International Journal of Environment, Agriculture and Biotechnology
Vol-9, Issue-5; Sep-Oct, 2024
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Using wood for fuel in the North-Eastern Part of India - A review of the current situation

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Received: 12 Jul 2024; Received in revised form: 15 Aug 2024; Accepted: 23 Aug 2024; Available online: 01 Sep 2024

***Abstract*— *The domestic usage of fuelwood as the primary energy source has created considerable deforestation in North East India. The extraction of most fuel wood from wood is one of the principal causes of disturbance to the native forest flora of north east India. In this study, scientific journals, edited books, and other scientific databases were studied to examine fuelwood consumption trends in the North East India. A total of 162 plant species from 53 families were utilized as fuel by the natives of the region of seven sister states, along with Sikkim, according to a review of the relevant literature. Depending on their local availability, different plant species have been used as fuels in diverse locations. Schima wallichi, A. procera, and Toona ciliata were the most profound species reported in scientific literature. The FVI ranges from 22678 to 2.43 in the listed species. The accumulated data on fuelwood consumption patterns and fuelwood species utilized in the NEH could serve as a baseline for future studies and policy formulation, thus aiding in conserving the region's forest resources.*

***Keywords*— Calorific value, fuelwood, Fuel-Value Index, socio-economic, sustainable energy.**

I. INTRODUCTION

One of the main factors contributing to the degradation of forests in many developing nations is fuelwood. In India, fuelwood is the cheapest and most accessible source for most of the population, especially those living in rural areas (Dayanand & Olivia E. Atherton1, Jennifer L. Tackett2, Emilio Ferrer1, 2018; Hussain et al., 2017; Sharma & Dash, 2022). The primary energy source in all Indian hilly settlements is fuelwood. In India, 49% of households use fuelwood as their primary fuel for cooking (Khanwilkar et al. 2021). In developing countries, including India, fuelwood is the primary and most important source of traditional domestic energy used for cooking, heating, and other purposes (Akpalu et al., 2011; Foundation, 2010; Singh et al., 2021). The demand for fuelwood has grown much faster than its supply. The North Eastern Himalayan (NEH) tribal regions experience a similar situation, clearly related to the loss of forest cover. In the North Eastern Himalayan (NEH) region, biomass is a major energy source used by almost 90% of the tribal population. However, the region's ecosystem has deteriorated significantly due to changing agriculture combined with excessive deforestation or the harvest of timber and fuel. In the north eastern zone of India, a huge amount, almost 3-4 fold higher fuelwood consumption rate, is used compared to other parts of the country. In the North Eastern Himalayan region, the demand for fuelwood is more than 228 million tons, with a substantial supply of 128 million tons (Iiyama et al., 2014; Saxena et al., 2016). There is a huge gap between the demand and supply of fuelwood, which leads to pressure on existing forests to overcome the scarcity of this huge demand. Based on satellite images and official estimates, the north eastern region has 163,799 sq km of forest, constituting approximately 64% of the total area (Ghilardi et al., 2009). Most (approximately 80%) of the North Eastern Himalayan (NEH) population lives in rural areas. The tribal of the NEH region relies heavily on forest resources for subsistence, and 90% of the region's population uses biomass as an important energy source (Khuman et al., 2011). Mass afforestation using suitable firewood tree species is required to meet the rising demand for fuelwood. Extensive farming of firewood could be the only alternative to bridge the gap between demand and supply (Campos et al., 2019; Tewari et al., 2003).

Farming farmers should prefer species with good calorific value, Fuelwood Value Index (FVI), and native species (Deka et al., 2007; Ojelel et al., 2015). Thus, the place's ecosystem remains balanced, and demand can be fulfilled. For this purpose, we need to compile existing information (availability, Fuel Value Index, species) on fuelwood resources utilized in India's north eastern region for policymaking to achieve sustainable development (Bhatt & Sachan, 2004; Negi et al., 2018). The present study was undertaken to review studies conducted on fuelwood consumption in different NEH region villages and to compile a comprehensive list of plant species used as fuel by the region's local people.

Study area

The North Eastern Himalayan region comprises the states of Manipur, Meghalaya, Nagaland, Sikkim, Tripura, Arunachal Pradesh, and Mizoram (Seven Sisters) (between 21.50 °N and 29.50 °N latitude and 85.5º-97.5ºE longitude). It represents a distinct agro-climatic area in India. The hilly states of the region have a total geographical area of 183,741 km^2 (5.589% of India) and are populated by 12.41m people (1.13% of the country). An undulating topography and wide variations in altitude, rainfall, temperature, and soil conditions characterize the NEH region. The climate is typically monsoonal, with approximately 85% of the annual precipitation occurring during the rainy season. The average maximum temperature during the rainy season is 30 °C, and the average minimum temperature is 14 °C, with a maximum and minimum of 20 °C and 8 °C, respectively, during winter.

II. MATERIALS AND METHODS

The literature on fuelwood consumption in various villages of the NEH available in scientific journals, edited books, and other scientific databases was searched. Only field-based surveys carried out in the NEH region that reported first-hand information on fuelwood consumption in different villages were included in this study. Confusing or erroneous data, where information on fuelwood consumption was unclear, were omitted from the analysis. An exhaustive list of plants used as fuel was compiled.

III. RESULTS

A detailed list of plant species reported to be used as fuelwood in NEH, India, along with their botanical name and calorific value of the respective species (KJg^{-1} dry weight), is given in (Table 1). A total of 162 plant species belonging to 53 families were used as fuelwood in NEH villages. Based on scientific literature citations, the most preferred fuelwood species used in the NEH were *Schima wallichi* and *Albizia procera*, cited in five studies. This was followed by *Toona ciliata*, which were mentioned in three studies. As reported in two studies, other preferred species were Cassia siamea, Terminalia myriocarpa, and Pinus kesiya. Fabaceae family species dominate 16.67%, followed by Theaceae and Meliaceae at 4.84% in this study. Different authors calculated the Fuel Value Index (FVI), obtained the highest value of 22,678 in Rhododendron arboretum and the lowest value of 2.43 in *Bombax ceiba*.

IV. DISCUSSION

The sustainable use of forests and associated resources is a complicated topic that encompasses social needs, ethical and cultural values, and the socio-economic situations of forest-dependent people (Plieninger et al., 2023; Purvis et al., 2019). The dependence on forests for fuelwood results in catastrophic deforestation throughout the Indian continent (Chakraborty et al., 2018; Ghanbari & Kern, 2021). In the developing world, biomass is the predominant energy source for residential consumption (Benti et al., 2021). Utilization of fuelwood is widespread in rural areas of the developing world, particularly in areas where these fuels are locally accessible (Ghazoul & Evans, 2004). Communities use fuelwood for numerous uses, mostly firewood and house construction, resulting in overuse and increased deforestation. In India, 49% of households use fuelwood as the primary fuel for cooking (Nagothu, 2001). Sudha et al. (2003) estimated that 11.28 million individuals collect firewood in India.

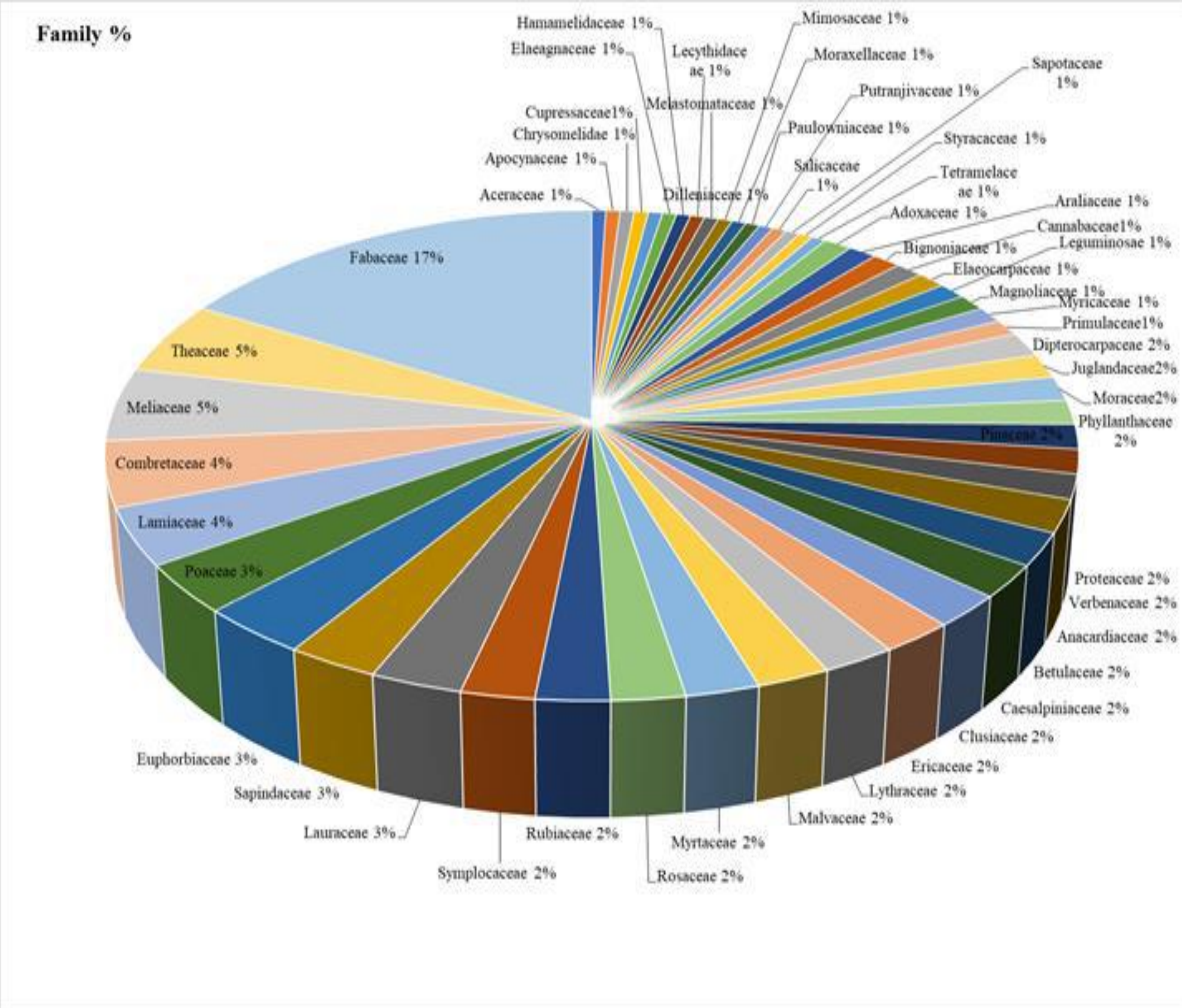

Fig 1: Graphical representation of Species Percentage

The International Energy Agency observed in its 2006 World Energy Outlook Report that Indian households favored using wood burners to bake traditional bread. (Kumar et al., 2020). Due to the reduction in forest cover, unsustainable firewood harvesting has considerably contributed to biodiversity loss and soil erosion (Damette & Delacote, 2011).

Several factors, including household size, education, lifestyle, ethnicity, geographic location, climatic condition, subsidies, energy supply factors, price, availability, and accessibility, influence fuel selection in the villages of the North Eastern Himalayan region (Narasimha Rao & Reddy, 2007; Zou & Luo, 2019).

Table 1: Plant species used as fuelwood in the Northeastern Himalayan Region, India.

S.No	Name of the Species	Family	FVI	References
1	*Acacia auriculiformis*	Fabaceae.	1851	Kataki and Konwer(2002)
2	*Acacia nilotica*	Fabaceae	2089	Kataki and Konwer(2002)
3	*Acer oblongum*	Sapindaceae	5403, n.a	Chettri and Sharma(2008), Bhatt and Sachan(2004)
4	*Acrocarpus fraxinifolius*	Fabaceae	306	Sahoo et.al(2014)
5	*Actephila excelsa*	Phyllanthaceae	370	Kataki and Konwer(2002)
6	*Adina cordifolia*	Rubiaceae	529	Sahoo et.al(2014)

7	*Adina polycephala*	Rubiaceae	554	Kataki and Konwer(2002)
8	*Aesculus assamicus*	Sapindaceae	1008, n.a	Kataki and Konwer(2002), Bhatt and Sachan(2004)
9	*Albizia chinensis*	Fabaceae	242	Sahoo et.al(2014)
10	*Albizia lebbeck*	Fabaceae	1329	Kataki and Konwer(2002)
11	*Albizia odoratissima*	Verbenacece	475.99	Sedai et.al(2016)
12	*Albizia procera*	Fabaceae	532, 16.588, 1793,291.6	Sahoo et.al(2014), Taran et.al(2016), Sahoo et.al(2014), Taran et.al(2016), Kataki and Konwer(2002), Rai et.al(2002)
13	*Albizia thomsoni*	Leguminosae	867	Sahoo et.al(2014)
14	*Albizzia chinensis*	Fabaceae.	477	Kataki and Konwer(2002)
15	*Alnus nepalensis*	Betulaceae	692, 780	Chettri and Sharma(2008), Kataki and Konwer(2002)
16	*Andromeda elliptica*	Ericaceae	3933.8	Rai et.al(2002)
17	*Anogeissus acuminata*	Combretaceae	1370,7.41	Sahoo et.al(2014), Taran et.al(2016)
18	*Aralia aramata*	Araliaceae	n.a	Lynser et.al(2020)
19	*Artocarpus integrifolia*	Moraceae	n.a	Bhatt and Sachan(2004)
20	*Bahunia Variegata*	Caesalpiniaceae	9.882	Taran et.al(2016)
21	*Bambusa balcooa*	Poaceae	n.a	Bhatt and Sachan(2004)
22	*Bambusa cacharensis*	Poaceae	n.a	Bhatt and Sachan(2004)
23	*Bambusa nutans*	Proteaceae	n.a	Bhatt and Sachan(2004)
24	*Bambusa pallida*	Poaceae	n.a	Bhatt and Sachan(2004)
25	*Bauhinia variegate*	Theaceae	2074.62	Sedai et.al(2016)
26	*Beilschmiedia sikkimensis*	Lauraceae	8935	Chettri and Sharma(2008)
27	*Betula alnoides*	Betulaceae	48,14	Chettri and Sharma(2008)
28	*Betula spp*	Betulaceae	n.a	Bhatt and Sachan(2004)
29	*Bischofia javanica*	Phyllanthaceae	272	Sahoo et.al(2014)
30	*Bombax ceiba*	Malvaceae	2.436	Taran et.al(2016)
31	*Bridelia retusa*	Sapotaceae	2162.7	Sedai et.al(2016)
32	*Callicarpa arborea*	Verbenaceae	580	Sahoo et.al(2014)
33	*Camellia sp.*	Theaceae	n.a	Lynser et.al(2020)
34	*Careya arborea*	Lecythidaceae	7.24	Taran et.al(2016)
35	*Cassia fistula*	Caesalpiniaceae	8.347	Taran et.al(2016)
36	*Cassia siamea*	Caesalpiniaceae	1062, 10.03	Kataki and Konwer(2002), Taran et.al(2016)
37	*Castanopsis hystrix*	Fagaceae	9080	Chettri and Sharma(2008)
38	*Castanopsis indica*	Primulaceae	1705.64	Sedai et.al(2016)
39	*Castanopsis tribuloides*	Fagaceae	726, 1469.1	Sahoo et.al(2014), Rai et.al(2002)
40	*Catanopsis sp.*	Fagaceae	n.a	Lynser et.al(2020)
41	*Cedrela serrata Royle.*	Meliaceae	1050	Kataki and Konwer(2002)

ISSN: 2456-1878 (Int. J. Environ. Agric. Biotech.)
https://dx.doi.org/10.22161/ijeab.95.3

42	*Celtis australis*	Phyllanthaceae	1241.58	Sedai et.al(2016)
43	*Chuckrasia tabularis*	Meliaceae	n.a	Bhatt and Sachan(2004)
44	*Cinnamomum impressinerium*	Lauraceae	982.8	Rai et.al(2002)
45	*Cryptomeria japonica*	Cupressaceae	n.a	Bhatt and Sachan(2004)
46	*Dendrocalamus hamiltonii*	Poaceae	n.a	Bhatt and Sachan(2004)
47	*Dendrocalamus sp.*	Poaceae	_	Rai et.al(2002)
48	*Derris robusta*	Fabaceae	691	Sahoo et.al(2014)
49	*Dillenia pentagyna*	Dilleniaceae	4.576	Taran et.al(2016)
50	*Dipterocarpus macrocarpus*	Dipterocarpaceae	n.a	Bhatt and Sachan(2004)
51	*Drypetes lancifolia*	Putranjivaceae	_	Rai et.al(2002)
52	*Duabanga indica*	Lythraceae	n.a	Bhatt and Sachan(2004)
53	*Dysoxylum binectariferum*	Myrtaceae	1331.21	Sedai et.al(2016)
54	*Dysoxylum procerum*	Meliaceae	10.952, 2493.49	Taran et.al(2016), Sedai et.al(2016)
55	*Elaeagnus umbellata*	Elaeagnaceae	1082	Kataki and Konwer(2002)
56	*Elaeocarpus lanceifolius*	Elaeocarpaceae	390	Sahoo et.al(2014)
57	*Elaeocarpus sp.*	Elaeocarpaceae	n.a	Lynser et.al(2020)
58	*Engelhardtia sp.*	Juglandaceae	_	Rai et.al(2002)
59	*Engelhertia spicata*	Juglandaceae	n.a	Lynser et.al(2020)
60	*Eurya acuminata*	Theaceae	3600,n.a	Chettri and Sharma(2008), Lynser et.al(2020)
61	*Exbucklandia populnea*	Hamamelidaceae	n.a	Lynser et.al(2020)
62	*Ficus hispida*	Moraceae	3.203	Taran et.al(2016)
63	*Ficus semicordata*	Moraceae	291	Sahoo et.al(2014)
64	*Garcinia paniculata*	Clusiaceae	n.a	Bhatt and Sachan(2004)
65	*Garcinia pedunculata*	Clusiaceae	n.a	Bhatt and Sachan(2004)
66	*Garcinia sp.*	Clusiaceae	n.a	Lynser et.al(2020)
67	*Gmelina arborea*	Lamiaceae	10.868	Taran et.al(2016)
68	*Grevillea robusta*	Proteaceae	742	Kataki and Konwer(2002)
69	*Helicia nilagirica*	Proteaceae	n.a	Lynser et.al(2020)
70	*Holarrhena antidysenterica*	Apocynaceae	3.962	Taran et.al(2016)
71	*Jambosa sp.*	Myrtaceae	_	Rai et.al(2002)
72	*Juglandaceae*	Juglandaceae	1358.6	Rai et.al(2002)
73	*Kydia calcyna*	Meliaceae	4091.38	Sedai et.al(2016)
74	*Lagerstroemia citrata*	Lythraceae	n.a	Bhatt and Sachan(2004)
75	*Lagerstroemia parviflora*	Lythraceae	448	Kataki and Konwer(2002)
76	*Lagerstroemia speciosa*	Lythraceae	n.a	Bhatt and Sachan(2004)
77	*Lantana camara*	Verbenaceae	516	Kataki and Konwer(2002)
78	*Leucosceptrum canum*	Lamiaceae	1027.8	Rai et.al(2002)
79	*Lithocarpus sp.*	Fagaceae	n.a	Lynser et.al(2020)
80	*Litsea elongata*	Lauraceae	448	Chettri and Sharma(2008)

81	*Litsea polyantha*	Lauraceae	369, 926.03	Kataki and Konwer(2002), Sedai et.al(2016)
83	*Macaranga denticulata*	Euphorbiaceae	n.a	Bhatt and Sachan(2004)
84	*Macaranga indica*	Euphorbiaceae	515	Sahoo et.al(2014)
85	*Macaranga pustulata*	Euphorbiaceae	672.6, 802.7	Rai et.al(2002), Sedai et.al(2016)
86	*Macropanax dispermus*	Araliaceae	220	Sahoo et.al(2014)
87	*Maesa chisia*	Primulaceae	429.9	Rai et.al(2002)
88	*Magnoli hodgsonii*	Magnoliaceae	1803.23	Sedai et.al(2016)
89	*Mallotus phillipensis*	Lamiaceae	1931.09	Sedai et.al(2016)
90	*Melastoma malabathricum*	Melastomataceae	6.498	Taran et.al(2016)
91	*Melia azedarach*	Meliaceae	968	Kataki and Konwer(2002)
92	*Melocanna baccifera*	Poaceae	n.a	Bhatt and Sachan(2004)
93	*Mesua ferrea*	Clusiaceae	1244	Sahoo et.al(2014)
94	*Michelia champaca*	Magnoliaceae	n.a	Bhatt and Sachan(2004)
95	*Momosops elengi*	Fagaceae	819.56	Sedai et.al(2016)
96	*Moraxella oblonga*	Moraxellaceae	n.a	Bhatt and Sachan(2004)
97	*Myrica esculenta*	Myricaceae	801	Sahoo et.al(2014)
98	*Myrica sp.*	Myricaceae	n.a	Lynser et.al(2020)
99	*Myrsine semiserrata*	Fabaceae	1723.68	Sedai et.al(2016)
100	*Oroxylum indicum*	Bignoniaceae	4.392	Taran et.al(2016)
101	*Persea sp.*	Lauraceae	n.a	Lynser et.al(2020)
102	*Photinia sp.*	Rosaceae	n.a	Lynser et.al(2020)
103	*Phyllocharis undulata*	Chrysomelidae	n.a	Bhatt and Sachan(2004)
104	*Pinus kesiya*	Pinaceae	n.a, 1308	Lynser et.al(2020), Kataki and Konwer(2002)
105	*Pinus wallichiana*	Pinaceae	560	Kataki and Konwer(2002)
106	*Premna integrifolia*	Fabaceae	274.01	Sedai et.al(2016)
107	*Prunus cerasoides*	Rosaceae		
108	*Prunus nepalensis*	Rosaceae	9046	Chettri and Sharma(2008)
109	*Pterospermum acerifolium*	Euphorbiaceae	2347.87	Sedai et.al(2016)
110	*Quercus delbata*	Fagaceae	661	Kataki and Konwer(2002)
111	*Quercus floribunda*	Fagaceae	895	Sahoo et.al(2014)
112	*Quercus glauca*	Fagaceae	725	Kataki and Konwer(2002)
113	*Quercus helferiana*	Fagaceae	1110	Sahoo et.al(2014)
114	Quercus lamellosa	Fagaceae	16431, 3860.7	Chettri and Sharma(2008), Rai et.al(2002)
115	*Quercus lineata*	Fagaceae	10,59,63,539.60	Chettri and Sharma(2008),Rai et.al(2002)
116	*Quercus pachyphylla*	Fagaceae	1361, 1210	Sahoo et.al(2014), Sahoo et.al(2014)
117	*Quercus semicaprifolia*	Fagaceae	748	Kataki and Konwer(2002)
118	*Quercus serrate*	Fagaceae	1077	Sahoo et.al(2014)

119	*Quercus sp.*	Fagaceae	n.a	Lynser et.al(2020)
120	*Quercus xylocarpa*	Fagaceae	1193	Sahoo et.al(2014)
121	*Rhododendron arboreum*	Ericaceae	22,678	Chettri and Sharma(2008)
122	*Rhododendron barbatum*	Ericaceae	9855	Chettri and Sharma(2008)
123	*Rhododendron falconeri*	Ericaceae	10,241	Chettri and Sharma(2008)
124	*Rhus javanica*	Anacardiaceae	n.a	Lynser et.al(2020)
125	*Rhus parviflora*	Anacardiaceae	370	Kataki and Konwer(2002)
126	*Rhus semialata*	Anacardiaceae	693.1	Rai et.al(2002)
127	*Rhus succedanea*	Anacardiaceae	594.8	Rai et.al(2002)
128	*Salix tetrasperma*	Salicaceae	687	Kataki and Konwer(2002)
129	*Sapindus laurifolius*	Sapindaceae	388	Kataki and Konwer(2002)
130	*Sapindus mukorossi*	Sapindaceae	801	Kataki and Konwer(2002)
131	*Schima khasiana*	Theaceae	n.a	Bhatt and Sachan(2004)
132	*Schima wallichi*	Theaceae	889.6, 694.81, 928,n.a,11365	Rai et.al(2002), Sedai et.al(2016), Sahoo et.al(2014),Lynser et.al(2020),Chettri and Sharma(2008)
133	*Shorea assamica*	Dipterocarpaceae	n.a	Bhatt and Sachan(2004)
134	*Shorea robusta*	Dipterocarpaceae	1027	Kataki and Konwer(2002)
135	*Simingtonia populnea*	Hamamelidaceae	n.a	Bhatt and Sachan(2004)
136	*Sterculia villosa*	Malvaceae	2.75	Taran et.al(2016)
137	*Stereospermum personatum*	Bignoniaceae	769	Sahoo et.al(2014)
138	*Styrax serrulatum*	Styracaceae	497	Sahoo et.al(2014)
139	*Symplocos crataegioides*	Symplocaceae	473	Kataki and Konwer(2002)
140	*Symplocos ramosissima*	Symplocaceae	1033	Chettri and Sharma(2008)
141	*Symplocos sp.*	Symplocaceae	n.a	Lynser et.al(2020)
142	*Symplocos theifolia*	Symplocaceae	713.4	Rai et.al(2002)
143	*Syzygium cerasoids*	Combretaceae	851.42	Sedai et.al(2016)
144	*Syzygium cumini*	Myrtaceae	9.083	Taran et.al(2016)
145	*Syzygium tetragonum*	Myrtaceae	n.a	Lynser et.al(2020)
146	*Tectona grandis*	Lamiaceae	12.353	Taran et.al(2016)
147	*Terminalia arjuna*	Combretaceae	714	Kataki and Konwer(2002)
148	*Terminalia bellerica*	Combretaceae	460	Kataki and Konwer(2002)
149	*Terminalia chebula*	Combretaceae	602	Kataki and Konwer(2002)
150	*Terminalia myriocarpa*	Combretaceae	n.a, 1801.73	Bhatt and Sachan(2004),Sedai et.al(2016)
151	*Terminalia tomentosa*	Combretaceae	433	Kataki and Konwer(2002)
152	*Tetrameles nudiflora*	Tetramelaceae	218	Sahoo et.al(2014)
153	*Toona ciliata*	Meliaceae	445, 8.158,343	Kataki and Konwer(2002), Taran et.al(2016),Sahoo et.al(2014)
154	*Trema orientalis*	Cannabaceae	2.729	Taran et.al(2016)

155	*Trewia nudiflora*	Euphorbiaceae	12.456	Taran et.al(2016)
156	*Viburnum contifolium*	Adoxaceae	991	Kataki and Konwer(2002)
157	*Viburnum sp.*	Adoxaceae	_	Rai et.al(2002)
158	*Vitex altissima*	Lamiaceae	2270.83	Sedai et.al(2016)
159	*Vitex peduncularis*	Lamiaceae	1276, 10.666	Sahoo et.al(2014),Taran et.al(2016)
160	*Wendlandia grandis*	Rubiaceae	877	Sahoo et.al(2014)
161	*Wendlandia wallichii*	Rubiaceae	n.a	Lynser et.al(2020)
162	*Wightia speciosissima*	Paulowniaceae	358	Sahoo et.al(2014)

Tribal reliance on wood for fuelwood as a key source of energy is generating severe deforestation in North Eastern Himalayan (Bhatt & Sachan, 2004; Bhatt & Tomar, 2002), which subsequently creates desertification in many parts of Meghalaya. Many people in north eastern India utilize fuelwood despite having access to alternative energy sources (Mottaleb & Rahut, 2021; Tofu et al., 2022). The average fuelwood consumption in NEH is 4.90 to 8.41 kg/capita/day, which is higher than previously reported values for other parts of Asia, such as 1.9–2.2 kg/capita/day for Southern India, 1.7–2.5 kg/capita/day for South and South-East Asian countries, 1.23 kg/capita/day for the Himalayan range of Nepal (Fox, 1984; Ives, 2004; Maikhuri, 1991).

Based on these tribal societies' fuelwood use patterns, deforestation must be carefully considered. It is vital to emphasize that if the current trends in fuelwood use in this region continue, there will be a shortage. Therefore, an urgent need is to educate indigenous tribes about preserving existing woods. Numerous studies have established a strong positive link between income and the amount of energy used (Angelsen et al., 2014; Chu & Karr, 2017; Coman et al., 2020). Many middle-income families in the region have access to LPG, but traditional chulha (wood burners) using fuelwood are still widely used for cooking. In addition, the remote areas of north eastern India have prevented many families from converting to modern fuels because of the distribution infrastructure. A literature review found that only a few studies have been undertaken on patterns of fuelwood consumption in North eastern India, and the majority were limited to small regions. Different approaches were utilized in further research to determine the pattern of per capita fuelwood usage. There is a need to record many aspects of fuelwood usage patterns in North Eastern India to formulate applicable laws. The data from the present study on fuelwood consumption patterns in North eastern India could be used to design and implement relevant technologies and management policies for the sustainable use of forest resources in this region.

V. CONCLUSION

People in the NEH have long relied on fuelwood as their primary energy source, which has resulted in significant deforestation across the state. On underutilized, deteriorated, and forested lands, it is imperative to construct large-scale energy plantations to avoid this catastrophe. However, when selecting tree species for energy plantations, special consideration should be given to Indigenous tree species traditionally favored for fuel by rural residents in the region. The fuel value index (FVI) is an essential screening criterion for acceptable fuelwood species. There is an urgent need for activities encouraging the conservation and sustainable use of imperiled forests in Northeast India. This paper outlines the tangible steps communities may take to better protect and manage impervious ecosystems. The woodlands in this region are renowned worldwide because of their rich biodiversity. The area is home to various cultural groups and has a staggering geographical variety.

ACKNOWLEDGMENT

The authors thank the Department of Forestry, Wildlife and Environmental Sciences head, Guru Ghasidas Vishwavidalayala, for providing the necessary facilities.

DECLARATION OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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