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Fodder, fuelwood consumption pattern and energy dynamics along elevation gradient in Giri Catchment, Himachal Pradesh, India

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ABSTRACT

The present study was carried out to understand the fodder and fuelwood consumption pattern, energy dynamics and problems related to fodder biomass removal in existing traditional hill agroforestry systems prevalent at different elevations of Giri catchment of Himachal Pradesh. The result showed that average number of villages were varied from 5-8, whereas 51-52 households and 6.85-7.09 average family size at different elevation ranges and average literacy rate is 85-87 %. The average landholding varies from 0.99 to 1.23 ha, from which they produce and collect fuelwood and fodder for their daily needs. Study comprises three elevation zones for further investigations, *viz.* elevation E_1 (900-1300 m), E_2 (1301-1700 m) and E_3 (1701- 2100 m. Green fodder consumption was highest at elevation E_3 (60.2±1.54 kg/household / day) and minimum at elevation E_1 (49.34±2.00 kg/household per day). Similarly, dry fodder consumption was highest at elevation E_3 (80.6±1.80 kg/household per day) and minimum at elevation E_1 (67.7±1.64 kg/household/ day). Similar trends were also observed in fuelwood consumption, highest fuelwood consumption was noticed at elevation E_3, *i.e.* 30.9±2.08 kg/household /day and minimum 22.±1.02 kg/household /day at elevation E_1. Energy consumption was also increased with increasing the elevation; maximum energy consumption was observed at elevation E_3 (1701-2100 m) and minimum at lower elevation E_1 (900-1300 m). In hilly region of Western Himalayas the farmers should be motivated and educated toward for better utilization of fodder as stall feeding options.

Key words: Elevation gradient, Energy, Fodder, Fuelwood, Giri catchment, Socio-economic condition

Biomass is an important characteristic of vegetation and is regarded as an important indicator of ecological and management processes. Measures of standing crop also reflect the amount of energy stored to sustain the environment, which can indicate the potential productivity at the site. Biomass collection, in the form of fuelwood, fodder, grazing and non-timber forest products (NTFPs) may create the most widespread pressure on forests resource of the country, where rural populations depend mostly on these activities for household and livelihood securities. Collection of fodder is the first step that turns the wheel of the agricultural economy of the village community (Makino 2009). Agriculture along with animal husbandry is the principal occupation and source of livelihood for over 80% of the population of hilly states of India in general, and in Himachal Pradesh in particular. Large population and low productivity are the hallmark of livestock in the state, across all species. In Himachal Pradesh, animal husbandry plays a vital role in the rural economy largely based on different land-based interventions. About 85% of the total human population is rural and because of geographical inaccessibility, it has very low connectivity with other areas of the country. This inaccessibility of the area and deprived socio-economic status of locals is responsible for the total dependence of local inhabitants on nearby forest areas for their fuelwood and fodder demands (Bhatt *et al.* 2004). In mountain villages, firewood is the main source of energy satisfying almost the entire energy requirement for cooking and other operations. Lack of availability of good quality fodder often limits not only, the productivity of livestock, but also reduces the manure quality produce from animal-dungs. The available information on resource utilization pattern, particularly fodder and fuel extraction in the Himalayan Region is insufficient. In the Himalayan region, domestic animals provide main draughtpower for agriculture system. Trees and shrubs often contribute substantial amount of leaf fodder during lean period through lopping/pruning activities. Himachal Pradesh has huge difference in supply and demand of green fodder to feed the livestock. Therefore, fodder scarcity could be reduced through fodder cultivation on farmlands and through silvipasture on wastelands. Promotion of silvipasture contributes in two ways by additional fodder supply that ensures proper rearing of livestock and environmental protections. The most serious problem is the unavailability of green forage, particularly in winter, causing deficiency of protein and vitamins, resulting in low milk

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production and decreased working capacity of bullocks. Though, the issue has been addressed consistently but there has been no attempt to access the quantity and equivalent values of biomass in terms of energy of fodder collected by the local inhabitants dwellings in Himalayan region. Present study provides a glimpse of problems associated with fodder removal in Giri catchment of Himachal Pradesh. The information in this communication could be utilized for developing various conservation and sustainable strategies in the region to mitigate the impact of forest resource for fodder and fuelwood. Keeping the importance of fodder and fuelwood to the rural population study was conducted to assess fodder, fuelwood consumption pattern and energy dynamics along elevation gradient in Giri Catchment, Himachal Pradesh, India.

MATERIALS AND METHODS

The present study was carried out in Giri catchment during the years 2011 and 2012, a component of Giri river in Himachal Pradesh, situated at 30o 33′ 48″ and 31o 16′ 08″ N latitude and 77o 02′ 32″ to 77o 38′ 22″ E longitude, in an area of about 2 389 km^2 (Rao et al. 1989). Catchment is distributed in three districts of Himachal Pradesh namely, Shimla, Sirmour and Solan which includes 135 sub-watersheds. However, investigation was focused on traditional food and fodder resources in chir pine zone of Giri catchment, located in these districts of Himachal Pradesh. Around 64% of the Giri catchment area falls under high altitude hills from 1500 m to 3000 m. The mean annual precipitation in the catchment is around 1 250 mm. Snow fall is a normal feature in areas above 1800 m. The region has distinct seasons of summer (April to mid-June), monsoon (mid-June to September), autumn (October-November) and winter (December-March). It was recorded that 71 % and 80 % of the annual rainfall was received in rainy season (June to September) in the years 2011 and 2012, respectively. Out of the 135 sub-watersheds in Giri catchment, 13 sub-watersheds were randomly selected. The range of elevation of the selected 13 watersheds varies from 900-2100 m. In hilly mountain region variation in vegetation, flora, fauna and livelihood changes within an elevation range of 300-400 m. Thus each selected sub-watershed was delineated into three elevations with an elevation variation range of 400 m for further investigations, viz. elevation E1 (900-1300 m), E2 (1301-1700 m) and E3 (1701-2100 m). At every elevation in the selected sub-watersheds, total number of villages was counted. The number of villages at any elevation did not exceed 10. Hence, one representative village was selected at every elevation in the selected sub-watersheds for socio-economic analysis. Thus, the number of households (families) sampled at each elevation was 65. The data was collected based on personal interview of household head through pre-tested schedule. The socio-economic parameters such as land holding (land holding and land use), demography (family size, sex ratio and educational level) and house hold activity (livestock data; fodder and fuelwood consumption) were covered in the study. All the information was collected through field visits over a period of 12 months during 2011-12. The quantification of fodder and fuel wood collected by each sample household was calculated as per the methods suggested by Mitchell (1979). Contribution of agricultural by-products, forest and tree fodder from agroforestry by estimation in the villages and by measuring the daily ration of food concentrates given to the animals by each household was considered for quantification of the source and supply of fodder. Similarly, observations were also made in each sample household to quantify fodder collection. Time spent on fodder collection by each sample household of village was also recorded by following the collectors. Standard energy equivalents (Mitchell 1979) were used for calculation of energy dynamics under study.

RESULTS AND DISCUSSION

Demography, social and economic conditions along the elevation gradient: The number of villages in sub-watersheds selected for the study varied from 5 to10 at elevation E1, 4 to 12 at elevation E2, and 4 to 8 at elevation E3. The average number of villages at elevation E1, E2 and E3was 6, 8 and 5, respectively (Table 1). The average number of households in villages at elevations E1, E2 and E3was52, 54 and 51, respectively. This indicates at elevation E2 number ofhouse hold was higher and when further increase in elevation, the household size was decrease means from higher altitudes peoples are migrated at mid elevation for sustaining their livelihood. Family size represented the total individuals in a household comprising of male and female persons (Table 1). An average family size of sampled households was6.85, 6.97 and 7.09 persons/household at elevations E1, E2 and E3, respectively. The male population at elevation E3 was 51.84 %, which was more than female population

Table1 Demography at different elevations in Giri catchment

Elevation	Average number of villages in a sub-watershed	Average number of households (families) in a village	Average family size in a village	Male persons	Female persons	Sex ratio
E_1 (900 – 1300 m)	6	52	6.85	231 (51.84)	211 (48.16)	929
E_2 (1301 – 1700 m)	8	54	6.97	230 (50.77)	223 (49.23)	971
E_3 (1701 - 2100 m)	5	51	7.09	239 (51.84)	222 (48.16)	941
Mean	6.33	52.33	6.97	233.33	218.67	947

Values in parenthesis are the percentages of 48.16 % with sex ratio of 941 females to 1000 males. At elevation E2, highest sex-ratio, 971 females to 1000 males was recorded. The lowest sex ratio existed at elevation E1 with 929 females to 1000 males (Table 1).The sex ratio in the Giri catchment is not dwindling (947 females to the 1000 males) but definitely less than the sex ratio recorded for Himachal Pradesh, i.e. 974 females for 1000 males (GoPH 2011). Household heads are mostly men; this observation is consistent with Demurger and Martin (2010). The complacent gender-ratio in the catchment perhaps is good for households as most of the activities of agro-ecosystem are women centered in this area. Except ploughing all the agricultural operations in this catchment are performed by women. Similar findings were also reported by Eneh and Nkamnebe (2011).

Education is an important ingredient in the development process and it has positive bearing on the managerial skills and decision-making ability of the farmers. The qualification (primary, middle, secondary, intermediate, graduate and post graduate) of the members of 65 households at each elevation showed that on an average 87.2% persons were literate at elevation $E_{2,}$ closely followed by 85.9% at elevation E_1 and85.7% at elevation E_3 (Table 2) Overall, literacy rate was around 85 % which is slightly higher than the literacy rate of Himachal Pradesh (83.8%). However, it was pertinent to note that only 10% population is graduate. In Giri catchment, though the literacy rate is comfortable but around 90 per cent villagers have education below graduation and that entitles them for small jobs that too many a times are not permanent. Thus, in current scenario the people living here seems to keep higher education at the back seat.Demurger and Martin (2010) also noted that average schooling level of household heads did not exceed primary school in their study on socio-demographic status of some villages in China.

Average land holdings across the elevation: Land is a basic resource in the agrarian economy. Size of the land holding is an important variable that directly affects the household income, consumption and savings. Perusal of data in Table 3 reveals that the land holding per household in the selected sub-watersheds at elevation E_3 was higher (1.23 ha) as compared to elevation E_1 (1.09 ha) and E_2 (0.99 ha). It was recorded that at elevation E_1 79.3% households cultivated land holding for meeting their food requirements whereas at elevation E_2 78.3% and at elevation E_3 77.1% households cultivated their land holdings. Orchards occupied4.50% of land holding of a farmer at elevation E_3 in comparison of 3.83% at elevation E_2 and 1.28% elevation E_1. The land utilization pattern determines the type of farming system prevailing in an area. Agricultural income is dependent upon availability of arable land, its proper use, cropping schedule, transportation cost and market value of the agricultural produce. Unscientific use of land lowers the efficiency of other factors of production such as labour and capital on their use. The extent of landholdings with people in the Giri catchment restricts the possibilities of extensive cultivation as the average landholding size per household is 1.10 ha. The increasing human population lowers landholding which affects production system and food, fuel and fodder insecurity (Sarvade *et al.* 2014). The percentage of land under orchards was higher at elevation E_3 (1701 – 2100 m) perhaps due to suitable climate for temperate fruits.In Giri catchment, the average household size is 6.97 with a maximum of 12. These results corroborates with the findings of Joshi (2011) and Sharma (2012).

Animal rearing, average fodder and fuel wood consumption and energy dynamics: Fodder requirements are met out from pastures and fallow lands that occupied less than 25% land of a household. The area under pasture and fallow land constituted 12.1 % and 6.4 % of operational land holding at elevation E_1; 8.49% and 9.37 % at elevation E_2 and 7.10 % and 11.27 % at elevation E_3. Livestock rearing is an integral part of farming system in the hilly states. They not only provide milk, meat, wool and manure but also serve as main source of energy for ploughing and transport. The productivity of the crops is enhanced by the use of farm yard manure (FYM).

Table 3 Land utilization pattern at different elevations in Giri catchment

Land use	Land holding (ha)		
	Elevation E_1 (900 - 1300 m)	Elevation E_2 (1301 - 1700 m)	Elevation E_3 (1701 - 2100 m)
Cultivated land	0.82 (79.32)	0.75 (78.30)	0.95 (77.13)
Orchards	0.04 (1.28)	0.05 (3.83)	0.06 (4.50)
Pasture	0.14 (13.05)	0.09 (8.49)	0.09 (7.10)
Fallow Land	0.10 (6.35)	0.09 (9.37)	0.14 (11.27)
Operational landholding size	1.09 (100.00)	0.99 (100.00)	1.23 (100.00)

Values in parentheses are the percentages of operational land holding

Table 2 Qualification and literacy rate of people in Giri catchment

Elevation	Number of people and their qualification							Literacy (%)
	Primary	Middle	Matric	Intermediate	Graduate	Post graduate	Illiterate	
E_1(900-1300m)	88 (19.90)	88 (19.76)	94 (21.28)	64 (14.59)	38 (8.32)	6 (1.41)	64 (14.74)	85.91
E_2(1301-1700m)	86 (18.26)	117 (25.73)	105(23.50)	53(12.51)	26(5.86)	5(1.38)	59(12.76)	87.24
E_3(1701m-2100m)	69 (15.03)	115 (25.00)	108(24.09)	71(15.34)	31(6.86)	6(1.41)	61(13.14)	85.70

Values in parentheses are percentages.

Table 4 Livestock number and fuelwood consumption of households at different elevations in Giri catchment

Elevation	Average livestock number per household						Fuelwood (kg/day / household)
	Heifer	Cow	Bullock	Goat	Sheep	Buffaloes	
E_1 (900 - 1300m)	2.23	3.77	2.24	3.36	1.00	0.91	22.77 ± 1.02
E_2 (1301 - 1700m)	2.71	5.67	2.40	3.24	1.23	1.08	25.63 ± 2.15
E_3 (1701 - 2100m)	3.06	6.51	2.35	4.22	1.77	0.55	30.92 ± 2.08

It was recorded that number of heifers, cows, goats and sheep per household was highest at elevation E_3 (Table 4). Buffaloes were higher in number at elevation E_2 (1.08/household). The average number of cows per household at elevations E_1, E_2 and E_3 was: 3.77, 5.67 and 6.51, respectively.Likewise, the number of goats per householdat elevations E_1, E_2 and E_3 was: 3.36, 3.24 and 4.22, respectively. Cows and goats accounted for the majority of livestock in a household. The consumption of fuelwood was recorded highest at elevation E_3, i.e. 30.92 kg/household/day while it was 25.65 kg/household/day at elevation E_2 and 22.77 kg/household/day at each elevation E_1. Fuelwood is the most common and primary energy source among rural populations in developing countries (Allen *et al.* 1998), and is used for cooking and heating rooms and water during the winter season. Other forms of commercial energy are beyond the reach of ordinary people because of poor socioeconomic conditions (Chettri *et al.* 2002). The study also revealed that average per capita consumption of the fuelwood in the Giri catchment is 3.79 kg/day. The consumption of fuelwood per household had showed decreasing trend with decrease in elevation with 30.9 kg/household/day at E_3 (1701 – 2100 m), 25.6 kg/household/day at elevation E_2 (1301-1700 m) and 22.8 kg/household/day at elevation E_1 (900-1300 m). The quantity of fuelwood used per household in Giri catchment, as recorded in the present study, is considerably higher than the figures quoted by Bhattand Sachan(2004) and Chandra *et al.* (2008) for Garhwal in Central Himalaya. However, it is certainly lower than the finding of Sundriyal and Singh (2009) for Central Himalaya in India. This indicates that the fuelwood consumption is regulated by climate and, socio-demographic features of any area like personal income, prices of fuelwood and kerosene oil and household size (Onoja and Idoko2012). The fuelwood collection is correlated to forest degradation for the reasons like, income, poverty, opportunity costs, preferences, market imperfections, institutional weaknesses, family time used in collection and credit constraints. Similar results were also reported by Cooke *et al.* (2008) and Demurger and Martin 2010).

In Giri catchment, the quantity of fodder harvested in two time periods of the year by local inhabitants of hills and its energy values are expressed in Table 5 and Table 6. The total green fodder consumption was highest at elevation E_3 (60.2 ± 1.54 kg/household/day) followed by elevation E_2 (56.8 ± 1.40 kg/household/day) and elevation E_1 (49.3 ± 2.00 kg/household/day). Similarly, the total dry fodder consumption was highest at elevation E_3 (80.6± 1.80 kg/household/day) followed by elevation E_2 (73.6 ± 1.1.72 kg/household/day) and elevation E_1 (67.7 ± 1.64 kg/household/day).In Giri catchment, average fodder consumption per household was 55.44 kg/day. This figure is considerably higher to the findings of Sharma *et al.* (2009) and Bagwari and Todaria (2011) for villages in Garhwal Himalaya. Similarly, Adhikari*et al.* (2004) quoted less fodder consumption in Nepal. This indicates that fodder requirements driven by climate, socio-demographic features of any area like personal income and livestock species composition and requirement of house hold. Similar observations were also reported by Bagwari and Todaria (2011). With reference to the energy dynamics, irrespective of elevation energy values of collected and uses dry fodder is quite high than the green fodder (Table 5&6). However, energy values of both dry and green fodder increase with increase of elevations. This indicates that at higher elevations, composition of

Table 6 Biomass quantity and equivalent energy values (elevation/season) of dry fodder collected during November-March at different elevation of Giri catchment

Elevation	Dry fodder (Kg/HH/day)	Dry fodder (kg/HH/season)	Energy (MJ/HH/season)
E1 (900 - 1300m)	67.65±1.64	77459.25	1084429.5
E2 (1301 - 1700m)	73.59±1.72	84260.55	1179647.7
E3 (1701 - 2100m)	80.57±1.80	92252.65	1291537.1

Table 5 Biomass quantity and equivalent energy values (elevation/season) of green fodder collected during April-October at different elevation of Giri catchment

Elevation	Green fodder (kg/household /day)	Green fodder (kg/household/season)	Energy1* (MJ/HH/season)	Energy2* (MJ/HH/season)
E_1 (900 -1300m)	49.34 ± 2.00	10361.40	163710.12	2750330.02
E_2 (1301 -1700m)	56.78 ± 1.40	11923.80	188396.04	3165053.47
E_3 (1701 -2100m)	60.20 ± 1.54	12642.00	199743.60	3355692.48

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livestock is different as compared to lower elevations which resulted in higher fodder consumptions. This also indicates that persons living at higher altitudes mostly depend upon livestock rearing to sustain their livelihoods and utilizes most of time for collection of fodder to feed them. These results were close conformity with the finding of Kumar *at el* (2009) and Dhyani*et al* (2011).

Thus, it is concluded that total fodder, fuel wood consumption per household increased with the increase in elevation (E_1<E_2<E_3). Similarly, green fodder consumption was highest at elevation E_3 (60.2±1.54 kg/household / day) and minimum at elevation E_1 (49.34±2.00 kg/household per day). Dry fodder consumption was highest at elevation E_3 (80.6±1.80 kg/household per day) and minimum at elevation E_1 (67.7±1.64 kg/household/ day). On the basis of this study various resource conservation and sustainable strategies in the region to be developed to mitigate the impact of forest resource for fodder and fuelwood.

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