Eco. Env. & Cons. 30 (October Suppl. Issue) : 2024; pp. (S167-S178)
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ISSN 0971–765X

DOI No. http://doi.org/10.53550/EEC.2024.v30i06s.025

Firewood Extraction Patterns and Preferred Species in Mamlay watershed in Sikkim Himalaya, India: A household model of three categories based on socio-economic status

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(Received 23 February, 2024; Accepted 14 May, 2024)

ABSTRACT

Firewood serves as a vital energy source for cooking and heating in many rural regions, but the impacts of harvesting firewood from forests are often overlooked. In numerous mountainous regions, impoverished communities rely solely on fuelwood sourced from natural forests as their primary energy source. Within Sikkim, rural families heavily rely on firewood for energy. Households of Mamlay watershed, Sikkim were divided into three categories according to their socioeconomic condition by the Government of Sikkim, India. Such households were surveyed to identify patterns of firewood extraction and use, species preference, and sources of extraction. Face-to-face interviews and questionnaires were used to gather data on many facets of the use and extraction of firewood. Every household included in the survey relies on firewood as their main fuel source for cooking and heating water. Utilizing firewood as a cost-free resource provides significant economic benefits to the communities, serving both as a tradable commodity and supporting income-generating endeavours like cooking pig feed and producing wine. Twenty-five plant species are used as firewood and the most preferred way of extraction is cutting dry branches. The most preferred species are *Albizia procera* (Roxb.) Benth, *Schima wallichii* Choisy., *Macaranga postulate* King., *Litsaea polyantha* Juss. & *Engelhardtia spicata* Lechen ex Blume. Although firewood is extracted from 93% of the private land the extraction of firewood from 43% of the forest area cannot be overlooked.

Key words: *Mamlay watershed, Firewood, Firewood extraction, Species preference, Sikkim, India*

Introduction

According to Arnold *et al.* (2006), fuelwood serves as the main source of cooking fuel for many impoverished individuals, particularly in emerging nations such as Southeast Asia, India, and Africa. It is sometimes referred to as'energy of the poor' (Horst and Hovorka, 2008). For daily household needs, fuelwood is the primary source of energy for individuals living in rural areas around the globe. To supply their energy needs, most people living in rural areas rely on fuelwood, charcoal, agricultural wastes, rice husks, and cow dung. The rural population in many developing nations depends on fuelwood from forests for their domestic energy requirements (Cecelski *et al.*, 1979). Fuelwood isthe most attractive among the various forms of biomass and occupies a predominant place intherural energy budget (Kataki and Konwer, 2002).

The use of fuelwood is prevalent worldwide, but

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the intensity and frequency of its use are high in poor and developing countries, especially in rural areas. In most parts of the world, fuelwood is the key basis of energy in cooking and heating (FAO, 2010). In rural households of the mountainous region of the Himalayas, fuelwood is the foremost source of energy for cooking, space heating, and boiling water (Rijal, 1999). Thus, subsistence mainly depends upon resources, which are derived from the natural woodlands (Chettri and Sharma, 2006). As a result, species richness, structure, productivity, and renewal of many high-quality and preferred species are declining (Sundriyal *et al.*, 1994; Sundriyal and Sharma, 1996; Chettri *et al.*, 2002). Local communities use fuelwood for a variety of uses, including cooking, animal feed preparation, housing and water heating, local wine and beer production, and festival celebrations.

In India, 31.4 % of households use kerosene for lighting, 65.9 % of households use bio-fuels for cooking and over 86 % of rural households use solid fuels for cooking (Chandramouli and General, 2011). According to the 68th NSSO report, almost 80% of Indian families used conventional fuels to meet their cooking and heating needs. The NSS data estimates that only 50% of India's cooking energy is derived from LPG (Jain *et al.*, 2015). Further, most of the rural population of India depends on traditional cookstoves or *chullahs* for cooking purposes (Balachandra, 2011; Jain *et al.*, 2015). Hence, a systematic and comprehensive analysis of determinants of the uses of different types of fuels in a bigger context is still limited. For instance, cultural and traditional practices also influence fuel choice (Treiber *et al.*, 2015).

People of northeastern states of India also mostly depend on woodlands for fuelwood as the chief energy source (Ramakrishnan, 1987) and 90% of inhabitants of this region use biomass as the foremost energy (Bhatt and Sachan, 2004). Furthermore, rural communities cannot afford commercial fuel due to their weak socioeconomic status. The extremely diverse climates and altitudes of India's northeastern states are well renowned for providing an optimal environment for the survival of several economically and ecologically significant plant and animal species. The state of Arunachal Pradesh is the largest in the northeast region of India and has 80.93% forest and tree cover which supports very rich floral and faunal diversity. Arunachal Himalaya contributed approximately fifty percent of the blooming plant species of India (Rao and Hajra, 1986). Nearly 34% of the geographic area of the state is under temperate forests (Shukla *et al*., 1994) which harbor varieties of aromatic, medicinal, ethnobotanical, economic, and commercially important plant species. Consequently, forests have a significant influence on the socio-cultural and traditional traits of the bucolic people.

However, there has been little effort to assess the fuel wood characteristics of forest species from the Sikkim Himalaya. The assessment of wood characters is important to select useful species for revegetating the wastelands and degraded forests to meet future fuel requirements. In hilly regions, watersheds are regarded as functional units for the sustainable management of resources, so the present study was in the Mamlay watershed which is representative of the eastern Himalayas (Sharma *et al.*, 1998).

Furthermore, accurate data on firewood use in Sikkim are scarce, and there has been little assessment of firewood used for domestic and commercial purposes in the study area in Mamlay village. Numerous questions are still unresolved in terms of firewood extraction and use in this village and the extraction of firewood may be having a conservation impact on the study area. However, the effects of firewood extraction on natural resources are often not fully understood (Brown *et al.*, 2009). To understand the answers to these questions, a study on firewood extraction and use was conducted in Mamlay village in the southern district of Sikkim. The main objectives of this study were to identify (1) the major firewood-use patterns in household classes in Mamlay village, (2) the plant species commonly preferred, and patterns of extraction, and (3) the different sources where firewood is extracted.

Methodology

Study area

Mamlay watershed, covering an area of 30.14 km², was chosen as a research site under the Namchi district, which is located between 27°102 82 and 27°14'16"N and 88°19'53" to 88°24'43"E. Located at elevations ranging from 300 to 2650 meters above sea level (masl), the watershed consists of 34 settlements, with 62% of its land allocated for agricultural use, 12% for forest, 5% for pastures, 3% for barren terrain, and 18% for cultural wasteland. The area

experiences sub-tropical and temperate climates. Two major forest types occur in the Mamlay watershed (i) Sub-tropical natural forest and (ii) Temperate natural forest with the dominance of mixed forest cover. There are 1133 populations in 280 households living in these villages. Most farmers grow crops such as maize, ginger, peas, beans, and spinach, and engage in forestry activities like firewood extraction to supplement their income. Mamlay village is composed of five wards: Changoan, Upper Mamlay, Middle Mamlay (Daragoan Doling), Lower Mamlay, and Nandang. The communities residing in these wards are the Manger, Rai, Bhutia, and Tamang. Among these communities, the Manger community is the most dominant.

Data collection and analysis

A preliminary households survey was held to obtain fuelwood consumption patterns by local communities of woody tree species including socio-economic conditions, village size, and distribution, number of households, and family size. Under Mamlay village three wards were selected including upper, middle, and lower using a simple random sampling method. Thirty households among the three wards were chosen for in-depth interviews. Families from the three specific government ration card categories were selected. Ration cards are given out by the Department of Food and Civil Supplies in Sikkim to families who qualify for public distribution system purchases of subsidized food grains. They also function as a typical means of proving identity. Up till June 2023, Sikkim had a total of 1,24,368 ration cards. There are three categories under this, which are as follows: 1) OPHH (Other Priority Household): The denizens of Sikkim who are above the poverty line and have an annual income above Rs 10,000 can hold OPHH cards; 2) PHH (Priority Household): denizens who earn less than Rs10,000 annually and live below the poverty line are eligible to receive PHH cards. 3) AAY (Antyodaya Anna Yojana): denizens who are economically weaker and do not have any Stable income source.

Questions were asked to the head of the Family about the type of house, monthly income, total number of livestock they have, land area, total number of children, firewood use in household activities, firewood source for daily use, cultivated crops, Governmental ration card category social religious type, amount of firewood used daily, methods of firewood extraction, source of fuel (only LPG/only fuel/mixed and family size small (1-4), medium (5-7), large (8-10). Questions were focused on firewood-related activities in their households.

Four main sections containing general information were addressed in this questionnaire. The socioeconomic factors (population, age, and occupation) were covered in the first section. The management of natural resources, including land usage and forest conditions, was covered in the second section. The third section concentrated on firewood extraction in terms of amount and species, while the fourth section concentrated on how firewood was used. Face-to-face interviews were held using a combination of predefined and open-ended questions. Inquiries concerning the household's history (type, size, age, and occupation), socioeconomic information (land uses and income-generating activities), and firewood extraction and usage patterns (why, where, and by whom) were posed to the respondents. Firewood usage was measured for things like boiling water, producing wine, feeding pigs, cows, and goats, and preparing meals. Gathering between 40 and 50 kilograms of firewood per household was necessary for daily usage.

Results

Socio-economic conditions of households in Mamlay village

Within Mamlay village, households had varying socioeconomic circumstances. The income obtained by the three ration card category classes (OPHH, PHH, and AAY household types) differed significantly ($p = 0.001$; $p < 0.05$) according to alpha value < 0.05. The highest average net annual household income is earned in OPHH households (Rs 98666.67 ± 32910.653), while the lowest average annual household income is earned in AAY households (Rs 7500). The area of agricultural land holdings varied with the household types; OPHH households had approximately 3.5 acres, PHH households had 3.2 acres and AAY households had 0.5 acres. Every member of the family had completed elementary, high school, or an advanced course of study. The results obtained from the PRA tools indicated that almost all the families in OPHH had a well-equipped pucca house, the highest annual income, several farm animals (1-2 cows and approximately 2 pigs), a substantial amount of agricultural land (3.5 acres), and they also earned from agriculture and

government employment. Additionally, many of the families had five to seven members and used LPG for cooking and a small amount of firewood as fuel for their cattle. The PHH families had a semi-pucca house, approximately 3.2 acres of agricultural land, 8 to 10 members in their family, and a large number of animals (approximately 1 to 4 cows, 5 goats & 3 pigs), most of them are agriculture & self-employed and most of the families depends on both the LPG & firewood as a source of fuel. AAY families' households are typically in a state of extreme need, lacking many amenities like modernized cooking stoves (*chullahs*), possessing barely any agricultural land (approximately 0.5 acres), and having one to five family members. Additionally, these families belong to the lowest annual income classes because they are dependent solely on their daily wages, making them economically weaker and lacking any reliable source of income (Table 1).

The use of firewood in domestic activities

There was no significant difference in the fuelwood used in household activities between OPHH, PHH, and AAY household types for cooking and boiling water ($p = 0.787$; $p < 0.05$), for cooking pig food ($p = 0.394$; $p < 0.05$), for cooking cow & goat food ($p = 0.747$; $p < 0.05$), and for making wine & charcoal ($p = 0.664$) respectively. On average, households in the three classes (OPHH, PHH, and AAY) used 6.3 ± 1.212 kg of firewood per day for cooking and boiling water. For cooking pig food, the daily firewood usage was 7.96 ± 3.234 kg per household, while for cooking cow and goat food, it was 7.96 ± 4.682 kg per household. However, AAY and OPHH households did not use firewood for making wine and charcoal and hence, the mean volume of firewood use for these households was 3.5 ± 0.263 (Table 2). The total firewood usage per day for OPHH, PHH, and AAY households was 21.47 kg, 35 kg, and 14 kg respectively.

Table 2. The percentage of houses surveyed that reported using firewood for various reasons, such as boiling and heating water, preparing food for pigs, cows, and goats, producing wine, and manufacturing charcoal, together with the mean daily firewood consumption for these activities (kg/household ± SD).

Fuelwood usage by Governmental Ration card category	Firewood used (% of interviewed households)	Mean daily volume (kg/household)
Cooking and boiling water		
OPHH	30	6.5± 0.915 (*NS)*
PHH	66.6	7.4± 1.113
AAY	3.3	5
Cooking pig food		
OPHH	13.3	6.2± 1.310
PHH	40	11.7± 1.666
AAY	3.3	6
Cooking cow and goat food		
OPHH	20	8.6± 2.172
PHH	43.3	12.3± 2.230
AAY	3.3	3
Making wine and charcoal		
OPHH	Not used	-
PHH	6.6	3.5± 0.264
AAY	Not used	-

NS: Non-Significant

Firewood sources for daily use

In the study area, firewood for daily use was extracted from three different sources: forest, private land, and home garden. According to Figure 3, most firewood supplies came from private land (93%), followed by home gardens (53%) and forests (43%). The study also revealed that OPHH and PHH households mostly collected firewood from private land, while AAY households primarily relied on home gardens.

Table 1. Socio-economic conditions in Mamlay village by Governmental Ration card category.

Household types	Number of households (% of total)	Education (%) primary school	High school	College/ Uuniversity	Average annual income (Rs)	Agricultural land (acres)
OPHH (Other Priority Household)	09 (30%)	13.3	23.3	0	98666.67 ± 32910.653*	3.5
PHH (Priority Household)	20 (66.6%)	36.6	20	10	7970.00 ± 329.282*	3.2
AAY(Antyodaya Anna Yojna)	01 (3.3%)	3.3	0	0	7500*	0.5
Total/Mean	30				35163.33 ± 12218.042	2.4

* The mean difference is significant at the 0.05 level ($a < 0.05$)

Plant species preferences

There was a selective collection of 25 species from the study area out of which five species showed a greater preference **(Table 3).** The highest preferences were for *Albizia procera* (Roxb.) Benth. (70% of the surveyed households), *Schima wallichii* Choisy. (46 %), *Macaranga postulata* King. (46%), *Litsaea polyantha Juss.* (36%), *Engelhardtia spicata* Lechen ex Blume (33%) and ranked by most extractors with several positive qualities. Among the 25 widely used fuelwood tree species *Albizia procera* (Roxb.) Benth ranked first according to the preferences of the local people. Fabaceae is the highest firewood-preferred species followed by Moraceae, Phyllantheae, and Theacae according to the preferences of local communities. In the preference hierarchy *Rhus semialata* Murr and *Ficus infectoria* Roxb. ranked last and was recommended for poor fuelwood quality.

People used different methods for the extraction of firewood for daily use **(Fig. 4)** such as cutting green branches, cutting dry branches, cutting whole living trees, cutting dead trees, and collecting from the ground. The most preferred firewood extraction method is cutting dry branches by approximately 60-70% of the household in all three types of households. Another preferred extraction method is cutting green branches by all three household types. The village residents' descriptions of the species they collected for firewood focused on both positive and negative aspects of the species, such as availability and reduced smoke output.

Discussion

Socio-economic conditions

In every community, the livestock, agricultural, and forestry industries account for the majority of household incomes, with socioeconomic class earnings differing significantly. As a result of their reliance on agriculture from comparatively fewer land holdings, AAY families earn significantly less than OPHH households and are more susceptible to risk.

Table 3. The percentage of households who utilize the preferred kind of firewood

Botanical name	Local name	Family	Rank	Conservation status	% Of households using
Albizia procera(Roxb.) Benth.	Seto siris	Fabaceae	I	LC	70
*Schima wallichii*Choisy.	Chilaune	Theaceae	II	LC	46
Macaranga postulata King.	Malata	Euphorbiaceae	II	VU	46
Litsea polyantha juss.	Kuthmero	Lauraceae	III	LC	36
Engelhardtia spicata Lechen ex Blume	Aule mahuwa	Juglandaceae	IV	LC	33
Drypeteslancifolia (Hook.f.) pax. & K. Hoffm.	Hare	Putranjivaceae	V	VU	23
Bauhinia purpurea L.	Taki	Fabaceae	VI	LC	20
Duabanga grandiflora (Roxb. Ex DC) Walp.	Lampatey	Lythraceae	VI	LC	20
*Bischofiajavanica*Blume	Kaijal	Phyllanthaceae	VII	LC	16
*Artocarpus lakoocha*Roxb.	Borar	Moraceae	VII	NT	16
*Bauhinia variegata*L.	Koirala	Fabaceae	VIII	LC	13
Bridelia retusa (L.) A. Juss.	Gayo	Phyllanthaceae	IX	LC	10
*Bassia butyracea*Roxb.	Chewri	Sapotaceae	IX	-	10
*Canarium sikkimensis*King.	Gokul	Burseraceae	IX	-	10
Castanopsis tribuloides (Sm.) A.DC.	Musrekattus	Fagaceae	X	LC	6
Eurya acuminata DC.	Phalamey	Theaceae	X	CD	6
*Acer laevigatum*Wall.	Khari	Sapindaceae	X	LC	6
*Ficus roxburghii*Wall.	Nevara	Moraceae	XI	LC	3
*Prunus cerasoides*D. Don	Payou	Rosaceae	XI	LC	3
*Rhus semialata*Murr.	Bhakimlo	Anacardiaceae	XI	LC	3
Dillenia indica L.	Panchpate	Dilleniaceae	XI	LC	3
Stereospermumchelonoides(L. fil.) DC.	Padari	Bignoniaceae	XI	LC	3
Terminalia elliptica Willd.	Panisaas	Combretaceae	XI	-	3
*Grewia eriocarpa*Juss.	Sayal fushre	Moraceae	XI	LC	3
*Ficus infectoria*Roxb.	Kabra	Moraceae	XI	LC	3

*Conservation status: LC Least concern, VU vulnerable, NT near threatened, CD conservation dependent

They typically work in professions that are insecure and have few options for employment outside of farms. Agricultural production carries a high risk for AAY households because of the vulnerability to climatic conditions (Centre for International Economics, 2002). Households who are rich and experienced in agriculture and have a stable livelihood do not depend on the forests, whereas poor households are heavily dependent (MARD-FSIV, 2002). The majority of OPHH and PHH families are sizeable and

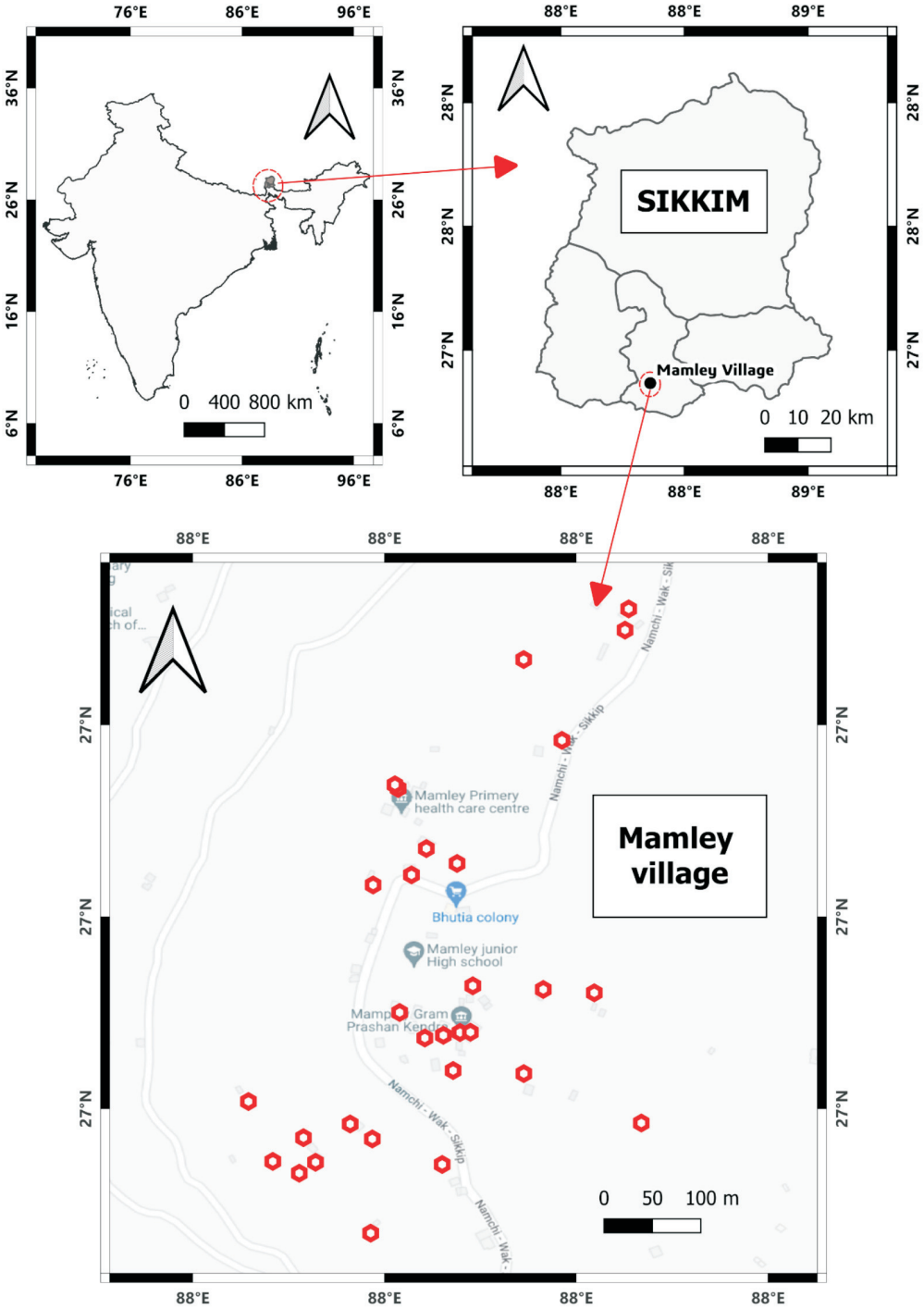


Fig. 1. Study sites at Mamley Village, Namchi, Sikkim

have a variety of revenue streams as compared to AAY families.

Firewood use

Numerous factors, including the size of the family, the number of livestock, and the household's financial status, primarily affect the pattern of daily firewood use. Cooking and boiling water for human use, cooking feed for pigs, cows, and goats, and producing charcoal and wine are the main applications of firewood. AAY, those who have fewer family members and animals consume only around 10-15 kg of firewood daily. Sundriyal *et al*., (1994) reported a higher limit of firewood consumption to be 21 kg per day per household while our study observed the consumption to be 35 kg per day per household. While firewood is easily accessible, other fuels such as propane and electricity are more expensive, making them unaffordable for the locals. Local people cannot afford the prices of alternative fuels such as electricity and gas, whereas firewood is readily accessible at no cost. (Pachauri *et al.,* 2004). Consequently, many households rely heavily on firewood for cooking. Further, firewood for cooking is an essential requirement for impoverished households (International Tropical Timber Organization ITTO 2006; SNV 2010) and is free of cost.

PHH communities with a greater number of family members, pigs, cows, and goats require more than 30-40kg of firewood daily. The people belonging to the PHH category prepared food thrice a day whereas some people cooked food twice a day as they used the leftover food for their morning meal. According to same authors households with larger family members consumed large quantities of firewood for cooking and boiling water as compared to smaller households. Furthermore, rearing cattle plays a vital role in generating household income patterns, and the increase in the number of cows and goats is interrelated with the lives of many people. It was observed that the mass of households who used firewood for cooking cow and goat food

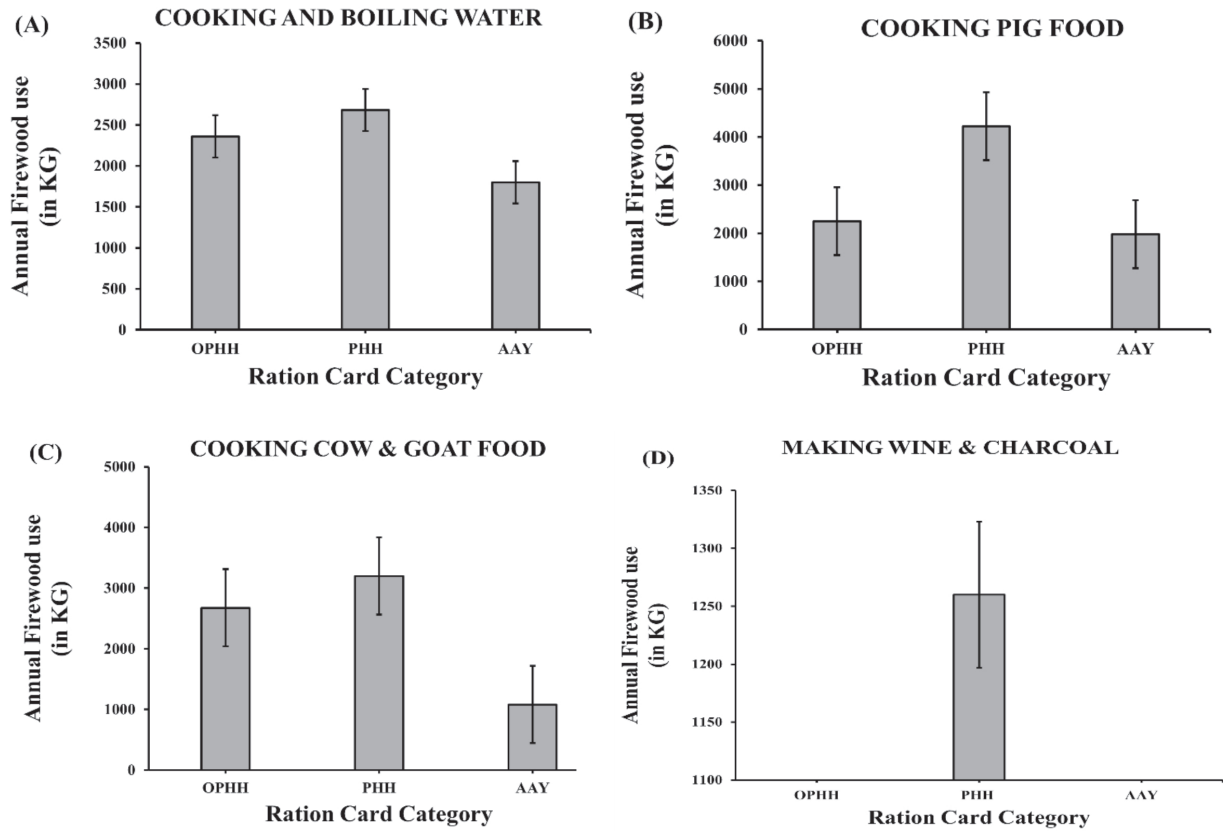


Fig. 2. Annual firewood volume (in kg) used for various domestic and commercial activities in Mamlay village such as **(A)**cooking and boiling water, **(B)**cooking pig food, **(C)** cooking cow and goat food, and **(D)**making wine and charcoal: OPHH (n=9), PHH (n=20), AAY (n=01).

were in the PHH household classes (43%) as these household groups had a greater number of cows and goats. Cow and goat food was cooked at least twice a day and consumed 8-12 kilograms of firewood per day.

An interesting revelation that was observed in our analysis is that despite the varied socio-economic scenarios of households, there was no significant difference between the firewood consumption patterns among the three household categories. A significant amount of reliance on fuelwood was observed in different diasporas of people belonging to different financial backgrounds. This is possible as some households in the OPHH category used maximum firewood for cooking, boiling water, and preparing cattle feed—household tasks that are similar to that of households belonging to PHH and AAY categories. While poor households rely exclusively on firewood (Baral *et al* 2019) another reason for the dependence on fuelwood by richer households could be the size of their landholdings.

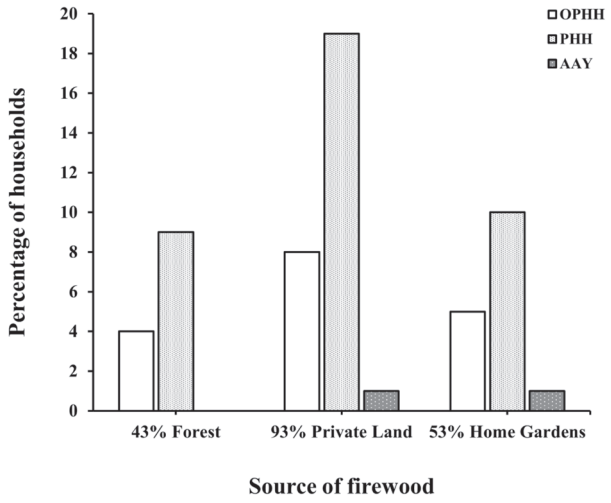


Fig. 3. Sources of firewood for OPHH, PHH, and AAY households in Mamlay village. The x-axis shows the percentage each source contributes to the total firewood collected by three ration card categories.

Firewood sources for daily use

In the study area, the three different extraction methods of firewood for daily use were forest, private land, and home garden with different household types having different preferences (Fig 3). PHH class, having the highest number of households, extracted the maximum firewood from all three methods. Similar findings have been reported by Kim *et al*., (2017) where middle-class households extracted firewood from every location available. Forest and home gardens were the major sources of firewood extraction for AAY households. Among the various sources of firewood, all three categories of households relied mostly on private land followed by home gardens and forest. According to Kim *et al*., (2017), this type of extraction might not be viewed as a significant factor in forest degradation. Research conducted in Indonesia by Pattanayak *et al.,* (2004) discovered that households with trees on their farms are more likely to collect firewood from their fields.

Plant species preferences

The families belonging to Fabaceae followed by

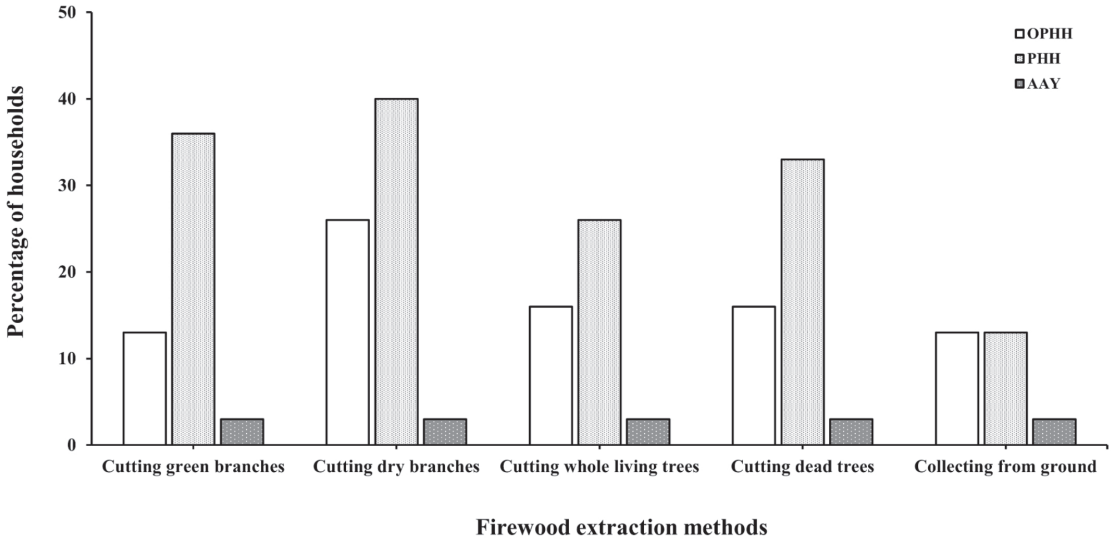


Fig. 4. Preferred fire wood extraction methods by three categories

Moraceae, Theaceae, and Phyllanthaceae were the most used species as firewood (Fig. 5). Collectively species *Albizia procera*, *Schima wallichii*, *Macaranga postulata*, *Litsaea polyantha,* & *Engelhardtia spicata* (Table 3). The extracted species are from conservation status of least concern, vulnerable, near threatened, and conservation dependent.

In the study area, 70% of the households used firewood from *Albizia procera*. This species can thrive where many species of trees cannot since it is adapted to a barren soil environment. It propagates readily from seeds or shoots and grows in secondary woods and barren slopes. As a result, they may be extracted as required. This species is highly valued for its ability to improve soil quality and is widely planted due to its capacity to bind the soil and fix nitrogen (Sivakrishnan and Kavitha, 2018). It is also a valuable source of livestock fodder, as it contains high levels of crude protein.

Unlike the research conducted in Vietnam by Kim *et al.,* (2017) where firewood extractors preferred green branches and entire live trees, our study revealed cutting dry and green branches as the most preferred way by firewood extractors. Owing to the challenges associated with managing and safeguarding property rights, natural forests have frequently been perceived by households as open-access resources. Although the firewood extractors preferred branches and not the whole tree, this type of extraction may not be considered detrimental to forest degradation. However, Matsika *et al.,* (2013) suggest that an increase in the demand for fuel would result in the extraction of live woody parts which may bring about forest degradation.

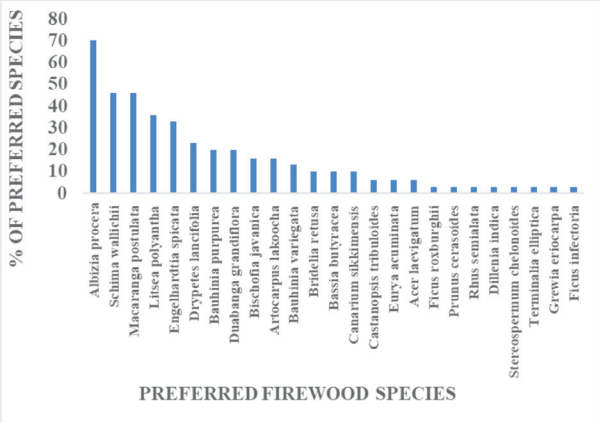


Fig. 5. Preferred fire wood species used by all the household

Deforestation effects of firewood use

The forests of Sikkim have been meeting the population's needs for fuelwood supplies but there is growing evidence of a loss in the number and variety of forest species (Rai *et al.,* 2002). Rai *et al.,* (2002) reported highly preferred species to be *Quercus lamellosa*, *Q. lineata* and *Castanopsis tribuloides, Schima wallichii* from the subtropical forest, and *Michelia excelsa* and *Engelhardtia* sp. from the temperate forest. Interestingly, after 22 years since the study conducted by Rai *et al.*, (2002), our study reports the change in the preference of species for fuelwood in the same study site. The premium firewood species extracted by the community according to species preference ranking were *Albizia procera*, *Schima wallichii*, *Macaranga postulata*, *Litsaea polyantha,* and *Engelhardtia spicata.* The reason people have shifted from Oak species to other species could be that forest degradation in Sikkim has mainly occurred in the temperate oak forest (Tambe *et al.,* 2011). Among the topmost preferred species, *Macaranga postulata* fall in the vulnerable class in the red data book. Therefore, the preference for extracting such species may lead to negative impacts on conservation aspects in this area. Besides, Sundriyal *et al.,* (1994) has already reported that Mamlay watershed is under increasing biotic pressure with high fuelwood demand.

The income status of households revealed key patterns in the dependence on fuelwood for their daily chores. Although the reliance on firewood was apparent in all three classes of households, the PHH category which accounted for the highest number of households, and had the largest family is highly dependent on the forest to sustain their day-to-day livelihood. A similar observation has been made by Kim *et al.,* (2017) where the middle class of the com-

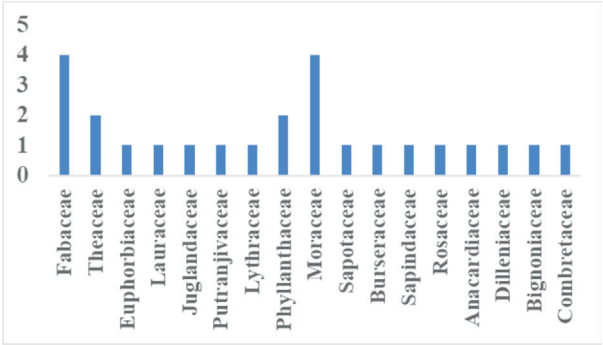


Fig. 6. Family-wise species composition

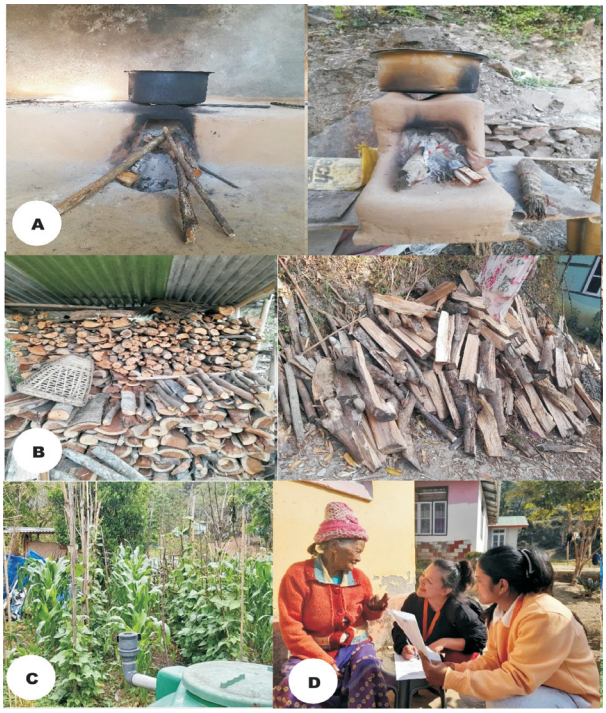
munity was seen to be heavily dependent on forests. The high dependence on forested lands for the income of middle-class households, coupled with their large population size in these communes, will possibly cause forest degradation in the future.

The density of trees in the forests of Sikkim is declining remarkably (Sundriyal *et al.*, 1994). The tropical montane forest of Sikkim is continuing to decline in Sikkim Himalaya, especially at the lower elevation (Kanade and John, 2018). Even though conservation should be the priority, it is evident that households are still largely dependent on firewood.

Conclusion

From the study area, forest-based resources and firewood collecting are an integral part of community livelihood. The local community depended largely upon private land followed by home gardens and forests. The extraction method of firewood was mainly cutting dry or green branches. The pressure is more pronounced on vulnerable species such as *Macaranga postulata* and *Drypetes lancifolia* if the dependence on firewood continues to rise. The socioeconomic status of the household appeared to have no effect on the usage of firewood by different categories of families. The people belonging to all the categories were seen to be involved in burning wood for their livelihood. However, it was observed that an increase in family members and livestock increased the usage of firewood among households. As a result, Mamlay watershed is experiencing unprecedented demand for firewood. The shift of preference of fuelwood from Oak species to other species such as *Albizia procera*, *Macaranga postulata* also poses serious queries about the status of the natural forest of Mamlay watershed. A clear correlation can only be drawn if further studies on the vegetation structure are conducted to see if there has been a decline in primary species such as Oak over the decade or is it just a change in the behavioral pattern.

Considering that an improvement in the socioeconomic condition has had no effect on the dependence of households on firewood tt is recommended that improved cooking stoves "*chullahs*" are introduced in villages. Further, awareness programs regarding burning of wood and its relation to pollution and health should be organized to ensure behavioral change. Regulations should be formulated to support a transition to other energy sources for those who need it. Further studies need to be conducted to understand the present scenario of population structure and dynamics of woody vegetation around Mamlay watershed.



Plates 1. **(A)***Chullah* and Tin made frame *(Agaytii)* used for burning fuelwood for household activities **(B)** Stockpile of preferred fire wood for domestic purposes**, (C)**. The local communities perform agricultural activity like cultivate mixed crops such as maize along with beans **(D)** Preliminary household survey to the oldest member of the household.

Acknowledgements

The authors wish to express their profound gratitude the Department of Botany, Sikkim Alpine University, Namchi, Sikkim, India for providing the support to the study.

Conflict of interests

The authors declare that there is no competing interest.

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