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# A COMPREHENSIVE REVIEW OF FUELWOOD RESOURCES AND THEIR USE PATTERN IN RURAL VILLAGES OF WESTERN HIMALAYA, INDIA

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## Abstract

Fuelwood is the primary source of energy in rural villages of Western Himalaya (WH), India, which is used for a plethora of purposes such as cooking, water heating, room heating, and lighting. Most of the fuelwood is extracted from the forests, which is one of the leading causes of disturbance to the natural forest flora of WH. In the present study, literature from the scientific journals, edited books, and other scientific databases was reviewed to study the fuelwood consumption pattern in the WH, India viz., Uttarakhand, Himachal Pradesh and Union Territory of Jammu & Kashmir. A review of literature has revealed that a total of 124 plant species (89 trees and 35 shrubs belonging to 87 genera and 45 families) are used as a fuel by the local inhabitants of the region. Average fuelwood consumption in villages of WH was found to be 3.15 kg/capita/day. Although fuelwood use patterns varied at villages situated at different locations but surprisingly, no relationship between altitude and fuelwood consumption pattern was observed. Different plant species based on their local availability were used as fuel at various locations. The most preferred species were *Quercus leucotrichophora*, *Pinus roxburghii, Q. floribunda, Rhododendron arboreum*, *Alnus nepalensis, Juglans regia, Lyonia ovalifolia, Pyrus pashia,* and *Q. semecarpifolia*. At many remote places, poor accessibility to alternate sources of energy and deprived socio-economic conditions of the people are primarily responsible for their reliance on freely available fuelwood in nearby forests. The compiled information on fuelwood consumption patterns and fuelwood species used in WH could form the baseline for future studies and policy formulation, which will help in the conservation of forest resources of the region.

***Keywords***: Fuelwood, Forest resources, Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Altitude, Energy.

## Introduction

Fuelwood is the primary source of energy for the rural household in the Western Himalaya (WH), where people still rely on fuelwood for cooking and other household tasks. Other commercially available sources of energy are still not preferred by local people due to poor road connectivity, deprived socioeconomic status, high prices, and limited supply of alternative sources of energy. The local inhabitants fulfill the majority of their energy demands by using biomass extracted from the forests (Gairola *et al.,* 2009). The Himalayan mountain system covers 18% of the geographical area and more than 50% forest cover of India. Due to the dry and cold arid environment, the demand for fuel is high in the temperate villages of WH. A considerable amount of energy is required for cooking of food as well as for keeping houses warm during severe winters. As a result, people in the region use all kinds of plants as fuelwood (Badoni and Bhatt, 1989), while crop residues and dung cakes are also used in place of fuelwood where wood is scarce (Madubansi and Shackeleton, 2006). Fuelwood demand in India is very high (Purohit and Dhar, 1997) that has caused severe depletion of forest resources in the vicinity of the villages (Tucker, 1987; Duke, 1994; Schickoff, 1995; Ali and Benjamisen, 2004). Due to the increasing population, fuel, fodder, timber, and other forest resources are becoming scarce in the region (Gairola, 2011; Gairola *et al*., 2009, 2012; Sharma and Gairola, 2007, 2009; Sharma *et al*., 2009a, 2009b,2011, 2012). However, recently Government of India has started Pradhan Mantri Ujjwala Yojana to distribute 50 million LPG connections to women of BPL families throughout India (PMUY, 2019). This scheme, up to some extent, has reduced the dependence of local people of WH on the fuelwood extracted from the wild. However, the majority of people in the temperate villages of the WH owing to their poor economic conditions still depend on the fuelwood resource for their energy needs. There is a need to compile and review available information on fuelwood resources utilized in the WH and their availability/use pattern to chalk out strategies for sustainable development in the region. Therefore, the present study was undertaken to review studies conducted on the fuelwood consumption in the different villages of the Western Himalayan Region, India, and compile a comprehensive list of plant species used as fuel by the region's local people.

### Study area

Western Himalaya (WH) comprises of two Indian states, namely Himachal Pradesh (HP) and Uttarakhand (UK), and two Indian Union territories of Jammu and Kashmir (J&K), and Ladakh (Fig. 1). The WH region is divided into Siwalik ranges or outer Himalaya, Pir Panjal ranges, inner Himalaya, Greater Himalaya, and Trans Himalaya with an altitudinal range from 2000 to 8000 m asl (Bhatt *et al.,* 2016). The WH region shows a wide range of variations in topography and climate. Western Himalaya is one of the rich floristic regions of India and harbors many endemic and rare, endangered and threatened plant species. The area is also acknowledged for the different types of forests on which indigenous communities depend for their livelihood. Local people of the region largely depend on these forests for medicine, wild edibles, and fodder for their cattle, fuelwood, timber, and other forest products. The detailed comparative geographical, environmental, and forest cover details of the two states and two union territories of India covering Western Himalaya are presented in Table 1.

## Materials and Methods

The literature on fuelwood consumption in various villages of WH available in the scientific journals, edited

books, and other scientific databases were searched. Only field-based surveys carried out in the WH region reporting firsthand information on fuelwood consumption in different villages of WH were included in this study. Confusing or erroneous data, where information on fuelwood consumption was not clear, was omitted from the analysis. An exhaustive list of plants used as fuel was compiled. Valid botanical names of all the species compiled in the present study were verified from The Plant List Version 1.1 (TPL, 2013).

## Results

The compiled data on fuelwood consumption patterns along an altitudinal gradient in different villages of the WH region is presented in Table 2. The relationship between altitude and fuelwood consumption (kg/capita/day) pattern is given in Fig. 2. Fuelwood consumption varied considerably at different locations of the WH region. It ranged from 0.05 kg/capita/day to 8.755 kg/capita/day. Bhatt and Sachan (2004) stated that fuelwood consumption in Himalaya varies due to altitudinal variations and climatic conditions. As per Pocs (1976), as altitude increases, temperature decreases with a lapse rate of about 0.6 °C/100m to 1.7 °C/100 m, and fuelwood consumption increases accordingly. Although fuelwood use patterns varied at villages situated at different locations but surprisingly, in the present study, no relationship between altitude and fuelwood consumption pattern was observed. The present review of the literature showed that fuelwood was the primary source of energy, which was used for various purposes in the villages of WH. In the WH, most of the villages are situated in the temperate zone, where the temperature is generally cold. Villagers extract a wide variety of plant species from forests. The preference of fuelwood is mainly based on plant species availability, quality, and accessibility in the community forests (Singh *et al.,* 1988).

The detailed list of plant species reported to be used as fuelwood in WH, India along with their botanical name, vernacular name, family and calorific value of the respective species ($KJg^{-1}$ dry weight) is given in Table 3. A total of 124 plant species (35 shrubs, 89 trees), (118 Angiosperm, 6 Gymnosperm) belonging to 87 Genera (83 Angiosperm, 4 Gymnosperm) and 45 families (44 Angiosperm, 1 Gymnosperm) were used as fuelwood in the villages of WH (Table 3). Out of the total 45 families, 19 were represented by one species, eight by 2 species, seven by 3 species, four by 4 species, and seven by more than 4 species. Among the Angiosperms, the dominant family used as fuelwood was Rosaceae (15 species and eight genera), which was followed by Lauraceae (8 spp. and seven genera), Betulaceae (6 spp. and three genera), Moraceae (7 spp. and two genera), Sapindaceae (5 spp. four genera), Fabaceae (6 spp. and four genera), Fagaceae (4 spp. and one genera), Ulmaceae (4 spp. and three genera), Euphorbiaceae (4 sp. and three genera), Combretaceae (4 spp. and two genera) and so on.

The most used genera for fuelwood consumption were *Ficus* and *Prunus* with five species each followed by *Quercus* with four spp., *Viburnum*, *Berberis, Cotoneaster* and *Symplocos* with three species each, *Persea*, *Carpinus*, *Betula*, *Alnus*, *Terminalia*, *Anogeissus, Rhododendron*, *Acacia*, *Morus*, *Toona*, *Albizia*, *Fraxinus*, *Pyrus*, *Acer* and *Ulmus* with two species each. Among the Gymnosperms, Pinaceae was the only family that was used as fuelwood. It was represented by six species belonging to 4 genera. Two species, each of *Abies* and *Pinus*, and one each of *Cedrus, Rhus,* and *Picea* were used as fuelwood. Bhatt and Sachan (2004) studied the Over-all Rank Sum Index (ORSI) for some of the species mentioned in the above list that was based on production, characteristics, and availability of the fuelwood in WH. In that study, as per ORSI, dominant firewood species recorded were *Quercus oblongata* (0.038), *Q. semecarpifolia* (0.037), *Shorea robusta* (0.037), *Q. glauca* (0.036), *Aesculus indica* (0.036) and *Toona ciliata* (0.036).

The most preferred fuelwood species used in WH based on the citations in the scientific literature, was found to be *Q. leucotrichophora*, which was cited in eight studies. It was followed by *Pinus roxburghii, Q. floribunda,* and *Rhododendron arboreum,* which were cited in seven studies. Other preferred species were *Alnus nepalensis, Juglans regia, Lyonia ovalifolia, Pyrus pashia,* and *Q. semecarpifolia,* which were reported in six studies each. *Abies pindrow, Aesculus indica, Celtis australis, Ilex dipyrena* and *Myrica esculenta* were reported in five studies each; *Daphniphyllum himalayense, Mallotus philippensis, Q. glauca,* and *Symplocos paniculata* were reported in four studies each. Overexploitation of these species for fuelwood may pose high pressure on their population.

## Discussion

Sustainable utilization of forest and associated resources is a complex issue that comprehends societal needs, ethical and cultural values and socio-economic status of communities dependent on forests (Chettri and Sharma, 2009). Biomass is the primary source of energy for domestic use in the developing world (Bhatt and Sachan, 2004). Fuelwood use is prevalent in rural regions of the developing world, particularly in places where these fuels are available locally (Fitzgerald *et al.,* 1990). Fuelwood is used by the communities for various purposes mainly for firewood, house construction, resulting in over-utilization and increase the rate of deforestation. In India, 49% of households use firewood as the primary fuel for cooking (Bhattacharya, 2015). Richard (2003) estimated that 11.28 million people are involved in fuelwood collection in India. In a World Energy Outlook Report 2006, International Energy Agency (IEA, 2006) pointed out that Indian households prefer to use wood stoves for baking traditional bread. Unsustainable firewood harvesting has significantly contributed to a loss of biodiversity and erosion due to loss of forest cover. Also, in hilly areas, houses are locally constructed in such a way that they do not allow any ventilation that leads to millions of deaths of people in India. Several factors, such as household size, education, lifestyle, ethnicity, geographic location, climatic condition, subsidies, energy supply factors, affordability, availability, and accessibility, determine the fuel choices in WH villages. Many people in WH use fuelwood even when they can afford to use other alternative sources of energy. The average fuelwood consumption in WH in the present study was found to be 3.15 kg/capita/day, which is higher than earlier reported values for other parts of Asia viz., 1.9–2.2 kg/capita/day for Southern India (Hedge, 1984), 1.7–2.5 kg/capita/day for South and South-East Asian countries (Donovan, 1981), 1.23 kg/capita/day for Himalayan range of Nepal (Mahat *et al.,* 1987) and 2.19–3.76 kg/capita/day for Himalayan range of Pakistan (Shaheen *et al.,* 2011).

Many studies found that there is a strong positive correlation between income and the amount of final energy used (Elias *et al.,* 2005; Fitzgerald *et al.,* 1990). In India, under Ujjwala yojana 715 District of India are covered, and 5,89,92,722 connections of LPG are released (PMUY, 2019). Government schemes like Ujjwala Yojna reduce the physical burden of people associated with carrying wood and widening their employment opportunities. A large number of middle–income families in the region own LPG connection, but traditional Chulha (wood stoves) using fuelwood is still popular for cooking purposes. Also, due to the inaccessible areas in WH, distribution systems have prevented many families from switching to modern fuels. The review of the literature revealed that only a few studies had been conducted on fuelwood consumption patterns in WH and most of which are restricted to small areas. It was observed that different methodologies were used in various studies to ascertain the per capita fuelwood consumption pattern. There is a need for documentation of different aspects of fuelwood consumption patterns in the entire WH region so that the possible regulations could be framed. The information obtained from the present study on fuelwood consumption patterns at WH could form the basis for designing/ implementing appropriate technologies and management policies for the sustainable utilization of the forest resources in the WH region.

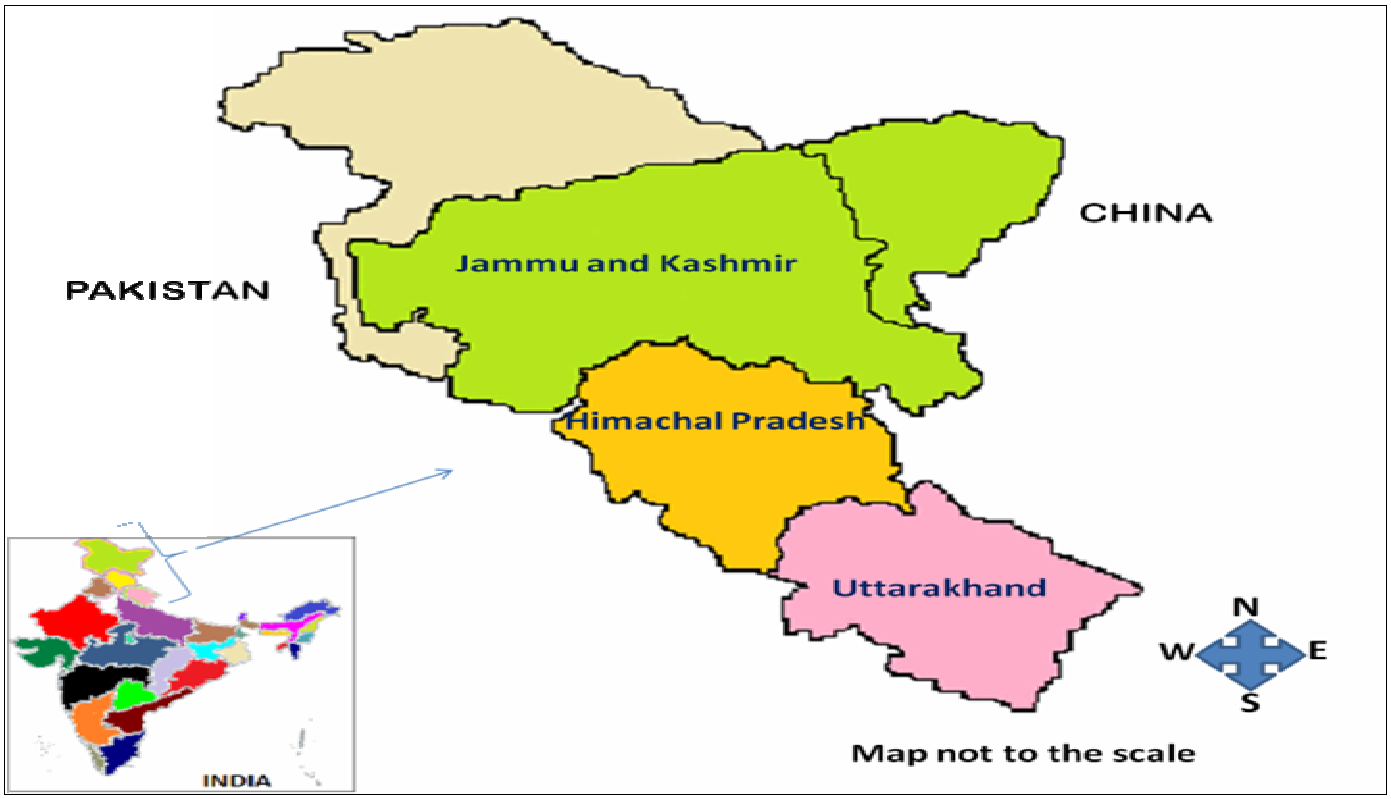


**Fig. 1**: Map of the study area.

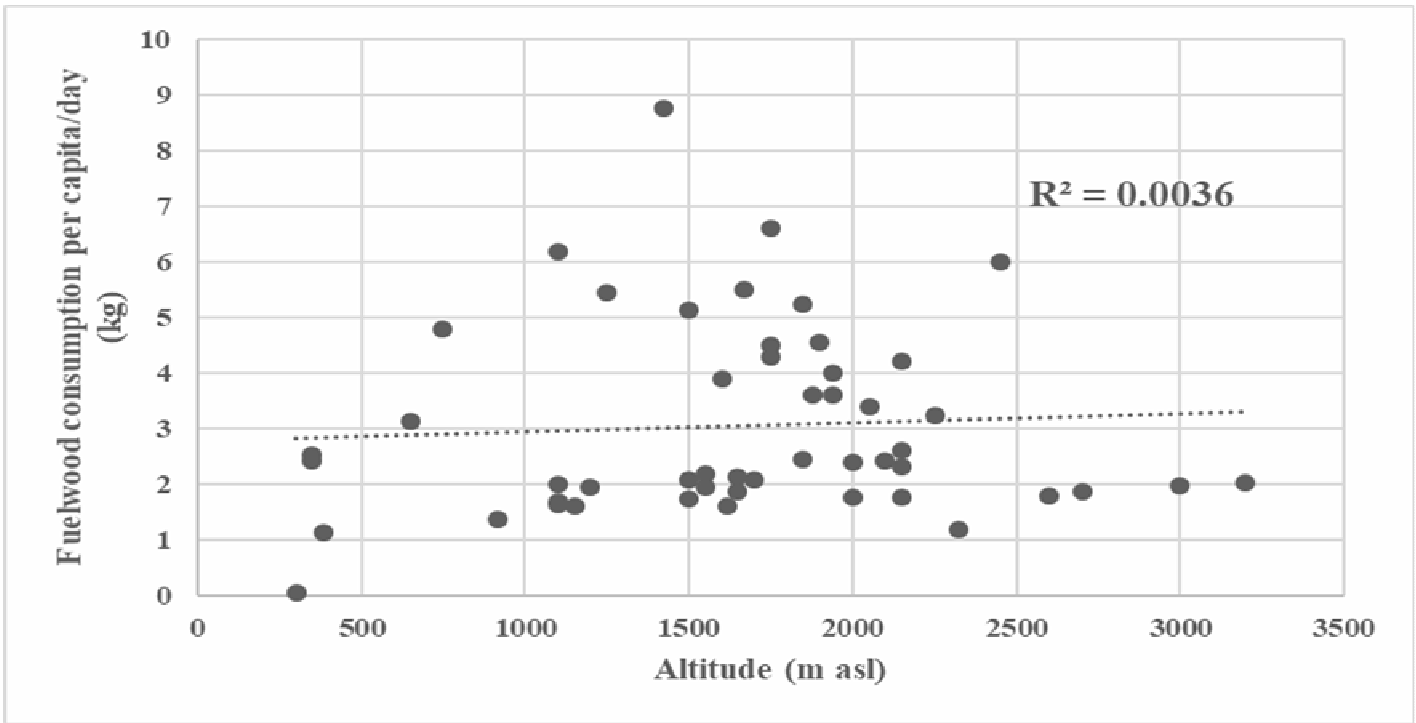


**Fig. 2**: Relationship between altitude and per capita per day fuelwood consumption.

**Table 1**: Comparative geographical, environmental, and forest cover details of the states and union territories of India covering Western Himalaya (Source: FSI 2017).

| | UT of Jammu & Kashmir (J&K) + UT of Ladakh | Himachal Pradesh (HP) | Uttarakhand (UK) |
|---|---|---|---|
| Total geographical area ($km^2$) | 2,22,236 | 55,673 | 53,483 |
| Latitude (N) | 32°17' to 37°05' | 30° 23' to 33° 13' | 28° 43' to 31° 27' |
| Longitude (E) | 72°31' to 80°20' | 75° 43' to 79° 40' | 77° 34' to 81° 02' |
| Altitudinal range (m asl) | 300 to > 4000 | 1500 to > 3000 | 300 to > 4000 |
| Mean temperature | Subzero to 40°C | Subzero to 35°C | Subzero to 43°C |
| Average annual rainfall (mm) | 600–800 | 1800 | 1550 |
| Total population in million (Census of India 2011) | 12.54 | 6.86 | 10.09 |
| Total forest & tree cover ($km^2$) | 31,056 | 15,922 | 25,062 |
| Forest & tree cover as % of the state's total geographical area | 13.97 | 28.60 | 46.86 |
| Forest & tree cover as % of India's total forest & tree cover | 3.87 | 1.99 | 3.12 |
| Per capita forest & tree cover (ha) | 0.25 | 0.23 | 0.25 |
| Carbon stock in forest (million ton) | 275,926 | 175,782 | 284,664 |

**Table 2**: Fuelwood consumption pattern along an altitudinal gradient in villages of Western Himalayan India.

| S. No. | Villages | District | State /UT | Altitude (m asl) | Per household fuel wood consumption (kg/day) (Avg. family size) * | Fuel wood consumption per capita/day (kg) | Fuel wood consumption per capita / year (kg) | Sources |
|---|---|---|---|---|---|---|---|---|
| 1 | Chak Chua | Jammu | J&K | 300 | 0.28 (5.60) | 0.05 | 18.25 | Akhter and Malviya (2014) |
| 2 | Gandikhata | Haridwar | UK | 300–1000 | 25.86 (8.26) | 3.13 | 1142 | Sharma *et al.* (2012) |
| 3 | Ganga Bhogpur | Pauri | UK | 300–400 | 13.30 (5.93) | 2.52 | 919.80 | Kumar and Sharma (2009) |
| 4 | Kunow | Pauri | UK | 300–400 | 12.80 (4.90) | 2.42 | 883.30 | Kumar and Sharma (2009) |
| 5 | Samba | Samba | J&K | 384 | 5.69 (5.00) | 1.13 | 412.45 | Tahir *et al.* (2014) |
| 6 | Takoligad Watershed | Tehri | UK | 500–1000 | 23.90 (5.00) | 4.78 | 1744.70 | Dhanai *et al.* (2015) |
| 7 | Patharkot | Almora | UK | 550–2301 | 52.53 (6.00) | 8.75 | 3193.75 | Singh and Sundriyal (2009) |
| 8 | Bhainswara | Pauri | UK | 900–1300 | 9.01 (4.75) | 1.70 | 620.50 | Kumar and Sharma (2009) |
| 9 | Ghargoan | Tehri | UK | 900–1300 | 8.63 (4.05) | 1.63 | 594.95 | Kumar and Sharma (2009) |
| 10 | Giri Catchment | Shimla | HP | 900–1300 | 22.70 (6.80) | 6.18 | 2255.70 | Singh *et al.* (2017) |
| 11 | Dandesar | Rajouri | J&K | 915 | 5.00 (3.60) | 1.38 | 503.70 | Kumar *et al.* (2015) |
| 12 | Takoligad Watershed | Tehri | UK | 1000–1500 | 27.34 (5.00) | 5.46 | 1992.90 | Dhanai *et al.* (2015) |
| 13 | Barmadi | Chamoli | UK | 1100 | 9.00 (4.50) | 2.00 | 730 | Malik *et al.* (2014) |
| 14 | Lamgondi | Rudraprayag | UK | 1150 | 7.94 (4.94) | 1.61 | 587.65 | Malik *et al.* (2014) |
| 15 | Pathali | Rudraprayag | UK | 1200 | 9.95 (5.13) | 1.94 | 708.10 | Malik *et al.* (2014) |
| 16 | Giri Catchment | Sirmour | HP | 1301–1700 | 25.65 (6.80) | 5.13 | 1872.45 | Singh *et al.* (2017) |
| 17 | Bhanigram | Tehri | UK | 1500 | 11.51 (6.62) | 1.74 | 635.10 | Sharma *et al.* (2009a) |
| 18 | Mandal | Chamoli | UK | 1500 | 11.60 (5.60) | 2.07 | 755.55 | Sharma *et al.* (2009b) |
| 19 | Takoligad Watershed | Tehri | UK | 1500–2000 | 33.33 (5.00) | 6.60 | 2409 | Dhanai *et al.* (2015) |
| 20 | Siroli, Mandal, Khalla, Koteshwar, Bandwara, Bairangana | Chamoli, Garwhal, Rudrapryag | UK | 1500–2200 | 21.00 (4.00) | 5.25 | 1916.25 | Singh *et al.* (2010) |
| 21 | Karokhi | Tehri | UK | 1550 | 11.68 (5.96) | 1.96 | 715.40 | Sharma *et al.* (2009a) |
| 22 | Khalla | Chamoli | UK | 1550 | 13.10 (5.80) | 2.20 | 803 | Sharma *et al.* (2009b) |
| 23 | Chaundiyar | Uttarkashi | UK | 1600 | 21.00 (5.30) | 3.90 | 1423.50 | Sharma *et al.* (2009b) |
| 24 | Ganderbal | Ganderbal | J&K | 1619 | 8.08 (5.00) | 1.61 | 587.65 | Baba *et al.* (2016) |
| 25 | Pab | Rudraprayag | UK | 1650 | 11.25 (6.02) | 1.87 | 682.55 | Sharma *et al.* (2009a) |
| 26 | Rail | Rudraprayag | UK | 1650 | 10.48 (4.90) | 2.14 | 781.10 | Malik *et al.* (2014) |
| 27 | Ganderbal | Ganderbal | J&K | 1650–3000 | 7.08 (6.18) | 1.18 | 430.70 | Islam *et al.* (2018) |
| 28 | ShahdarahSharief | Rajouri | J&K | 1668 | 27.50 (5.00) | 5.50 | 2007.50 | Qureshi *et al.* (2015) |
| 29 | Dhar Gaon | Chamoli | UK | 1700 | 8.96 (4.33) | 2.07 | 755.55 | Malik *et al.* (2014) |
| 30 | Giri Catchment | Solan | HP | 1700–2100 | 30.92 (6.80) | 4.55 | 1660.75 | Singh *et al.* (2017) |
| 31 | Saura, Saari, Saalu, Syaba | Uttarkashi | UK | 1700–2300 | 14.65 (6.00) | 2.40 | 876 | Awasthi *et al.* (2003) |
| 32 | Jenti, Dudhatoli | Pauri | UK | 1750 | 30.60 (6.80) | 4.50 | 1642.50 | Sharma *et al.* (2011) |
| 33 | Dikhol | Uttarkashi | UK | 1750 | 24.60 (5.60) | 4.30 | 1569.50 | Sharma *et al.* (2009b) |
| 34 | Jamu | Rudraprayag | UK | 1850 | 14.26 (5.80) | 2.46 | 897.90 | Malik *et al.* (2014) |
| 35 | Farkande, Dudhatoli | Chamoli | UK | 1880 | 29.90 (8.20) | 3.60 | 1314 | Sharma *et al.* (2011) |
| 36 | Dhaulana | Almora | UK | 1900–2400 | 12.29 (5.92) | 2.32 | 846.80 | Kumar and Sharma, (2009) |
| 37 | Chunnikhal | Tehri | UK | 1900–2400 | 9.38 (5.20) | 1.77 | 646.05 | Kumar and Sharma, (2009) |
| 38 | Parwadi, Dudhatoli | Chamoli | UK | 1940 | 29.70 (8.30) | 3.60 | 1314 | Sharma *et al.* (2011) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 39 | Toliyo, Dudhatoli | Pauri | UK | 1940 | 28.10 (7.00) | 4.00 | 1460 | Sharma *et al.* (2011) |
| 40 | Chunnikhal | Rudraprayag | UK | 2000 | 9.25 (5.20) | 1.78 | 649.70 | Sharma *et al.* (2009a) |
| 41 | Banaun, Manali, Dhungri, Nasogi | Kulu | HP | 2000–2100 | 17.08 (5.00) | 3.41 | 1244.65 | Rana *et al.* (2012) |
| 42 | Dhaulana | Rudraprayag | UK | 2100 | 14.38 (5.92) | 2.43 | 886.95 | Sharma *et al.* (2009a) |
| 43 | Daira, Dudhatoli | Pauri | UK | 2150 | 28.20 (10.80) | 2.60 | 949 | Sharma *et al.* (2011) |
| 44 | Sarkot, Dudhatoli | Chamoli | UK | 2150 | 28.50 (6.70) | 4.20 | 1533 | Sharma *et al.* (2011) |
| 45 | Dadon, Nail, Nauli, Kalsir | Almora, Garhwal Chamoli | UK | 2200–2700 | 24.00 (4.00) | 6.00 | 2190 | Singh *et al.* (2010) |
| 46 | Triyuginarayan | Rudraprayag | UK | 2250 | 17.13 (5.29) | 3.24 | 1182.60 | Malik *et al.* (2014) |
| 47 | Kuthar | Lahul Spiti | HP | 2600 | 13.40 (3–10) | 0.91–2.68 | 332.15–978.20 | Rawat *et al.* (2009) |
| 48 | Hinsa | Lahul Spiti | HP | 2700 | 1.00 (3–10) | 0.98–2.74 | 357.70 –1000.10 | Rawat *et al.* (2009) |
| 49 | Jahlma | Lahul Spiti | HP | 3000 | 14.00 (3–10) | 1.02–2.91 | 372.30–1062.15 | Rawat *et al.* (2009) |
| 50 | Khoksar | Lahul Spiti | HP | 3200 | 15.00 (3–10) | 1.06–3.00 | 386.90–1095 | Rawat *et al.* (2009) |

**Table 3:** Plant species used as fuelwood in Western Himalaya, India.

| S.No. | Botanical name | Vernacular name | Family | Source for columns No. 2 to 4 | Calorific value in $KJg^{-1}$ dry weight (Source) |
|---|---|---|---|---|---|
| 1 | *Abies pindrow* (Royle ex D.Don Royle | Raga, Rasal, Rai, Tosh | Pinaceae | Sharma *et al.* (2011, 2009a), Singh *et al.* (2010), Awasthi *et al.* (2003), Rana *et al.* (2012) | 19.17 (Krishna and Ramaswamy 1932) |
| 2 | *Abies spectabilis* (D.Don) Mirb. | Rai | Pinaceae | Singh *et al.* (2010) | n.a. |
| 3 | *Acacia catechu* (L.f) Willd. | Khair | Fabaceae | Kumar and Sharma (2009), Sharma *et al.* (2012) | 21.54 – 21.97 (Krishna and Ramaswamy 1932) |
| 4 | *Acacia modesta* Wall. | Phalai | Fabaceae | Kumar *et al.* (2015) | 20.14 – 21.50 (Krishna and Ramaswamy 1932) |
| 5 | *Acer acuminatum* Wall. ex D.Don | Rath–Kanchula | Sapindaceae | Singh *et al.* (2010) | n.a. |
| 6 | *Acer caesium* Wall. ex Brandis | Mandru, Kanchula | Sapindaceae | Rana *et al.* (2012), Singh *et al.* (2010), Malik *et al.* (2014) | n.a. |
| 7 | *Justicia adhatoda* L. | Brainker | Acanthaceae | Kumar and Sharma (2009) | 17.00 (Singh and Khanduja 1984) |
| 8 | *Aegle marmelos* (L.) Correa | Bel | Rutaceae | Sharma *et al.* (2012), Kumar and Sharma (2009) | 18.83 (Krishna and Ramaswamy 1932) |
| 9 | *Aesculus indica* (Wall. ex Camb. Hook. | Panger Kanor Bankhor | Sapindaceae | Sharma *et al.* (2009b), Malik *et al.* 2014), Awasthi *et al.* (2003), Rana *et al.* (2012), Singh *et al.* (2010) | 18.60 (Jain and Singh 1999) |
| 10 | *Albizia chinensis* (Osbeck) Merr | Seris | Mimosaceae | Malik *et al.* (2014) | 18.49 (Kataki and Konwer 2002) |
| 11 | *Albizia lebbeck* (L.) Benth | Sirsi | Mimosaceae | Sharma *et al.* (2012), Singh *et al.* (2010) | 21.63 (Krishna and Ramaswamy 1932) |
| 12 | *Alnus nepalensis* (D.Don) | Utees, Kolsh | Betulaceae | Sharma *et al.* (2009a, 2009b, 2011), Malik *et al.* (2014), Singh *et al.* (2010), Dhanai *et al.* (2015) | 15.29 (Kataki and Konwer 2002) |
| 13 | *Alnusnitida* (Spach) Endl. | Chaamp | Betulaceae | Rana *et al.* (2012) | n.a. |
| 14 | *Anogeissus acuminata* (Roxb. ex DC.) Wall. ex Guillem. & Perr. | Bankli, Tau | Combretaceae | Sharma *et al.* (2012), Sharma *et al.* (2009a) | 21.00 (Krishna and Ramaswamy 1932) |
| 15 | *Anogeissus pendula* Edgew. | n.a. | Combretaceae | Kumar and Sharma (2009) | 18.30–20.70 (Krishna and Ramaswamy 1932; Jain 1994) |
| 16 | *Bombax ceiba* L. | Sembal | Bombacaceae | Sharma *et al.* (2012) | 20.47 (Krishna and Ramaswamy 1932) |
| 17 | *Bauhinia variegata* L | Quiral | Caesalpiniaceae | Singh *et al.* (2010), Malik *et al.* (2014) | 20.07–20.23 (Krishna and Ramaswamy 1932; Jain 1993) |
| 18 | *Berberis aristata* DC. | Kembal | Berberidaceae | Singh *et al.* (2010) | n.a. |
| 19 | *Berberis asiatica* Roxb. ex DC | Simblu | Berberidaceae | Kumar and Sharma (2009) | n.a. |
| 20 | *Berberis lyceum* Royle | Kashmal | Berberidaceae | Rana *et al.* (2012) | n.a. |
| 21 | *Betula alnoides* Buch.–Ham. ex D.Don | Saud, Sod | Betulaceae | Sharma *et al.* (2009b), Malik *et al.* (2014), Singh *et al.* (2010) | 19.65 (Jain and Singh 1999) |
| 22 | *Betula utilis* D.Don | BojPatar | Betulaceae | Malik *et al.* (2014) | n.a. |
| 23 | *Buxus wallichiana* Baill. | n.a. | Buxaceae | Malik *et al.* (2014) | n.a. |
| 24 | *Caesalpinia decapetala* (Roth) Alston | n.a. | Caesalpiniaceae | Singh *et al.* (2010) | n.a. |
| 25 | *Carissa spinarum* L. | Gharanda | Apocynaceae | Kumar and Sharma (2009), Kumar *et al.* (2015) | 20.66–20.74 (Krishna and Ramaswamy 1932; Kataki and Konwer 2002) |
| 26 | *Carpinus faginea* Lindl. | n.a. | Betulaceae | Singh *et al.* (2010) | n.a. |
| 27 | *Carpinus viminea* Wall. ex Lindl. | Chamkharik | Betulaceae | Sharma *et al.* (2011, 2009b), Singh *et al.* (2010) | 20.51 (Jain 1993) |
| 28 | *Cassia fistula* L. | Karangal | Caesalpiniaceae | Sharma *et al.* (2012) | 21.64 (Krishna and Ramaswamy 1932) |

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|---|---|---|---|---|---|
| 29 | *Cedrus deodara* (Roxb. ex D.Don) G.Don | Devdar, Deodar | Pinaceae | Sharma *et al.* (2011), Awasthi *et al.* (2003), Rana *et al.* (2012) | 23.09 (Krishna and Ramaswamy 1932) |
| 30 | *Celtis australis* L. | Kharik | Ulmaceae | Sharma *et al.* (2009a), Singh *et al.* 2010), Rana *et al.* (2012), Sharma *e al.* (2012), Kumar *et al.* (2015) | 19.86 –21.32 (Krishna and Ramaswamy 1932; Jain 1998) |
| 31 | *Cinnamomum tamala* (Buch.–Ham.) T.Nees & Eberm. | Dal chini | Lauraceae | Malik *et al.* (2014) | n.a. |
| 32 | *Cornus macrophylla* Wall. | Khagsu | Cornaceae | Malik *et al.* (2014), Singh *et al.* (2010) | n.a. |
| 33 | *Cotoneaster acuminatus* Wall. e Lindl. | Cham–ruins | Rosaceae | Singh *et al.* (2010) | n.a. |
| 34 | *Cotoneaster bacillaris* Wall. ex Lindl. | Kiunsh, Rensu | Rosaceae | Kumar and Sharma (2009), Malik *et al.* (2014), Rana *et al.* (2012) | n.a. |
| 35 | *Cotoneaster microphyllus* Wall. ex Lindl. | Bugarchilla | Rosaceae | Singh *et al.* (2010) | n.a. |
| 36 | *Crateva adansonii* DC. | Barni | Capparaceae | Sharma *et al.* (2012) | n.a. |
| 37 | *Dalbergia sissoo* DC | Talli | Fabaceae | Sharma *et al.* (2012, 2009a), Kumar *et al.* (2015) | 20.56 (Krishna and Ramaswamy 1932) |
| 38 | *Daphniphyllum himalayense* (Benth.) Mull. Arg. | Ratnalu | Daphiniphyllaceae | Sharma *et al.* (2011, 2009b), Malik *e al.* (2014), Singh *et al.* (2010) | 18.66 (Jain 1992) |
| 39 | *Debregeasia saeneb* (Forssk.) Hepper & J.R.I.Wood | Sansaruu | Urticaceae | Singh *et al.* (2010) | n.a. |
| 40 | *Desmodium elegans* DC. | Safed kathi | Fabaceae | Rana *et al.* (2012) | n.a. |
| 41 | *Diospyros exsculpta* Buch.–Ham | Temburini | Ebenaceae | Sharma *et al.* (2012) | 21.47 (Krishna and Ramaswamy 1932) |
| 42 | *Dodecadenia grandiflora* Nees | n.a. | Lamiaceae | Singh *et al.* (2010) | n.a. |
| 43 | *Dodonaea viscos*a (L.) Jacq. | Saintha | Sapindaceae | Kumar *et al.* (2015) | 19.27–25.82 (Krishna and Ramaswamy 1932; Singh and Khanduja 1984; Jain 1994) |
| 44 | *Ehretia laevis* Roxb. | Chamror | Ehritiaceae | Sharma *et al.* (2012) | 16.71 (Jain 1992) |
| 45 | *Elsholtzia flava* Benth. | n.a. | Lamiaceae | Singh *et al.* (2010) | n.a. |
| 46 | *Engelhardtia spicata* Lechen ex Blume | Mowa | Juglandaceae | Malik *et al.* (2014) | n.a. |
| 47 | *Eurya acuminata* DC. | n.a. | Pentaphylacaceae | Singh *et al.* (2010) | n.a. |
| 48 | *Ficus auriculate* Lour. | Trimbal | Moraceae | Singh *et al.* (2010) | n.a. |
| 49 | *Ficus neriifolia* Sm. | n.a. | Moraceae | Singh *et al.* (2010) | n.a. |
| 50 | *Ficus racemosa* L. | Rombad | Moraceae | Sharma *et al.* (2012) | n.a. |
| 51 | *Ficus roxburghii* Steud. | Trimbal | Moraceae | Sharma *et al.* (2009a) | n.a. |
| 52 | *Ficus subincisa* Buch.–Ham. ex Sm. | Rumbal | Moraceae | Sharma *et al.* (2009a) | n.a. |
| 53 | *Fraxinus micrantha* Lingelsh | Anhgu | Oleaceae | Singh *et al.* (2010), Sharma *et al.* (2009b), Malik *et al.* (2014) | 21.45 (Jain 1998) |
| 54 | *Fraxinus xanthoxyloides* (G.Don Wall. ex A.DC. | Thelka | Oleaceae | Sharma *et al.* (2009b) | n.a. |
| 55 | *Grewia optiva* J.R. Drumtnond ex Burret | Tamman | Tiliaceae | Sharma *et al.* (2012, 2009a, 2009b) | 19.50 (Jain 1998) |
| 56 | *Haldina cordifolia* (Roxb.) Ridsdale | Haldu | Rubiaceae | Sharma *et al.* (2012) | n.a. |
| 57 | *Holmskioldia sanguinea* Retz. | Khagsoo | Lamiaceae | Dhanai *et al.* (2015) | n.a. |
| 58 | *Holoptelea integrifolia* (Roxb.) Planchon | Kanju | Ulmaceae | Sharma *et al.* (2012), Kumar and Sharma (2009) | 22.03 (Krishna and Ramaswamy 1932) |
| 59 | *Ilex dipyrena* Wall. | Kanel/ Kanarkha | Aquifoliaceae | Sharma *et al.* (2011, 2009b), Malik *e al.* (2014), Singh *et al.* (2010), Awasthi *et al.* (2003) | n.a. |
| 60 | *Indigofera heterantha* Brandis | Sakinjo, Kali kathi | Fabaceae | Dhanai *et al.* (2015), Rana *et al.* (2012) | n.a. |
| 61 | *Juglans regia* L. | Akhroot | Juglandaceae | Singh *et al.* (2010), Sharma *et al.* 2011, 2009b), Awasthi *et al.* (2003) Rana *et al.* (2012), Malik *et al.* (2014 | 22.51 (Jain 1993) |
| 62 | *Lagerstroemia parviflora* Roxb. | Dhauri | Lythraceae | Sharma *et al.* (2012) | 20.47 (Krishna and Ramaswamy 1932) |
| 63 | *Lannea coromandelica* (Houttuyn) Merrill | Kembal | Anacardiaceae | Sharma *et al.* (2012), Kumar and Sharma (2009) | 17.14 (Jain 1992) |
| 64 | *Lantana camara* L. | Ghaneri | Verbenaceae | Kumar and Sharma (2009) | 18.70 (Kataki and Konwer 2002) |
| 65 | *Lindera pulcherrima* (Nees) Hook. f. | n.a. | Lauraceae | Malik *et al.* (2014) | n.a. |
| 66 | *Litsea elongata* (Nees) Hook. f. | Moida | Lauraceae | Singh *et al.* (2010), Malik *et al.* (2014) | 15.90 (Bhatt and Todaria 1992) |
| 67 | *Lyonia ovalifolia* (Wall.) Drude | Anyar, | Ericaceae | Sharma *et al.* (2011, 2009b), Malik *e* | 18.05 (Jain and Singh 1999) |

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|---|---|---|---|---|---|
| | | Aiyangyaar | | *al.* (2014), Singh *et al.* (2010), Awasthi *et al.* (2003), Dhanai *et al.* (2015) | |
| 68 | *Mallotus philippensis* (Lam.) Müll.Arg. | Royenda, Kamila, Ruin | Euphorbiaceae | Malik *et al.* (2014), Sharma *et al.* (2012), Dhanai *et al.* (2015), Kumar and Sharma (2009) | 20.26 (Krishna and Ramaswamy 1932) |
| 69 | *Malus pumila* Mill. | Seb | Rosaceae | Rana *et al.* (2012), | n.a. |
| 70 | *Melia azedarach* L | Daraink | Meliaceae | Kumar *et al.* (2015) | 20.90–21.28 (Krishna and Ramaswamy 1932; Jain and Singh 1999;Kataki and Konwer 2002) |
| 71 | *Morus alba* L. | Toot | Moraceae | Kumar *et al.* (2015) | n.a. |
| 72 | *Morus serrata* Roxb. | Kriun | Moraceae | Rana *et al.* (2012) | 16.80 (Bhatt and Todaria 1992) |
| 73 | *Murraya koenigii* (L.) Sprengel | Karanguli | Rutaceae | Kumar and Sharma (2009) | n.a. |
| 74 | *Myrica esculenta* Buch.–Ham. ex D. Don | Kafal | Myricaceae | Sharma *et al.* (2009a, 2011), Singh *et al.* (2010), Kumar and Sharma (2009), Malik *et al.* (2014) | 18.31 (Jain and Singh 1999) |
| 75 | *Neolitsea pallens* (D.Don) Momiy. & H. Hara | Pinna | Lauraceae | Sharma *et al.* (2011, 2009b), Singh *et al.* (2010) | 15.50 (Bhatt and Todaria 1992) |
| 76 | *Ocotea lancifolia* (Schott) Mez | n.a. | Lauraceae | Singh *et al.* (2010) | n.a. |
| 77 | *Desmodium oojeinense* (Roxb.) H.Ohashi (Synonym. *Ougenia oojeinense* Roxb.) | Sandin | Fabaceae | Malik *et al.* (2014), Sharma *et al.* (2012), Kumar and Sharma (2009) | 16.93 (Jain 1992) |
| 78 | *Machilus duthiei* King | Kaula | Lauraceae | Sharma *et al.* (2011) | 19.64 (Jain 1998) |
| 79 | *Persea odoratissima* (Nees) Kosterm. | n.a. | Lauraceae | Singh *et al.* (2010) | n.a. |
| 80 | *Persea* spp. | Kaul | Lauraceae | Sharma *et al.* (2009b) | 19.64 (Jain 1998) |
| 81 | *Picea smithiana* (Wall.) Boiss | Rai | Pinaceae | Rana *et al.* (2012), Sharma *et al.* (2011), Malik *et al.* (2014) | 20.81 (Krishna and Ramaswamy 1932) |
| 82 | *Pinus roxburghii* Sarg | Chir | Pinaceae | Singh *et al.* (2010), Awasthi *et al.* 2003), Dhanai *et al.* (2015), Malik *et al.* (2014), Sharma *et al.* (2009b, 2011), Kumar *et al.* (2015) | 23.17 (Jain 1992) |
| 83 | *Pinus wallichiana* A.B. Jacks. | Kail | Pinaceae | Rana *et al.* (2012) | n.a. |
| 84 | *Populus ciliata* Wall. ex Royle | Safeeda | Salicaceae | Rana *et al.* (2012) | 20.78 (Jain 1998) |
| 85 | *Prinsepia utilis* Royle. | Bhekhal | Rosaceae | Rana *et al.* (2012) | 21.60 (Jain 1998) |
| 86 | *Prunus armeniaca* L | Shada | Rosaceae | Rana *et al.* (2012) | n.a. |
| 87 | *Prunus avium* (L.) L | Cherry | Rosaceae | Rana *et al.* (2012) | n.a. |
| 88 | *Prunus cerasoides* Buch.–Ham. ex D.Don | Aaru | Rosaceae | Sharma *et al.* (2009a), Singh *et al.* (2010) | 19.34 (Kataki and Konwer 2002) |
| 89 | *Prunus cornuta* (Wall. ex Royle) Steud. | Jammu | Rosaceae | Rana *et al.* (2012) | 22.06 (Jain and Singh 1999) |
| 90 | *Prunus domestica* L. | Palum | Rosaceae | Rana *et al.* (2012) | n.a. |
| 91 | *Pyracantha crenulata* (Roxb. ex D.Don) M.Roem. | Ghingaru | Rosaceae | Sharma *et al.* (2011), Kumar and Sharma (2009) | 22.38 (Jain 1993) |
| 92 | *Pyrus communis* L | Nakh | Rosaceae | Rana *et al.* (2012) | n.a. |
| 93 | *Pyrus pashia* Buch. Ham. ex D. Don | Melu, Kainth Shegal | Rosaceae | Sharma *et al.* (2011, 2009a, 2009b), Malik *et al.* (2014), Singh *et al.* (2010), Rana *et al.* (2012) | 19.50 (Jain and Singh 1999) |
| 94 | *Quercus floribunda* Lindl. ex A.Camus | Moru, Tiloj | Fagaceae | Sharma *et al.* (2009b, 2011), Malik *et al.* (2014), Singh *et al.* (2010), Awasthi *et al.* (2003), Dhanai *et al.* (2015), Rana *et al.* (2012) | 22.92 (Jain 1998) |
| 95 | *Quercus glauca* Thunb. | Haring | Fagaceae | Malik *et al.* (2014), Singh *et al.* (2010), Sharma *et al.* (2011, 2009b) | 23.50 (Krishna and Ramaswamy 1932) |
| 96 | *Quercus oblongata* D.Don (Synonym. *Q. leucotrichophora* A. Camus) | Banj | Fagaceae | Kumar and Sharma (2009), Malik *et al.* (2014), Singh *et al.* (2010), Awasthi *et al.* (2003), Dhanai *et al.* (2015), Sharma *et al.* (2009a, 2009b, 2011) | 24.07 (Jain 1993) |
| 97 | *Quercus semecarpifolia* Sm | Kharsu | Fagaceae | Awasthi *et al.* (2003), Dhanai *et al.* (2015), Sharma *et al.* (2009b, 2011), Malik *et al.* (2014), Singh *et al.* (2010) | 23.82 (Krishna and Ramaswamy 1932) |
| 98 | *Rhamnus triquetra* (Wall.) Brandis | Chaunsha | Rhamnaceae | Rana *et al.* (2012) | 15.80–22.72 (Bhatt and Todaria 1992; Jain and Singh 1999) |
| 99 | *Rhododendron arboreum* Sm | Burans | Ericaceae | Malik *et al.* (2014), Dhanai *et al.* (2015), Sharma *et al.* (2009b, 2011), Kumar and Sharma (2009), Singh *et al.* (2010), Awasthi *et al.* (2003) | 21.54 (Krishna and Ramaswamy 1932) |

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| 100 | *Rhododendron campanulatum* D Don | Maddad | Ericaceae | Singh *et al.* (2010) | n.a. |
| 101 | *Brucea javanica* (L.) Merr. | Titri | Simaroubaceae | Rana *et al.* (2012) | 18.40 (Bhatt and Todaria 1992) |
| 102 | *Rhus parviflora* Roxb. | Tungla | Anacardiaceae | Kumar and Sharma (2009), Dhanai *et al.* (2015) | 17.70 (Kataki and Konwer 2002) |
| 103 | *Robinia pseudoacacia* L. | Kikar | Euphorbiaceae | Rana *et al.* (2012) | n.a. |
| 104 | *Salix daphnoides* Vill. | Willo | Salicaceae | Rana *et al.* (2012) | n.a. |
| 105 | *Schleichera oleosa* (Lour.) Merr | Kumbha | Sapindaceae | Sharma *et al.* (2012) | 20.74 (Krishna and Ramaswamy 1932) |
| 106 | *Shorea robusta* Gaertn | Sal | Dipterocarpaceae | Sharma *et al.* (2012) | 21.35 (Krishna and Ramaswamy 1932) |
| 107 | *Sorbaria tomentosa* (Lindl.) Rehder | Shain | Rosaceae | Rana *et al.* (2012) | n.a. |
| 108 | *Spiraea canescens* D. Don | Chakhu | Rosaceae | Rana *et al.* (2012) | n.a. |
| 109 | *Symplocos chinensis* (Thunb.) Miq | n.a. | Symplocaceae | Singh *et al.* (2010), Awasthi *et al.* (2003), Kumar and Sharma (2009) | n.a. |
| 110 | *Symplocos paniculata* (Thunb.) Miq. | Lodh | Symplocaceae | Sharma *et al.* (2009a, 2011), Singh *et al.* (2010), Rana *et al.* (2012) | 21.16 (Kataki and Konwer 2002) |
| 111 | *Symplocos ramosissima* Wall. ex G. Don | n.a. | Symplocaceae | Malik *et al.* (2014), Singh *et al.* (2010), | 17.90 (Bhatt and Todaria 1992) |
| 112 | *Taxus baccata* L. | Thuner | Taxaceae | Sharma *et al.* (2009b, 2011), Malik *et al.* (2014) | 17.36 (Krishna and Ramaswamy 1932) |
| 113 | *Terminalia alata* Heyne ex Roth | Asin | Combretaceae | Sharma *et al.* (2012) | 21.15 (Krishna and Ramaswamy 1932) |
| 114 | *Terminalia bellirica* (Gaertner) Roxb. | Bahera | Combretaceae | Sharma *et al.* (2012) | 20.83 (Krishna and Ramaswamy 1932) |
| 115 | *Toona ciliata* M. Roemer | Mannu | Meliaceae | Sharma *et al.* (2009a), Dhanai *et al.* (2015) | 19.19–23.00 (Jain 1993; Kataki and Konwer 2002) |
| 116 | *Toona hexandra* (Wallich ex Roxb.) M. Roemer | Tunu | Meliaceae | Sharma *et al.* (2012), Malik *et al.* (2014) | 23.00 (Jain 1993) |
| 117 | *Mallotus repandus* (Willd.) Müll Arg. | Bakhara | Euphorbiaceae | Sharma *et al.* (2012) | n.a. |
| 118 | *Ulmus villosa* Brandis ex Gambl | Chor | Ulmaceae | Rana *et al.* (2012) | n.a. |
| 119 | *Ulmus wallichiana* Planch | Mahun, Emrohi, Chamar | Ulmaceae | Rana *et al.* (2012), Sharma *et al.* (2009b) | n.a. |
| 120 | *Viburnum cotinifolium* D. Don | Talana | Adoxaceae | Rana *et al.* (2012), Singh *et al.* (2010 | 21.22–21.47 (Jain 1998; Kataki and Konwer 2002) |
| 121 | *Viburnum grandiflorum* Wall. ex DC | Veolda, Thakl | Adoxaceae | Singh *et al.* (2010) | n.a. |
| 122 | *Viburnum mullaha* Buch.–Ham. ex D. Don | Maleo, Richhoi | Adoxaceae | Singh *et al.* (2010) | 18.40 (Bhatt and Todaria 1992) |
| 123 | *Woodfordia fruticosa* (L.) Kurz | Daula | Lythraceae | Kumar and Sharma (2009), Singh *et al.* (2010), Dhanai *et al.* (2015) | 18.81 (Jain 1992) |
| 124 | *Ziziphus jujuba* Mill | Baari | Rhamnaceae | Kumar and Sharma (2009) | n.a. |

n,a.= Not available

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