, 25 households were visited in each village. The per village consumption of fodder varied from 960 kg/day/village to 2263.48 kg/day/village in Dikhol and Maun villages, respectively for winter season and 1066 kg/day/village to 2527.44 kg/day/village for Dikhol and Maun villages, respectively for summer season.

The maximum fodder consumption varied from 8.41 kg/day/cattle head to 18.76 kg/day/cattle head in winter season and 9.35 kg/day/cattle head to 20.63 kg/day/cattle head in summer season. The maximum fodder consumption (kg/day/cattle head) was recorded for Dargi village for both season and minimum fodder consumption for Dikhol in both summer and winter season. The farmers use green as well as dry fodder for their animals. The dependency on dry fodder was more during winter season as there was a scarcity of green fodder during winter season. For dry fodder the farmers either collected it from grass land and pasture lands or forest lands or crop residues. The amount of fodder used to feed the animal also varied with economic status of the farmer. The farmer does not purchase the fodder from market society.

Livestock population of study area comprised mainly of cow, bullock and buffalo with very few goats. The Maun village has highest number of livestock it is 51, and the least number of livestock in Manjyur village 29. The average daily fuel wood consumption in different villages varied from 253.43 kg/day/village to 1202.05 kg/day/family in summer and 928.52 kg/day/village to 3712.28 kg/day/village in winter. Majority of fuel wood demand was met out from forest areas. The average per capita fuel wood consumption during summer and winter in all the villages ranged from 0.57 kg/capita/day to 1.68 kg/capita/day and 2.11 kg/capita/day to 5.18 kg/capita/day. Highest moisture content was reported in *Toona ciliata* (109.85%) and lowest in *Pyrus pashia* (48.42%). *Pyrus pashia* has poorest ash content (2.3%), followed by *Toona ciliata* (5.3%). The ash content is the remaining inorganic part of wood matter that cannot be combusted.

(Deepika Rawat)

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सत्र एवं प्रवेश वर्ष	: प्रथम सत्र, 2014	उपाधि	: स्नातकोत्तर (वानिकी)
मुख्य विषय	: कृषि वानिकी	संस्थान	: वानिकी महाविद्यालय, वी0च0सिं0ग0 उत्तराखण्ड औद्यानिकी एवं वानिकी विश्वविद्यालय, रानीचौरी परिसर, उत्तराखण्ड

शीर्षकः "उत्तराखण्ड में टिहरी गढ़वाल क्षेत्र के विभिन्न गॉवों में ईधन लकडी और चारा खपत की रूपरेखा"।

वर्तमान अध्धयन टिहरी गढ़वाल छः गॉव में 1300 मी0 से लेकर 2000 मी0 की ऊॅचाइयों के सम्पन्न किया गया। ईधन लकडी और चारे की खपत सामाजिक एवं आर्थिक सर्वेक्षण, सामान्य प्रश्नावली, अर्द्व संरचित प्रश्नावली एवं परिवार के मुखिया एवं बुढे व्यक्तियों के टिप्पणियों के माध्यम से किया गया। प्रश्नो के सही जवाब सुन्निश्चित करने के लिये हर गॉव में पच्चीस परिवारो का भ्रमण किया गया। सर्दियो के मौसम में दिखोल और मौण गॉव में चारे की खपत कमशः 960 किलो/दिन/गॉव से लेकर 2263.48 किलो/दिन/गॉव और गर्मियों में दिखोल और मौण गॉव में चारे की खपत कमशः 1066 किलो/दिन/गॉव से लेकर 2527.44 किलो/दिन/गॉव दर्ज किया गया।

अधिकतम चारे की खपत सर्दी के मौसम में कमशः 8.41 किलो/दिन/मवेशी से लेकर 18.76 किलो/दिन/मवेशी और गर्मी के मौसम में कमशः 9.35 किलो/दिन/मवेशी से लेकर 20.63 किलो/दिन/मवेशी दर्ज किया गया। दोनो ही मौसम (सर्दी एवं गर्मी) मे अधिकतम चारे की खपत (किलो/दिन/मवेशी) डारगी गॉव मे और न्यूनतम दिखोल गॉव दर्ज किया गया। किसान अपने जानवरो के लिये हरे एवं अच्छी तरह से सूखे चारे का उपयोग करते है। सर्दी के मौसम के दौरान सूखे चारे पर निर्भरता अधिक होती हैं और हरे चारे की कमी होती ह। सूखे चारे को किसान या तो घास के मैदान, चारागाह भूमि, वन भूमि या फसल के अवशेष से एकत्र करते हैं। किसानो की आर्थिक स्थिति जानवरो को खिलाने में प्रयोग किये गये चारे के साथ विविध है। किसान बाजार समाज से चारे की खरीद नही करते।

अध्धयन क्षेत्रो मे पशुधन आबादी मे मुख्य रूप से गाय, बैल और भस के साथ बहुत कुछ बकरियां भी शामिल है। सबसे कम पशुधन संख्या मौण गॉव में 51 और न्यूनतम मंज्जूड गॉव 29 दर्ज किया गया। सभी गॉवो मे गर्मियों के मौसम के दौरान औसत दैनिक खपत कमशः 253.43 किलो/दिन/गॉव से लेकर 1202.05 किलो/दिन/गॉव और सर्दियो के मौसम में कमशः 928.52 किलो/दिन/गॉव से लेकर 3712.28 किलो/दिन/गॉव दर्ज किया गया। सभी गॉवो मे गर्मियो और सर्दियो के मौसम के दौरान ईधन की लकडी खपत कमशः 0.57 किलो/सदस्य/दिन से लेकर 1.68 किलो/सदस्य/दिन और 2.11 किलो/सदस्य/दिन से लेकर 5.18 किलो/सदस्य/दिन अंकित किया गया। तुन मे सबसे अधिक नमी की मात्रा (109.85 प्रतिशत) और सबसे कम मेलू मे (48.42 प्रतिशत) अंकित किया गया। मेलू मे सबसे कम राख की मात्रा (2.3 प्रतिशत) और तुन मे सबसे अधिक (5. 3 प्रतिशत) अंकित किया गया।

दीपिका रावत

शोधार्थी

VITAE

The author, Miss Deepika Rawat was born on July 3, 1992 at Uttarakashi, Uttarakhand. She has passed High School and Intermediate examination in 2007 and 2010, respectively from Uttarakhand Board. Later on, she passed B.Sc. (Forestry) from H.N.B.G.U. Srinagar Garhwal, (Uttarakhand) a Central University in year 2014. She was admitted to College of Forestry, Ranichauri, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Bharsar in 2014 to pursue her post-graduation studies in M.Sc. Forestry with major in Agroforestry.

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