

# Fuelwood Consumption in Takoli Gad Watershed of TehriGarhwal in Garhwal Himalaya, India

Suraj Kumar and Munesh Kumar\*

Department of Forestry and Natural Resources, HNB Garhwal University, Srinagar Garhwal Uttarakhand, India

## Abstract

The aim of the present study was to understand fuelwood consumption pattern of the villager at different altitudes in Takoli Gad Watershed. Three different altitudes i.e., 500-800 m (lower altitude) 800-1100 m (middle altitude), 1100-1500 m (upper altitude) were selected. At each altitude three villages were selected i.e., Dangchaura, Pali, Sauru (500-800 m), Takoli Tolu Amoli (800-1100 m) and Maikhandi Riscoti Kwili (1100-1500 m). Each selected village was further categorized based on family size into small, medium and large to observe impact of family size on fuelwood consumption.

The results indicate that fuelwood consumption among family size (irrespective villages) ranged from 430.70 to 643.61 kg/capita/year (lower altitude), 486.66 to 689.90 kg/capita/year (middle altitude), 406.57 to 675.25 kg/capita/year (upper altitude). The consumption of fuelwood increased with increasing altitudes as 541.8 (500-800 m), 554.97 (800-1100 m) and 557.71 kg/capita/year (1100-1500 m). However, fuelwood consumption with family size (irrespective altitudes), showed reduced with increasing family size from small > medium > large as 669.58 (small family), 543.35 (medium family) and 441.88 (large family). In the study, it has been observed that villagers collected fuelwood from forest and agro forestry field where agroforestry contributed 25-30% fuelwood consumption for villager's need, which directly helps in reducing pressure on forest.

**Keywords:** Fuelwood; Consumption; Forest; Agroforestry; Per capita; Household

## Introduction

In many developing countries the consumption of biomass as fuel has been identified as one of the most significant cause of forest degradation. According to Academy of Science (1980), fuelwood scarcity is most acute in the countries of Indian sub-continent alone requires about 274 million m<sup>3</sup> fuelwood annually [1]. Fuelwood demand in India has increased from 60 million tons in 1991 to 158.45 million tons in 2000 [2].

The use of wood as a means of generating heat energy, particularly for cooking and heating is still very much relevant in the developing countries, most especially those of sub-Saharan Africa [3]. Reports such as Arnborg [4] had earlier shown that as much as half of the timber harvested in the world is used as fuelwood for cooking and heating, most of which are used in the developing countries [5], where recent estimates showed that fuelwood accounts for about 90% of the timber harvested [6]. It is also estimated that over 90% of the people of Africa depend on either fire wood or charcoal for cooking and heating. Apart from the use of biomass, especially wood, for cooking and heating, the inhabitants of these countries have depended, for livelihood and sustenance, on their indigenous plants resources for centuries. They depend on them for food security and a host of everyday products, from medicines to fibers [7].

The increases in the use of fuelwood have partly contributed to the depletion of forests [8] and the implications of this on the environment, biodiversity stability and by extension on the wellbeing of human beings are well documented in literature. Owing to the increasing consumption of woody biomass as fuel in the world, it is imperative to be in tune with other traditional uses to which accepted fuelwood species are put by the cross section of users.

The major determinants of the energy needs and consumption in rural India are income distribution preferences, private discount

rates and micro financing [9]. The energy use pattern in rural India is changing, with uptake of clean energy, but traditional fuels including fuelwood, crop residue and cow dung still constitute the main source of household cooking energy due to inadequate and unreliable supply of clean energy [10].

The fuelwood demand in the country ranges from 96 to 157 million tons annually, including a rural demand of 80-128 million tones, thus raising the consumption level to 148-242 kg per capita [11]. 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 [12,13]. A survey of use pattern in the region revealed that non-commercial energy formed 98.59% of the total household energy demand. Thus, the commercial energy component formed only 1.41% of the total, comprising of kerosene and electricity [14]. Thus, it is evident that most of this demand is met from the adjoining forests almost uninterrupted [15,16] and biomass extraction is the major reason for such depletions [17].

In India, 80% of the population live in villages and wood is the main source of fuel for these villages, which is continuously depleting fuelwood resources and therefore, the rural poor are being forced to use some time other forms of energy such as crop residues and dung [18]. People of the Himalaya had traditional rights to collect limited amount

\*Corresponding author: Munesh K, Department of Forestry and Natural Resources, HNB Garhwal University, Srinagar Garhwal Uttarakhand, India, Tel: +911370267529; E-mail: [muneshmzu@yahoo.com](mailto:muneshmzu@yahoo.com)

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of fuelwood from forested areas. However, new environmental law by Government agencies have restricted fuelwood collection without providing the alternative source of energy, thus local people are facing problem [19]. Although fuelwood collection is still going on which may affect the existing forest resources in the Himalaya in coming periods.

In Indian mountain, fuelwood is the only main source of energy for villages, for cooking purposes. In India, about 70% of energy requirement is taken by the fuelwood, collected from the forests and nearby sites and about 50 million tons of wood are removed every year [20].

In the mountains of Garhwal Himalaya, generally ordinary people, due to their socio-economic conditions people fulfill their energy demand almost entirely from the forests. Alternative fuels such as animal dung and crop residues may also be utilized.

In the Garhwal Himalayan region of present study, many species have been identified by the villagers, which have been used for fuelwood and other purposes. The trees identified in the forest areas are; *Quercus leucotrichophora*, *Mallotus philippensis*, *Terminalia tomentosa*, *Anogeissus latifolia*, and in agroforestry fields; *Grewia oppositifolia*, *Quercus leucotrichophora*, *Adina cordifolia*, *Celtis australis*, *Ficus palmata*, *F. auriculata*, *F. glomerata*, *Melia azedarach*, *Bauhinia variegata*, *Boehmeria rugulosa*, *Terminalia bellerica*, *Butea monosperma*, *Toona ciliata*, *Woodfordia fruticosa*, *Rhus parviflora* etc. In the villages of Garhwal Himalaya, it has been noticed that usually villagers collected fuelwood from adjacent existed traditional agroforestry field and forest.

The aim of the present study was to understand the available fuelwood collection sources to the villager's needs, impact of family size on fuelwood consumption pattern and impact of altitude on fuelwood consumption pattern. Therefore, following objectives were selected for the study are; (i) Fuelwood collection sources to the villages need (ii) Impact of family size on fuelwood consumption pattern and impact of altitudes on fuelwood consumption pattern.

## Materials and Methods

### Location of the study area

The present study was carried out in 'Taki Gad Watershed' in a part of Tehri District of Uttarakhand State. Uttarakhand state extend over an area of 53000 km<sup>2</sup> from 28°43' to 31°27' N latitude and from 77° 34' to 81° 21'E longitude. The state is drained by eight major river systems and is thus divided into eight major catchment areas. These are the Yamuna, the Ganga 'A', the Ganga 'B', the Bhagirathi, the Alaknanda, the Ramganga, the Koshi and the Kali. The river Alaknanda represents the second biggest river system of Uttarakhand after the Kali river system. The study is carried out in the Takoli Gad watershed which is

the part of Alaknanda catchment area. The total human population of villages in Takoli Gad Watershed is given in Table 1 as per census 2011.

Geographically the catchment "Takoli Gad Watershed" is between the 30° 14' to 30° 23' N latitude and 78° 37' to 78°46' longitudes in the Survey of India toposheet No. 53 J/11, 53 J/12 and 53 J/15 with an area of about 131.43 km<sup>2</sup>. It comes under jurisdiction of district Tehri Garhwal, Uttarakhand. The area falls in inner Garhwal lesser Himalaya and is characterized by gentle and mature topography. The Takoli Gad originates from the Eastern slope of the Chandrabadni Peak (2278 meter) and joins the AlaknandaRiver at JuyalGarh (605 meter). Jakhand and Dagar Gad are the two main sub streams/tributaries of the Takoli Gad watershed.

### Methodology adopted

In the 'Takoli Gad watershed' agriculture is practiced between 500 to 2000 m elevations where villagers are intestinally managed trees in their agriculture field for their daily needs such as fodder, timber, minor forest products including fuelwood. In the present study as per suitability of the study sites three different altitudinal zones viz., 500-800 m, 800-1100 m and 1100-1500 m above mean sea level (a.m.s.l) were selected for the assessment of fuelwood consumption. In each altitude three representative villages were selected i.e., 500-800 m (Dangchaura, Pali, Sauru), 800-1100 m (Takoli Tolu Amoli) and 1100-1500 m (Maikhandi Riscoti Kwili) (Figure 1) to conduct detailed study on fuelwood consumption functioning and each village were further categorized on the basis of family size i.e., small, medium and large. In each village for family size three representatives household were selected for data collection. Basic household information like number of family members, livestock holding, source and requirements of fodder for livestock, source and requirement for fuelwood, distance from the forest, irrigation water, road and other infrastructure, socio-economic status and educational level has been collected through questionnaire during the survey in the study area. The fuelwood consumption of selected was calculated based on collected data. The questionnaire survey covered 81 households in entire study area at different altitudes. The quantity of fuelwood consumption in the sampled villages was estimated over a period of 24 hour by using a weight survey method [21]. Quantification of fuelwood was done using collected data. To quantify the fuelwood consumption initially a wood lot was weighted and left in the kitchen of the household and the household was requested to burn wood only from given bundle. After 24 hrs the household was visited again and the actual fuelwood consumption was measure. Per capita per day consumption of fuelwood was calculated on the basis of total wood consumed by the family, divided by the total number of family members, as followed by Gupta et al, [22], as;  $F = \frac{TFc}{TFm}$  Where; F=per day per capita fuelwood consumption, TFc=total fuelwood consumption by the sample household, and TFm =total number of members in the family.

Altitude (m amsl)	Village Name	House holds	Population			Literacy/illiteracy	
			Male	Female	Total	Literate	Illiterate
500-800	Dangchaura	53	116	110	226	146	80
	Pali	18	29	35	64	45	19
	Sauru	93	166	209	375	243	132
800-1100	Takoli	84	136	163	299	192	107
	Tolu'	-	-	-	-	-	-
	Amoli	52	93	96	189	128	61
1100-1500	Maikhandi	137	291	328	619	420	199
	Riscoti'	-	-	-	-	-	-
	Kwili	52	79	94	173	131	42

**Table 1:** Population and literacy pattern in selected villages of Takoli Gad Watershed (Source: census, 2011) \*The villages not mentioned in census 2011.

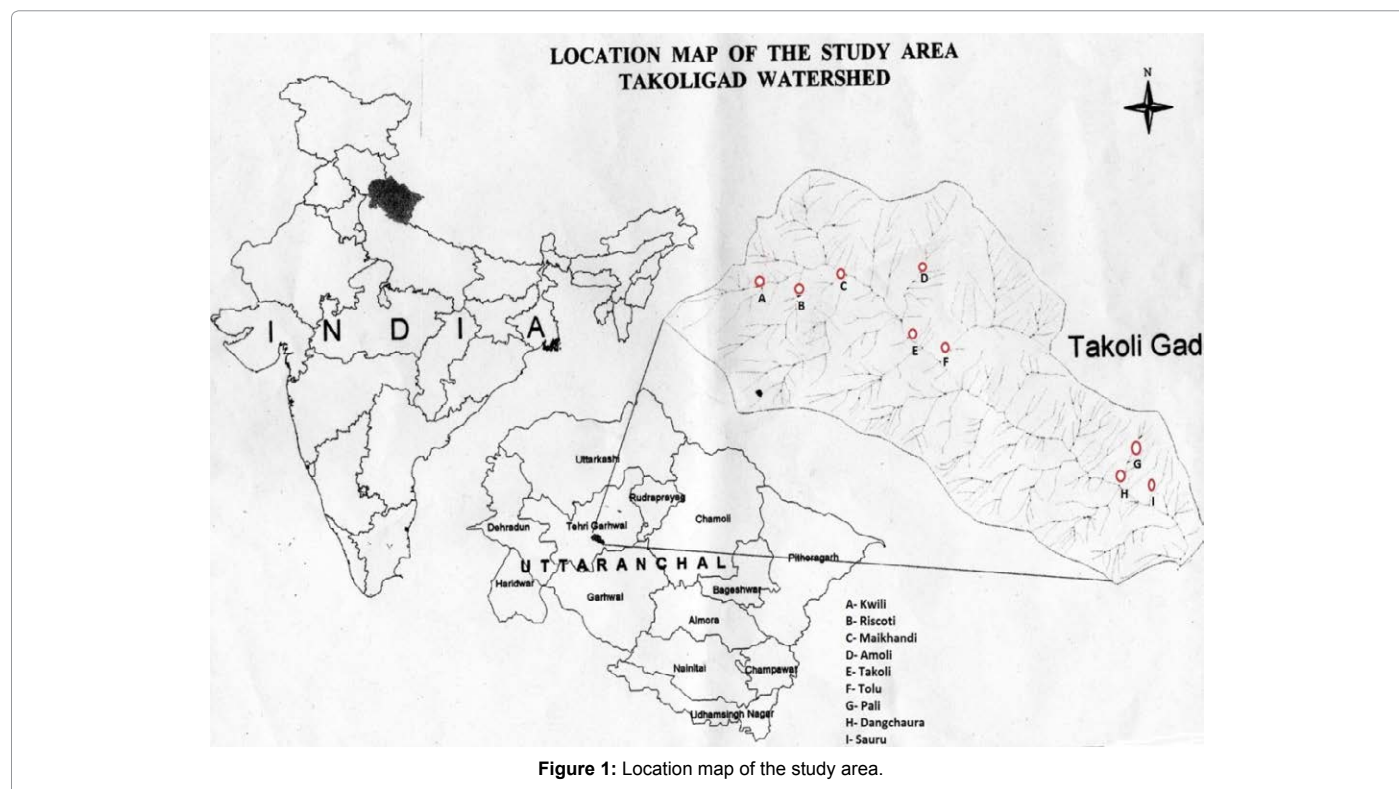


Figure 1: Location map of the study area.

Altitude (m amsl)	Village	Forest			Agroforestry		
		Small	Medium	Large	Small	Medium	Large
500-800	Dangchaura	496.40	408.80	350.40	146.00	109.50	105.85
	Pali	456.25	339.45	313.90	135.05	102.20	91.25
	Sauru	536.55	383.25	332.15	160.60	113.15	98.55
800-1100	Takoli	496.40	448.95	354.05	146.00	135.05	105.85
	Tolu	454.80	339.45	346.75	164.25	102.20	102.20
	Amoli	339.45	321.20	350.40	168.80	113.15	105.85
1100-1500	Maikhandi	627.80	514.65	324.85	186.15	135.05	94.90
	Riscoti	394.20	383.25	427.05	116.80	113.15	124.10
	Kwili	554.80	485.45	124.83	146.00	142.35	124.10

Table 2: Fuel consumption (kg/capita/year) from forest and agroforestry in different villages of Takoli Gad.

## Results

### Fuelwood consumption (kg/capita/year)

**Forest:** Table 2 revealed fuelwood consumption in different altitude. At lower altitude (500-800 m), in village Dangchaura, fuelwood consumption in small family was observed the highest (496.40 kg/capita/year), whereas, the lowest value of fuelwood consumption was reported in large family (350.40 kg/capita/year). The value of fuelwood consumption in the medium family was 408.80 kg/capita/year. In village Pali fuelwood consumption in the small family was 456.25 kg/capita/year, in medium family 339.45 kg/capita/year and in large family reported 313.90 kg/capita/year. In village Sauru fuelwood consumption in small family was the highest (536.55 kg/capita/year), followed by medium family (383.25 kg/capita/year) and in large family consumption the lowest (332.15 kg/capita/year (Table 2).

At medium altitude (800-1100 m), in village Takoli, fuelwood consumption reported maximum (496.40 kg/year) in small family followed by medium family (448.95 kg/capita/year) and in large family

(354.05 kg/capita/year). In village Tolu the consumption in small family was again reported highest (454.80 kg/capita/year) and lowest in medium family (339.45 kg/capita/year). However, in large family the fuelwood consumption was 346.75 kg/capita/year. In village Amoli, fuelwood consumption in small family was maximum (339.45 kg/capita/year) and minimum in medium family (321.20 kg/capita/year). The consumption of fuelwood in large family was reported 350.40 kg/capita/year (Table 2).

At high altitude (1100-1500 m), in village Maikhandi, fuelwood consumption in small family was maximum (627.80 kg/capita/year) followed by 514.65 kg/capita/year (medium family) and in large family (324.85 kg/capita/year). In village Riscoti, the consumption in small family observed 394.20 kg/capita/year, in medium family 383.25 kg/capita/year and in large family 427.05 kg/capita/year. In village Kwili, fuelwood consumption was highest (1248.3 kg/capita/year) in large family size followed by small family (554.80 kg/capita/year) and medium family (485.45 kg/capita/year) (Table 2).

**Agroforestry:** Similar as forest the consumption of fuelwood

was also calculated from agroforestry field of Takoli Gad Watershed, which is shown in Table 2. At lower altitudes (500-800), in village Dangchaura, fuelwood consumption in small family was reported highest (146 kg/capita/year), followed by medium family (109.50 kg/capita/year) and large family (105.85 kg/capita/year). In village Pali fuelwood consumption in small family was highest (135.05 kg/capita/year), than in medium family (102.20 kg/capita/year) and in large family (91.25 kg/capita/year). In village Sauru, fuelwood consumption in small family was 160.60 kg/capita/year followed by medium family (113.15 kg/capita/year) and in large family (98.55 kg/capita/year) (Table 2).

At medium altitude (800-1100 m), in village Takoli, fuelwood consumption in small family was 146 kg/capita/year which reported highest and it reduced in medium family and large family with the values of 135.05, 105.85 kg/capita/year respectively. In village Tolu fuelwood consumption in the small family was 164.25 kg/capita/year, however, the fuelwood consumption value in medium family and large family was reported same (102.20 kg/capita/year) for both. In village Amoli, fuelwood consumption in the small family was 168.80 kg/capita/year, while in medium family and large family the values were of 113.15 kg/capita/year and 105.85 kg/capita/year respectively (Table 2).

At the high altitude (1100-1500 m), in village Maikhandi fuelwood consumption in the small family was maximum (186.15 kg/capita/year) reduced in medium family (135.05 kg/capita/year) and in large family (94.90 kg/capita/year). In village Riscoti fuelwood consumption in small family was 116.80 kg/capita/year, followed by medium family (113.15 kg/capita/year) and in large family (124.10 kg/capita/year). In village Kwili fuelwood consumption in small family were 146.00 kg/capita/year, in medium family 1423.50 kg/capita/year and in large family 124.10 kg/capita/year (Table 2).

### Fuelwood consumption (kg/household/year)

**Forest:** Fuelwood consumption of villages of Takoli Gad watershed in different altitude on household basis is shown in Table 3. In village Dangchaura, fuelwood consumption was reported highest in small family size (1489.20 kg/household/year) followed by medium family (1226.40 kg/household/year) and in large family size (1058.50 kg/household/year). In village Pali fuelwood consumption in small family was highest (1368.75 kg/household/year), followed by medium family (1022.00 kg/household/year) and large family (949 kg/household/year). In village Sauru, fuelwood consumption in small family was 1609.65 kg/household/year, followed by medium family (1153.40 kg/household/year) and in the large family (1003.75 kg/household/year) (Table 3).

At the medium altitude (800-1100 m), in village Takoli, fuelwood

consumption in small family was 1489.20 kg/household/year, which was reported highest followed by medium family (1346.85 kg/household/year) and in large family (1062.15 kg/household/year). In village Tolu, fuelwood consumption in small family was maximum (1671.70 kg/household/year) than in medium family (1022.00 kg/household/year) and in large family (1040.25 kg/household/year). In village Amoli, fuelwood consumption in the small family was 1022.00 kg/household/year, in medium family 970.92 kg/household/year and in large family 1058.50 kg/household/year (Table 3).

At high altitude (1100-1500 m), in village Maikhandi the highest (1834.40 kg/household/year) value of fuelwood consumption was reported in the small family, which reduced in medium family (1547.60 kg/household/year) and large family (981.85 kg/household/year). In village Riscoti, fuelwood consumption values in small family was 1186.25 kg/household/year, however, the values in medium and large family size were 1153.40 kg/household/year and 1281.15 kg/household/year respectively. In village Kwili, fuelwood consumption reduced in order of small family, medium family and large family with the observed values of 1671.70, 1423.50 and 1248.30 kg/household/year respectively (Table 3).

**Agroforestry:** Similar as forest the consumption of fuelwood was also calculated household basis from agroforestry field. At lower altitude (500-800 m), in village Dangchaura, fuelwood consumption in the small, medium and large families reported as 445.30, 328.50 and 525.60 kg/household/year respectively. In village Pali, fuelwood consumption in the small family was 408.80 kg/household/year, followed by medium family (306.6 kg/household/year) and in large family (281.05 kg/household/year). In village Sauru, fuelwood consumption in small family was 481.80 kg/household/year, which reduced medium family (346.75 kg/household/year) and in large family (299.30 kg/household/year) (Table 4).

At the medium altitude (800-1100 m), in village Takoli, fuelwood consumption in the small, medium and large families were reported as 445.30, 405.15 and 317.55 kg/household/year respectively. In village Tolu, fuelwood consumption in small family was 500.05 kg/household/year, in medium family 306.60 kg/household/year and in large family 310.25 kg/household/year. In village Amoli, fuelwood consumption in the small family was 354.05 kg/household/year, however, in medium and large family the values were 346.75 kg/household/year and 317.55 kg/household/year respectively (Table 3).

At the high altitude (1100-1500 m), the selected villages were Maikhandi, Riscoti and Kwili. In village Maikhandi, fuelwood consumption was in order of 565.75, 405.15 and 292 kg/household/year in small, medium and large families respectively. In village Riscoti, fuelwood consumption in the small family was 354.05 kg/household/

Altitude (m amsl)	Village	forest			agroforestry		
		Small	Medium	Large	Small	Medium	Large
500-800	Dangchaura	1489.20	1226.40	1058.50	445.30	328.50	525.60
	Pali	1368.75	1022.00	949.00	408.80	306.60	281.05
	Sauru	1609.65	1153.40	1003.75	481.80	346.75	299.30
800-1100	Takoli	1489.20	1346.85	1062.15	445.30	405.15	317.55
	Tolu	1671.70	1022.00	1040.25	500.05	306.60	310.25
	Amoli	1022.00	970.92	1058.50	354.05	346.75	317.55
1100-1500	Maikhandi	1834.40	1547.60	981.85	565.75	405.15	292.00
	Riscoti	1186.25	1153.40	281.15	354.05	346.75	379.60
	Kwili	1671.70	1423.50	1248.30	445.30	427.05	372.30

Table 3: Fuelwood consumption (kg/household/year) from forest of different villages of Takoli Gad.



Altitude (m amsl)	Village	Small (2-4)	Medium (4-6)	Large (6-9)
500-800	Dangchaura	642.40 (22.72)	518.30 (21.12)	456.25 (23.20)
	Pali	591.30 (22.83)	441.65 (23.12)	405.15 (20.00)
	Sauru	697.15 (23.03)	696.40 (16.24)	430.70 (22.88)
	<b>Total</b>	<b>643.61(22.86)</b>	<b>552.11(20.16)</b>	<b>430.70(22.02)</b>
800-1100	Takoli	642.40(22.72)	584.00(23.12)	559.90(18.90)
	Tolu	619.05(26.53)	441.65(23.14)	448.95(22.76)
	Amoli	808.25(20.88)	434.35(26.05)	456.25(23.200)
	<b>Total</b>	<b>689.90(23.37)</b>	<b>486.66(20.77)</b>	<b>488.36(21.62)</b>
1100-1500	Maikhandi	813.95(22.86)	649.70(20.78)	419.75(22.60)
	Riscoti	511.00(22.85)	496.40(22.79)	551.15(22.51)
	Kwili	700.80(20.83)	627.80(22.67)	248.83(49.87)
	<b>Total</b>	<b>675.25(22.18)</b>	<b>591.30(22.08)</b>	<b>406.57(31.66)</b>

**Table 4:** Total Fuelwood consumption (kg/capita/year) from forest and agroforestry in different villages of Takoli Gad watershed (values in the parenthesis of small, medium and large show range of family size; however values in parenthesis of each villages is percent contribution of agroforestry of total fuelwood consumption).

Author(s)	Name of the region	Tribe/ sub- region	kg/capita/year
Maikhuri (1991)	Arunachal Pradesh	Nishis, Karbi, Kacharis, Chakma	949-5511.50
Maikhuri and Gangwar (1991)	Meghalaya	Garos, Khasis, Mikirs, Nepalese	146-912.50
Bhatt and Sachan (2004b)		Jaintia, Khasi, Garos	879.65-2620.70
Sundriyal et al. (1994)	Sikkim	Sikim Himalaya	1277.50
Bhatt and Sachan (2004a)	Uttarakhand	Garhwal Himalaya	390.55-1022.00
Bhatt et al. (1994)		Garhwal Himalaya, Tehri	408.80-890.60
Bartwal, 1987		Garhwal Himalaya	560
Dhanalet al.2014		Garhwal Himalaya	646.05-1091.35
Kumar and Sharma(2009)		Garhwal Himalaya	1215.45-1803.00
Sagar et al. 1985		Dehradun	540
Srivastava (1981)		National average	600
Rajwar and Kumar (2009)		Nanda Devi Biosphere Reserve	1032.90 to 2157.15
Awasthi et al. (2003)		Garhwal Himalaya	1095
Reddy (1981), Hedge (1984)		South India	693.50 to 803.00
Mehatet al. (1987)	Nepal	Nepal Himalaya	448.95
Donovan (1981)	Asian countries.	South-east Asian countries.	620.50
Wijesinghe, (1984)		South-east Asian countries	985.50
Morton, (2007)	West Africa	Mali, West Africa	574, 380, and 291
Vishvakarma et al. (1998)	Himachal Pradesh	Kullu valley, H.P	1569.50
Rai and Chakrabarti (2001)		Hill forest urban areas, hill forest urban areas, plane forest areas, hill non-forest rural areas	441.65-5515.15
Rawatet al. (2009)		Khoksar, Jahlma, Hinsar, Kuthar	332.15-1095
Present study		Takoli Gad (Tehri Garhwal): 500-800	430.70-643.61
Present study	Garhwal Himalaya (Uttarakhand)	Takoli Gad (Tehri Garhwal):800-1100	486.66-689.90
Present study		Takoli Gad (Tehri Garhwal):1100-1500	406.57-675.25

**Table 5:** Fuelwood consumption (kg/capita/year) pattern in the Himalayan and other regions.

year, which reduce in medium family (346.75 kg/household/year) and again the value reported higher in large family (379.60 kg/household/year). In village Kwili, fuelwood consumption in the small family was 445.30 kg/household/year, followed by medium family (427.05 kg/household/year) and large family (372.30 kg/household/year) (Table 3).

## Discussion

Fuelwood in the Himalayan regions is considered one of the important sources of energy, where majority of the villagers collect fuelwood from different sources such as forest, agro forestry, pasture land, community land etc. The present study focused on fuelwood collection by the villagers from forest and agroforestry at different altitudes. Among the altitudes, fuelwood consumption in lower altitude ranged from 430.70 to 643.61, middle altitudes 486.66 to 689.90 and upper altitudes 406.57 to 675.25. Many workers carried out study on fuelwood consumption in different parts of the world,

country and Garhwal Himalayan region reported consumption values comparatively higher, lower and closed to present study.

Maikhuri [18] carried out fuelwood consumption study on different tribes of Arunachal Pradesh based on family size and recorded fuelwood consumption values from 2409.00-5511.5 kg/capita/year (Nishis), 1314-2774 kg/capita/year (Karbi), 949-1679 kg/capita/year (Kacharis) and 1095-2409 kg/capita/year (Chakma) tribes, where these values lowest to highest ranges from 949-5511.5 for Kacharis and Nishis respectively (Table 5). Bhatt and Sachan [23] Carried out a fuelwood consumption study in Garhwal Himalaya, ranges from 390.55-1022.00 kg/capita/year. Maikhuri and Gangwar [24] conducted fuelwood study in different tribes of Meghalaya and reported fuelwood consumption values between 328.50-912.50 kg/capita/year (Garos), 292.00-547.50 kg/capita/year (Khasis) 219-365 kg/capita/year (Mikirs), 146-365 kg/capita/year (Nepalese), where the lowest to highest consumption values ranges from 146-912 kg/capita/year for Nepalese tribes Garos (Table 5). Bhatt and Sachan [25] also carried out a study in the tribes

of Meghalaya and reported fuelwood consumption values of 879.65-2051.30, 1573.15-2657.20 1365.10-2620.70 kg/capita/year for Jaintia, Khasi and Garos tribes respectively. The lowest and highest values ranged from 879.65-2620.70 for Jaintia and Garos respectively. Bhatt et al. [26] reported fuelwood consumption values between (408.80-890.60 kg/capita/year) for Western Himalaya are within the range of present study. However, the value reported (1095 kg /capita/year) by Awasthi et al. [27] in Garhwal Himalaya is quite higher than the present study. The fuelwood consumption of Raath area in Garhwal Himalaya reported 560 kg/capita/year [28]. Pandey and Singh [29] reported average fuel consumption (Table 5) value of 543.85 kg/capita /year for Central Himalaya.

Kumar and Sharma [30] have conducted a study in Garhwal Himalaya (Table 5). at three different altitudes (tropical region, sub-tropical region and temperate region) and reported fuelwood consumption values maximum (1803 kg/capita/year) in tropical region followed by 1492.85 kg/capita/year (temperate region) and 1215.45 kg/capita/year (sub-tropical region). Although the trend of fuelwood consumption for different purposes (cooking, heating, boiling of water and other purposes) was increased with increasing altitude, but higher values of fuelwood consumption in tropical region could be because of extra fuelwood consumption used for protection of crops from wild animals. In a similar study Sagar et al., [31], reported fuelwood consumption 540 kg/capita/year in rural areas of District Dehradun, however, the values reported (national average) of fuelwood consumption by Srivastava [32] was 600 kg/capita/year.

Rajwar and Kumar [33] conducted a study for fuelwood consumption in the villages Lata and Dunagiri in Nanda Devi Biosphere Reserve where fuelwood consumption was ranged between 1032.95 to 2157.15 kg/capita/year. Between the villages, higher values were recorded in village Dunagiri due to its location at higher elevation and its cooler condition than the village Lata. In other studies [34,35] of fuelwood consumption values were reported between 693.50 to 803.00 kg/capita/year for southern region of India (Table 5). Mehat et al. [36] reported fuelwood consumption value (448.95 kg/capita/year) for Nepal Himalaya. The fuelwood consumption for South and South East Asian countries reported as 620.50 kg/capita/year [37] and 985.50 kg/capita/year [38]. Jaiswal et al. [39] reported in their study that the fuelwood consumption was 657 kg/capita/year and at household level reported 5183 kg/household/year. The household level consumption is quite similar to the consumption level in low altitude areas of Uttarakhand reported as 4745 kg/capita/year [40]. In the study of Bhattacharya and Joshi [41], in the Eastern Himalayan area of North Bengal, the per household fuelwood consumption in average five-member household was found to be 4015-4745 kg/household/year. In rural areas of Garhwal Himalaya presented the per capita fuelwood consumption for cooking ranging from 412.45 to 664.30 kg/capita/year depending upon the altitudinal difference of the region [30].

A study carried out by [20] in the similar range of watershed of present study reported fuelwood consumption values ranged from 646.05 to 1091.35 kg/capita/year, these reported values are higher than present study. The reason for higher consumption values could be because of the study conducted at higher altitude up to 2000 m whereas; in the present study the sampling for fuelwood consumption was taken only up to 1500 m. It is evident from the several studies carried in Himalayan regions that increasing altitude leads more consumption of fuelwood because of severe cold with altitude. Therefore, the consumption reported lower

It is evident from our study region that villagers fulfill their major

fuelwood demand from agroforestry field and forest. Although the major source of fuelwood consumption was taken from forest area which is almost 70% of total fuelwood consumption and rest 30% consumption was taken from agroforestry field. Jaiswal [39] suggested that major source of fuelwood was forest and local people try to meet fuelwood demand from agriculture field, pasture land, roadside plantations and open fallow land etc. Jaiswal [39] also suggested that nearly 87% households fulfill their fuelwood requirement completely from forest. Mahapatra and Mitchell [42] have suggested 50% household dependence in Orissa. In North-West Bengal, around 84% of the rural households collect fuelwood directly from the State forests [41].

The results of various workers have been given in Table 5, indicated that the fuelwood consumption varies with site to site, variation in altitudinal gradients. The higher consumption fuelwood reported in north-eastern regions which might be because of high consumption of meat and for cooking them need extra sources of energy including other daily routine works. Similarly, in Himalayan region consumption comparatively increased with increasing attitudes, where villagers consume more energy for space heating due to severe cold particularly in winter seasons and need more time for cooking because of low temperature which provides more consumption of fuelwood.

Figure 2, indicates the fuelwood consumption (irrespective family size) increased with increasing altitudes i.e., 541.8 (500-800 m), 554.97 (800-1100 m) and 557.71 kg/capita/year (1100-1500 m). Figure 3, indicates the fuelwood consumption (irrespective altitudes) reduced with increasing family size as small > medium > large i.e., 669.58 (small family), 543.35 (medium family) and 441.88 (large family).

The distance travelled by villagers for fuelwood collection is shown in Table 6. The distance of forest was the highest (5 km) at upper altitude (800-1100 m) followed by middle altitude (3.16 km) and lower altitude (1.43 km). However, the distance travelled by villagers for fuelwood collection from agroforestry again reported the highest (0.56 km) at upper altitude followed by middle altitude (0.33 km) and lower altitude (0.3 km). Although distance travelled by the villagers for the collection of forest produce especially fuelwood would not affect the consumption requirement but affect other activities of villager where they can contribute more time for other activities.

## Conclusion and Suggestions

The study in the Takoli Gad Watershed of Garhwal Himalaya is

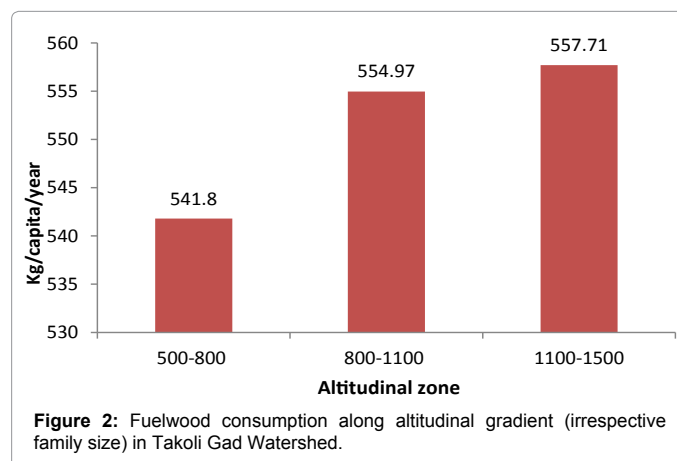
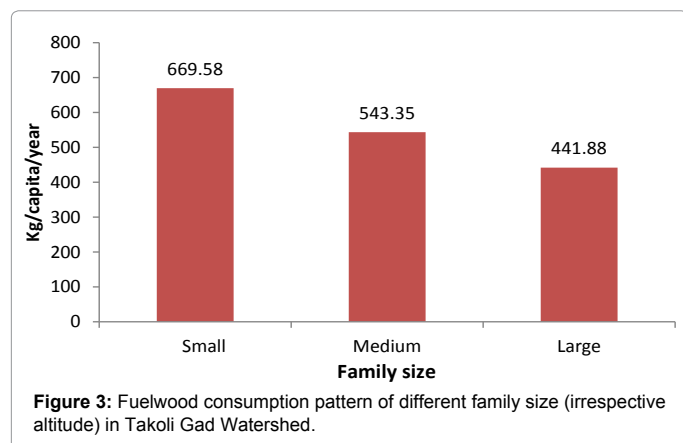


Figure 2: Fuelwood consumption along altitudinal gradient (irrespective family size) in Takoli Gad Watershed.



Altitude	Distance from forest (km)	Distance from agroforestry (km)
500-800 amsl	1.43 ± 0.40	0.3 ± 0.1
800-1100 amsl	3.16 ± 0.76	0.33 ± 0.21
1100-1500amsl	5 ± 1	0.56 ± 0.15

**Table 6:** Distance travelled (km) by the villagers for fuelwood collection in Takoli Gad watershed.

focused on consumption of fuelwood from forest and agro forestry by the villagers in different altitudes. It has been noticed that the proportion of fuelwood consumption of agroforestry compared to total fuelwood was 25-30%. This consumption of fuelwood from agroforestry reduces direct pressure on forest resources. Therefore introduction of more existed traditional tree species in agroforestry systems can reduce pressure on forest and will enhance health of our degraded/degrading forests. But before introducing trees in agroforestry systems the suitable screening should be done with agricultural crops for its least adverse effect i.e., shading, allelopathic effect, etc. Thus the system can run for longer period.

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