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Firewood value assessment: A comparison on local preference and wood constituent properties of species from a trekking corridor, West Sikkim, India

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Local people's preference scores for firewood species were studied through pair-wise ranking tools of Participatory Rural Appraisal technique from Yuksam-Dzongri trekking trail, Sikkim, India. A wide variety of plant species used as firewood was enlisted. These woody tree species with potential firewood use value were analysed for their Firewood Value Index (FVI) considering energy value, density, moisture content and ash content. The local people's preference scores and the constituent properties were then compared with 17 widely used firewood species using Pearson correlation and multiple regressions. *Quercus* spp. and *Rhododendron* spp. were the most desirable firewood according to their high ranks in local preference scores as well as FVI compared to other species. Local people's preference ranking energy and ash contents were vital con-

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stituents for determination of firewood quality. Local knowledge and scientific assessment closely matched to each other emphasizing that highly preferred species by the communities invariably showed better firewood value. However, there were some disparities when people's perception in relation to availability of species and convenience was considered. The local knowledge could be a good tool for species selection in forestry programmes.

Keywords: Firewood values, forestry programme, *in situ* conservation, local knowledge.

IN the Himalayas, 76% of the total resources needs are derived from natural forests because of their free and easy access and simplicity in use[1–7]. It was observed that these resources were vulnerable to deterioration due to selective use, over exploitation and bad management practices[2,3,5,6]. The ever-increasing human and livestock population in rural areas exerts immense pressure on forests and aggravates direct pressure on livelihoods causing shortage of resources[3–6]. This results in the disappearance of forests[8]. It is therefore necessary to have a knowledge of firewood quality of potential species to initiate *in situ* farming of these species, especially in the mountain areas.

About 43% of Sikkim's total geographical area is under forest cover, of which 34% is dense forest[2]. Majority of the rural people in Sikkim depend on forests for firewood, fodder and timber, and utilization of resources by selection of species with preference is widely practised[5–7]. However, studies on constituent properties of such preferred species are few and thus the basis on which preferences are made is obscure and poorly known[7]. This communication is an attempt to compare the firewood quality of different woody tree species with reference to people's preference ranking and their constituent properties.

The study was carried along the Yuksam-Dzongri trekking corridor (Figure 1). The Yuksam-Dzongri trail falls under three main vegetation types, namely temperate, subalpine and alpine (see Chettri *et al.*[2,3] for details). Firewood and fodder collection, interior forest grazing and leaf litter collection are common resource-use practices among the different ethnic groups as well to tourism services providers[3,9]. These have been one of the major factors of change in species composition and destruction of forest along the trail[2]. Therefore, it is important to understand the basis of firewood preference for reducing threats to high value firewood species and address this with better management approaches.

Matrix ranking tool of Participatory Rural Appraisal (PRA) technique was used for people's preference ranking on firewood species[10]. The exercise was conducted with diverse groups using PRA tools as done in our earlier study (see Rai *et al.*[7]). On the other hand, samples of majority of these preferred species along with other potential firewood species of the area were collected and their constituent properties assessed using the following formula (see Rai *et al.*[7], and Purohit and Nautiyal[11] for details).

$$\text{Firewood value index (FVI)} = \frac{\text{Energy value (kJ/g)} \times \text{density (g/cubic cm)}}{\text{Ash content (g/g)} \times \text{moisture content (g/g)}}$$

These wood attributes were then compared with the people's scores among the 17 widely used firewood species of the study area. Initially, Pearson correlation analysis was performed among the people's score, FVI and other wood attributes. A stepwise backward regression was also used keeping the people's score as the dependent variable and other wood attributes as independent variables to see the relationship between people's preference and wood characteristics. Statistical analysis was performed using in SYSTAT[12].

Among the 39 enlisted firewood species, 17 were found to be widely preferred in the study area (Table 1). Among these, *Quercus lamellosa* ranked the highest with

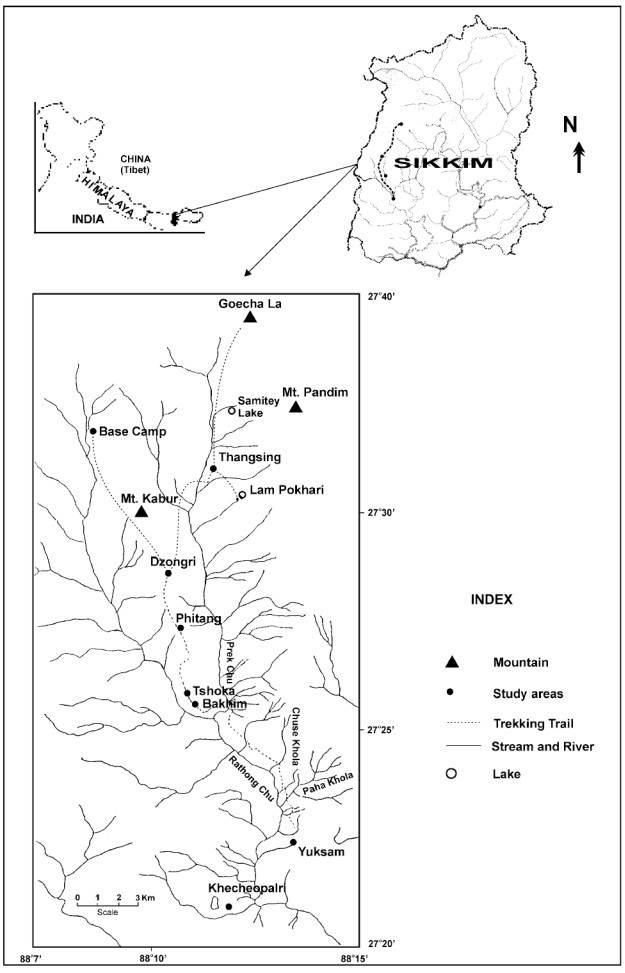

Figure 1. Location map of Yuksam-Dzongri trekking corridor in the Khangchendzonga Biosphere Reserve.

Table 1. Firewood value index (FVI) and other wood attributes of firewood species enlisted from Yuksam-Dzongri trekking corridor, West Sikkim

Latin name (local names in parenthesis)	People's scores	Energy value (kJ/g)	Moisture content (%)	Density (g/sq. cm)	Ash content (%)	FVI
***Rhododendron arboreum* (Lali guras)**	6	19.72	25	0.69	0.24	22678
Rhododendron grande (Patle korling)		20.15	42	0.68	0.19	17170
***Quercus lamellosa* (Bajrant)**	10	20.47	39	0.72	0.23	16431
Rhododendron fulgen (Chimal)		20.20	45	0.62	0.24	11596
***Rhododendron falconeri* (Korling)**	4	19.30	49	0.65	0.25	10241
***Schima wallichii* (Chilaune)**	9	19.41	59	0.76	0.22	11365
***Quercus lineata* (Phalant)**	11	20.21	47	0.69	0.28	10596
***Prunus cerasoides* (Panyun)**	5	17.15	44	0.73	0.27	10538
Rhododendron decipiens (Jhukaune guras)		19.87	49	0.67	0.26	10450
Symingtonia populnea (Pipli)		17.92	45	0.86	0.33	10378
***Rhododendron barbatum* (Lal chimal)**	6	17.91	47	0.75	0.29	9855
Rhododendron lanatum (Bhutle guras)		18.82	54	0.62	0.22	9822
***Castanopsis hystrix* (Jat katus)**	4	18.78	43	0.79	0.38	9080
***Prunus nepalensis* (Arupate)**	2	18.46	47	0.76	0.33	9046
***Beilschmiedia sikkimensis* (Tarsing)**	5	15.79	41	0.58	0.25	8935
Quercus sp. (Ainte)		18.81	41	0.77	0.4	8832
Castanopsis indica (Dhalne katus)		18.84	38	0.62	0.38	8089
Andromeda elliptica (Angeri)		18.75	39	0.56	0.37	7277
Castanopsis tribuloides (Musre katus)		18.84	51	0.78	0.7	4116
Acrocarpus fraxinifolius (Mandane)		16.46	48	0.58	0.32	6215
***Acer oblongum* (Phirphire)**	4	17.78	35	0.67	0.63	5403
Machilus edulis (Kaulo)		17.75	39	0.69	0.62	5065
***Betula alnoides* (Saur)**	8	18.91	56	0.67	0.47	4814
***Eurya acuminata* (Jhiguni)**	8	16.75	50	0.72	0.67	3600
Elaeocarpus sikkimensis (Bhadrase)		19.57	48	0.46	0.82	2287
Viburnum cordifolium (Asare)		16.84	38	0.69	1.47	2080
Cinnamomum cecidodaphne (Malagiri)		19.23	43	0.47	1.63	1289
Cinnamomum impressinervium (Sisi)		18.57	41	0.41	1.48	1255
***Symplocos ramosissima* (Kharane)**	1	15.24	76	0.67	1.3	1033
Glochidion acuminatum (Lati kath)		17.96	57	0.69	2.3	945
Symplocos glomerata (Kholmen)		11.89	54	0.66	1.86	781
Casearia glomerata (Badkunle)		13.58	48	0.54	2.18	701
Rhus semialata (Bhakimlo)		14.14	33	0.43	2.66	693
***Alnus nepalensis* (Uttis)**	2	16.25	66	0.45	1.6	692
Macaranga pustulata (Malata)		20.06	54	0.41	2.25	677
Evodia fraxinifolia (Khanakpa)		13.37	62	0.46	1.87	530
Engelhardtia spicata (Mahuwa)		17.75	52	0.45	2.98	515
***Litsaea elongata* (Kali pahenli)**	2	13.59	58	0.35	1.83	448
Echinocarpus dasycarpus (Gobre)		12.82	52	0.42	3.11	333

Species in bold are used in PRA for comparison.

people's preference score followed by *Schima wallichii* and others. *Viburnum cordifolia* and *Symplocos ramosissima* were ranked as the least preferred species.

Higher energy value was found in *Q. lamellosa* followed by *Quercus lineate* and others (Table 1). Among rhododendrons, *Rhododendron fulgen* showed the highest energy value followed by *R. grande*, *R. decipiens* and *R. arboreum*. Other wood attributes (moisture content, ash content, density along with FVI) are presented in Table 1. The highest FVI was recorded from *R. arboreum* followed by *R. grande* and *Q. lamellose*.

Compared to the people's scores values and FVI, *Q. lineata* and *Q. lamellosa* are the most preferred species (Table 1). Though *R. arboreum*, *R. falconeri* and *R. barbatum* possess higher FVI, they are least preferred by the people. Likewise, *Prunus cerasoides* and *P. nepalensis* also have higher FVI, but lower preference. This disparity in preferences is mainly due to other factors. First, these species are not widely available near major settlements such as Yuksam and Tshoka. The other possible reason is that the local people's choice of species is not solely based on the four attributes of FVI. To validate this further we used Pearson correlation.

It was observed that almost all the wood attributes were significantly related to people's scores and FVI. The energy value was significantly and positively related to the people's scores and FVI (0.671, $P < 0.01$), and negatively to ash content (–0.628, $P < 0.01$). It was noted that the moisture content of these species was significantly and negatively related to FVI (–0.651, $P < 0.01$), but not with the people's scores (–0.247, not significant). Other relationships such as density and energy (0.664, $P < 0.01$); biomass ash ratio and people's score (0.605, $P < 0.01$) and biomass ash ratio and energy (0.705, $P < 0.01$) were

also significant. Interestingly, the correlations also support the relationship between the FVI and energy value (0.741, $P < 0.01$), density (0.483, $P < 0.05$), ash content (–0.776, $P < 0.01$) and moisture content (–0.651, $P < 0.01$). These analyses revealed that there are strong relationships between the wood attributes and FVI as well as with people's score, assuring that local preferences do have implications on the quality of firewood species.

A stepwise regression was used amongst people's score and firewood attributes to see the basis of preferences. This analysis further clarified that energy value, density, moisture and ash contents were the key attributes for people's preference. However, it revealed that moisture content is least importance with respect to people's choice. Communities look for higher energy value as a key factor (0.671, $P < 0.05$) followed by density (0.458, not significant) and ash content (–0.280, not significant). This is an interesting reflection showed by the people on their basis of preferences.

Communities living along the Yuksam-Dzongri trekking corridor use a wide variety of plant species by preference as firewood, fodder and timber[3]. Though extraction was within the carrying capacity, there has been a visible change in species composition, and regeneration status of many high-quality firewood species is at risk[2]. Human pressure in terms of resources extraction is aggravating along the corridor[2,3]. Since constituent analysis can indicate the gross firewood value[11], we felt that it is important to understand the basis of local people's preferences. In general, for ideal firewood, species with high heat of combustion or energy, high wood density, low ash content and low moisture content are the most desirable[7,11].

The present study supports the view that people's knowledge regarding firewood selection is based on these four attributes, but local priorities focus more on high combustion with high energy release and low ash content, as revealed earlier[7,11]. The study also revealed that wood attributes are similar to those of species in the region reported from the Mamlay Watershed[7] but with higher values, suggesting that species found at sub-alpine areas such as *Rhododendron* spp. and *Quesrcus* spp. have higher density and energy values compared to the same species found in temperate regions (at lower elevations). Preferences for species were based on availability and ease in use and not solely on the FVI values. Two major observations were recorded in this context. People do prefer species that are of high energy value, but at the same time they also consider availability. It was also observed that people's preferences were based on quality wood (high energy content, high density, low ash content and low moisture content), but they also consider woods which are easy to cut and yield less smoke on burning. This was reflected from the fact that the corridor does have many other highly preferred species such as *R. arboreum*, *R. fulgen*, *R. decipiens* and *Symingtonia populnea*, but they were not widely available either due to their low density in the forest or are found only at distant areas from the trail, as revealed earlier[2]. Systematic research on silviculture practice and promotion of such species in the community land could help address the firewood needs.

Sustainable utilization of resources is a complex issue that encompasses societal needs and values such as ethical, cultural and economic status of communities, which ultimately have direct implications on resources utilization. As local knowledge by pairwise ranking was found applicable for a gross idea on firewood values for most of the resources utilization, serious attention should be given to know the depth of local knowledge to improvise high potential firewood species by farming or *in situ* conservation. The result of this study suggests that local knowledge and constituent properties of species should be the basis for *in situ* conservation and cultivation of high-value firewood species to meet the present and future demands.

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