Article

Estimation of fuel wood consumption and its negative impact on surrounding vegetation: A case study of Baffa town, Mansehra, Pakistan

Zulfiqar Khan[1], **Abbas Hussain Shah**[1], **Muhammad Farooq**[1], **Khalid Rasheed Khan**[1], **Manzoor Hussain**[2], **Ghulam Mujtaba Shah**[2], **Azhar Mehmood**[3], **Laiba Zohra**[2], **Inayat Ur Rahman**[1]

[1]Department of Botany, Govt. Post Graduate College, Mansehra-21300, Pakistan

[2]Department of Botany, Hazara University Mansehra-21300, Pakistan

[3]Department of Botany, Govt. Post Graduate College, Mandian Abbottabad, Pakistan

E-mail: abshah2086@gmail.com

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Abstract

Fuel wood has a great socio economic value in rural areas of Pakistan. In present research project fuel wood consumption in Baffa town of western Himalayan region was estimated by market survey and its effects on the surrounding vegetation were studied by field survey. In market survey 18 sales points of the study area were targeted. Market based data was collected from the sales point account record. As price, quantity and type of fuel wood were entered carefully in account registers by sales persons. More data was obtained by questionnaires regarding utility of fuel wood as domestic or commercial and trends for last three year, preference of fuel wood type and increase or decrease of a particular type of fuel wood species. Fire wood species commercially exploited were observed in their natural habitats and relevant ethnobotanical information was gathered from locals as well. During survey, 18 different sale points were investigated and 22 fuel wood species were recorded. Maximum fuel wood species were noted in Baffa Doraha sale point. University road 3 sale points show maximum quantity (30000 Munds) of fuel wood sold annually. According to this survey *Acacia modesta* was the most preferred plant species for fuel wood secondly *Morus nigra* and third was *Olea ferruginea*. The use of *Brossonetia* species has decreased for the last three years while the use of several other plant species increased like *Populus ciliata, Melia azadarch* and *Morus nigra*. The most preferred fire plant species (*Acacia modesta*) was found disappearing alarmingly in the natural habitat. Extraction of fuel wood species impacts the surrounding vegetation of the study area negatively and altering the vegetation structure adversely.

Keywords biodiversity; sales point; fuel wood; Baffa; Mansehra.

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1 Introduction

Wood is one of the oldest source of energy and the commonest service material known to man and has been used for over 0.5 million years (Sharpe, 1976). People harvest fuel wood by cutting shrubs, by lopping branches off mature trees, or by felling whole trees. In many rural areas, local people prefer fuel wood from shrub species that will regenerate after coppicing (Gonzalez, 2001). Wood in rough form obtained from the trunk and branches of trees to be used for fuel purposes such as cooking, heating and power generation (Pandey, 2000). Fuel wood gathered from forested areas is the most important source of domestic energy for the developing world (Heltberg et al., 2000). The FAO study provided estimates for 1980 that, in aggregate, some 2000 million people dependent on fuel wood (FAO, 1981; De Montalembert and Clement, 1983). Fuel wood and charcoal provide 40% of energy used in Africa and 10% of energy used in Latin America (WEC, 2001), and 80% of the wood used in tropical regions goes to fuel wood and charcoal (Roda, 2002). Demand for fuelwood is increasing many folds (FAO, 2011). In the area under investigation huge quantity of fire wood is consumed domestically and commercially. Sales point of fuel wood play a significant role in economy of the region. The fire wood is extracted from the surrounding forests and thus affecting the vegetation adversely. The main objective of the investigation is to quantify the fuel wood consumption at one hand and study its adverse effects on the surrounding vegetation on the other hand.

2 Study Area and Methodology

2.1 Study site

The study area Baffa town of Pakhal valley is situated in district Mansehra, Khyber Pakhtunkhwa, Pakistan. It is located 21 km north of Mansehra city on the Karakoram Highway silk route to China. Its location can be found between 34^{o}28'0 N and 73^{o}16'60 E at an altitude of 1019 meters (Naheed et al., 2013). The Pakhal valley is the largest and the last plain area of Pakistan towards China. Deosai National park is located at the junction of Pakistan-China Himalayan frontier. The study area is also one of important towns situated in the vicinity of great China–Pakistan Economic Corridor (CPEC) project. The rainfall in baffa is considerable with precipitation even during the dry months. The average rain fall is 1494mm; lowest precipitation is 34mm during the month of November. In Baffa average annual temperature is 19.3˚C whereas 28.9˚C in June which is the hottest month of the year and 8.5˚C in January being the coldest month. (Climate–Data.ORG). The Baffa has extremely fertile land, well established irrigation system and the hills covered with rich flora mostly of Pinus species (Survey of Pakistan, 2006). Seventy percent of the people are involved in agricultural activities. Main agricultural yields include vegetables, wheat, maize, rice, sugarcane and tobacco (Rashid and Arshad, 2002).

2.2 Data collection

Market survey was carried out to investigate the fuel wood cultural and economic importance at several sale points during 2016. Several sale points were targeted to collect information regarding diversity of fuel wood species, preference and prices. The data for fuel wood was recorded by its local name. Different types of equipments were used for collection of data like field notebook, pencil, digital camera and GPS (Global positioning system). In each sale point, the data/information recorded on different parameters like quantity sold per year in each sale points, number of species available in all sale points, rate or cost of each species in every sale points, preference order of each species in all sale points, use of plant species either domestically or commercially and trends for last three year. Data regarding the use of fuel wood species was noted on the basis of their domestic and commercial use. Demand of each fuel wood species in sale points was evaluated for the last three years.

Market survey was conducted to evaluate the economic, commercial and domestic rates/importance and value of different fuel wood species at various sale points. A questionnaire was devised and used for data collection during interviews. The interview was conducted at different sale points. Questionnaire was used and filled with information gathered from informants i.e. owner of the sale points. The questionnaire sought the name of the plant preferred, price and quantity utilized. Data from accounts registers of sales points was also obtained with the permission of owners. The methodology was adopted first time and authenticated data was gathered owing to the fact that sales men entered type of wood , quantity and price accurately. This source of data is very useful in estimation of fuel wood consumption in the town,

The data regarding adverse effects of fuel wood consumption on surrounding vegetation was obtained by field visits. In field surveys occurrence, regeneration potential and threatening factors of fire wood species were recorded. Information was also collected from the locals through questionnaires. Both market based and field visit data was entered in Microsoft Excel sheet (MS-Excel 2010) for analysis.

3 Results

The data obtained from 18 different sale points and field visits was processed and analyzed. The following results were obtained

3.1 Quantity sold per year at each sale point

In each sale point the quantity of fuel wood species sold per year is different. Uni road 3 sales points show maximum quantity (30000 Mund) of fuel wood sold annually followed by sale point Baffa Doraha 3 (25000 Mund). Sale point Baffa doraha 5 and Uni road 4 show similar quantities of 20000 Mun sold per year while in 8 sale points quantity of fuel wood sold per year ranges from 2000 to 5000 Mund (Fig. 1).

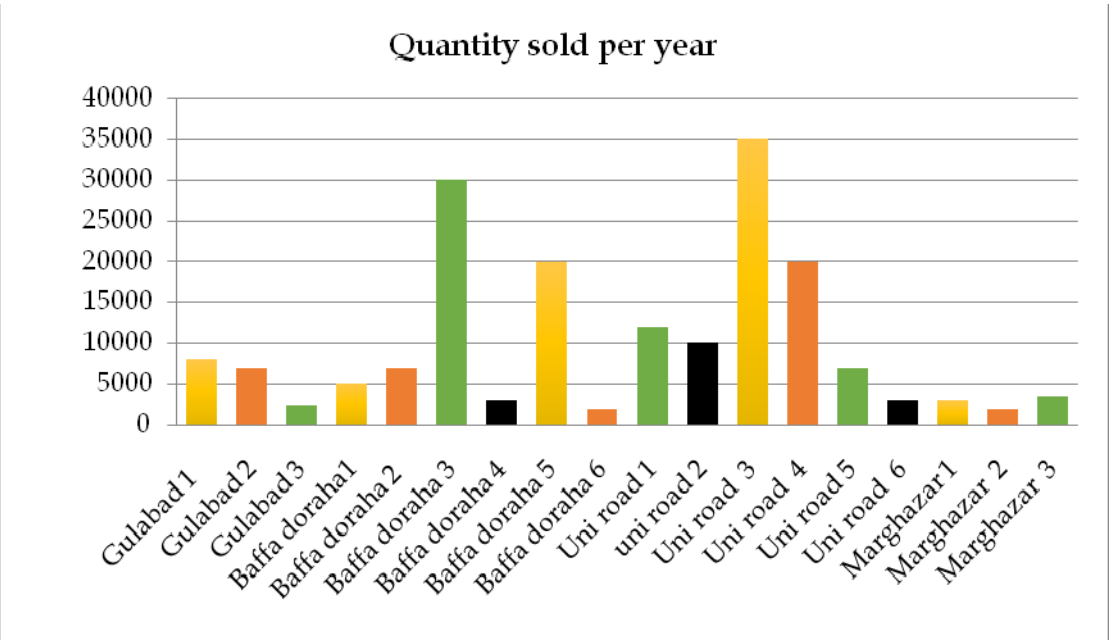

Fig. 1 Quantity of fuel sold per year at each sale point.

3.2 Number of species

In all sale points, 22 different plant species were sold as fuel wood and utilized in Baffa town and adjacent places. Some species were sold in all sale points and some were recorded in several sale points while not found in other sales points. The plant species present in all sale points have high fuel value or importance. Number of fuel wood species present in Baffa Doraha 2 is maximum (17) then other sale points and followed by the sale point Uni road1 having 10 plant species. The sale point Gulabad1, Gulabad5 and Uni road 4 have same number of plant species i.e., 9. Similar numbers of fuel wood species were also found in Gulabad 2 and Uni road 2 and 3 which is 8. Other 11 sale points contain species less than 8 like sale points Gulabad3, Uni road 6 and sale point Marghazar 2 and 3 contain 5 plant species followed by Baffa Doraha1, Baffa doraha 4 and uni road 5 contain 4 plant species each. Marghazar1 sale point has 3 plant species followed by Gulabad 3 sale point which has only two fuel wood species (Table 1).

Table 1 Presence (+) and absence (-) of fuel wood species at different sales points (GB1 to MG3).

Name of species	GB1	GB2	GB 3	BD1	BD 2	BD 3	BD 4	BD 5	BD6	UR 1	UR 2	UR 3	UR 4	UR 5	UR 6	MG 1	MG 2	MG 3
Acacia modesta Wall.	+	+	-	+	+	-	-	+	-	+	+	+	+	-	+	+	-	+
Morus spp L.	+	+	+	+	+	+	-	+	-	+	-	-	+	+	+	+	-	-
Melia azedarach L.	-	-	+	-	+	+	-	+	+	+	+	+	-	-	-	-	+	+
Eucalyptus citrodora	+	+	-	+	+	+	+	+	-	-	-	+	+	-	-	-	-	+
Pinus roxburghii Sarg.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Olea ferruginea Royle	+	-	-	-	+	-	-	-	-	+	+	+	+	-	+	-	-	+
Robinia pseudo-acacia L.	-	-	-	-	+	-	-	-	+	+	-	-	+	-	+	+	+	-
Ficus palmata Forssk.	-	-	-	-	+	+	-	-	-	+	-	+	-	-	-	-	-	-
Alienthus alticema	+	+	-	-	+	-	+	+	+	+	+	+	+	+	+	-	+	-
Dodonaea viscosa (L.) Jacq.	+	+	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-
Prunus domestica L.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus alba	+	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-	+	-
Alnus nitida	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-
salix acmophylla	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Pistacia integerrima	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-
Celtis australis	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-
ficus banglinces	-	-	-	-	+	-	-	-	-	-	-	-		-	-	-	-	-
Quercus incana	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Glochidion veltuinum	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Broussonetia papyrifera	-	+	-	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+
Ziziphus jubjuba	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-
Dalbergii sisso	-	-	-	+	+	-	-	+	-	+	+	-	-	-	-	-	-	-

3.3 Habit of fuel wood species

In study area the reported plant species used as fuel wood were mostly trees and few shrubs. Out of 22 total plants species 20 were found trees and only 2 were shrubs.

3.4 Order of preference

The fuel wood species present in different sale points vary from one sale point to other. According to survey *Acacia modesta Wall.* was the most preferred plant species for fuel and secondly *Euclyptus citrodora* and the third most preferred plant species was *Alienthus alticema.* On the basis of second preference according to the survey, *Melia azedarch* was the most preferred plant species for fuel and secondly *Alienthus elticema* and the third most prefered plant species was recorded *Morus* species. On third order preference according to survey *Morus sp.* are the most preferred fuel wood species and secondly *Acacia modesta Wall.* and the third most prefered plant species was found *Olea ferruginea* (Fig. 2).

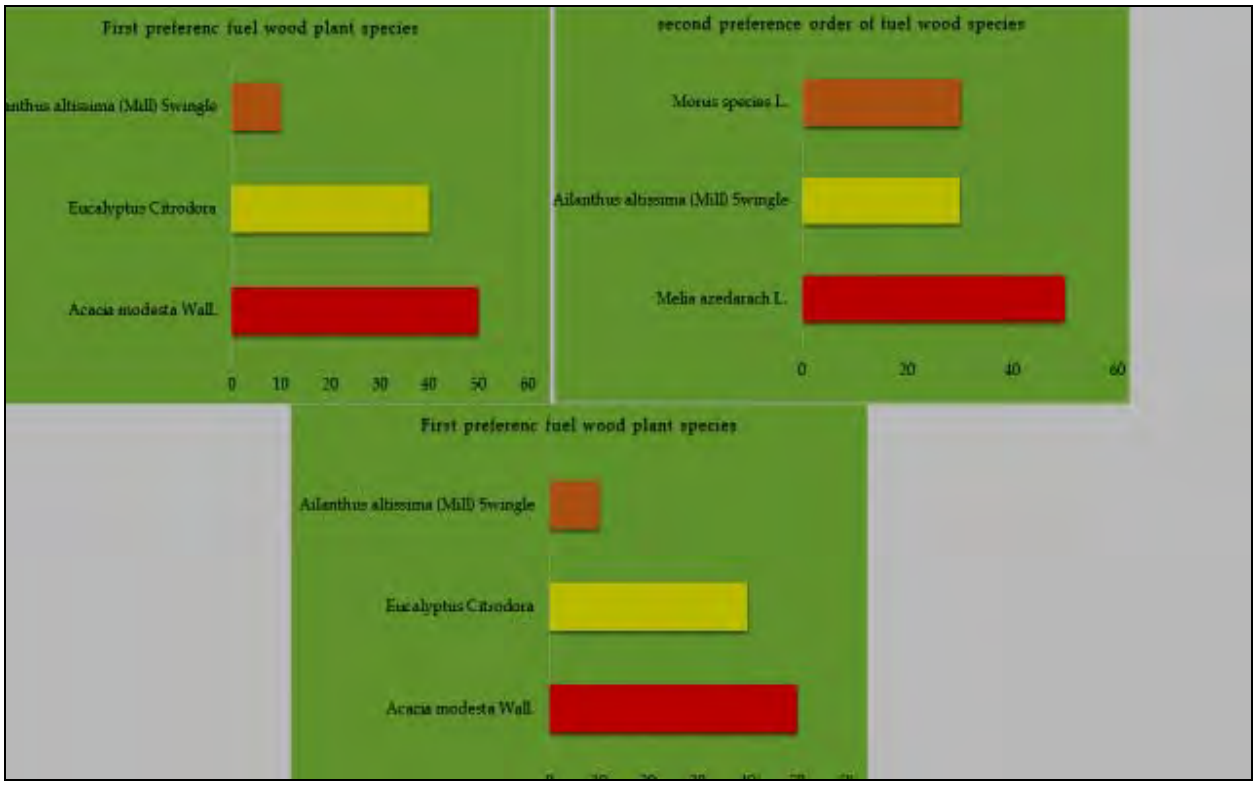

Fig. 2 Order of preference in accordance with fuel value.

3.5 Trends for the last three years

During the collection of information for fuel wood from targeted sale points, different plant species showing decreasing trends and some plant species depicting increasing trends in term of fuel for the last three years. *Brossonentia* species consumption decreases for the last three years and several other species utilization increases in context of fuel wood consumption like *Acacia modesta, Poppulos alba, Melia azadarch* and *Morus species.* During investigation of one or two sale points owners or informants, it was found that *Ficus bengalensis* consumption also decreases (Fig. 3).

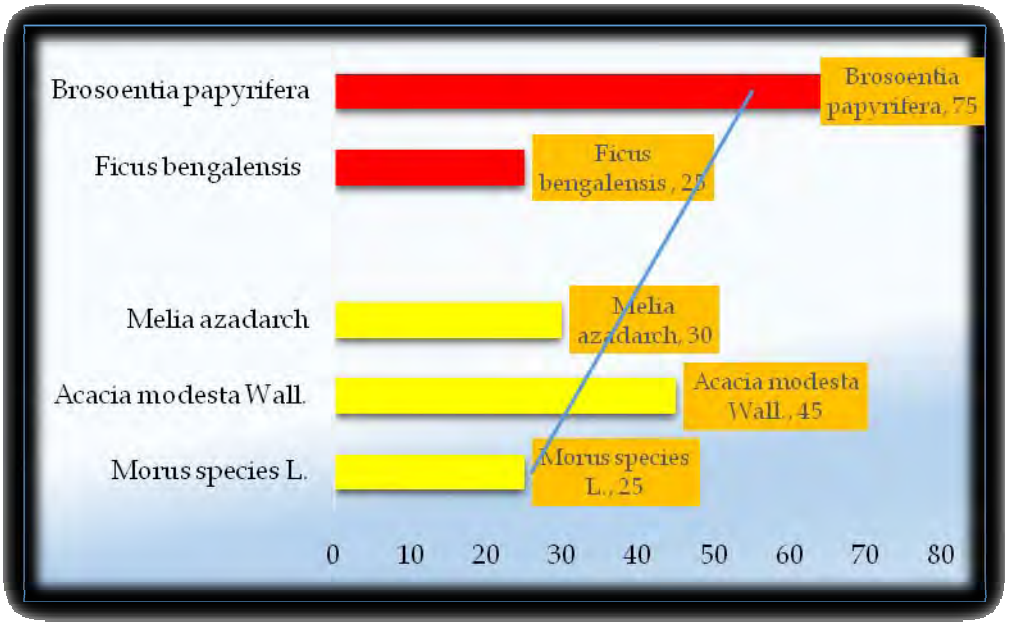

Fig. 3 Trends for the last three years of fuel wood species (Red Color indicates''Decrease'' and Yellow ''Increase '').

3.6 Conservation status

A preliminary conservation status of fire wood species was assessed on the basis of field visits, information from the locals, increasing and decreasing trends for the last three years at sales point. Assessment of conservation by local wisdom is a popular technique and contributes a lot in assessing conservation (Shah et al., 2019). Three species were found critically endangered, 8 species endangered, 3 vulnerable, 1 rare and 7 common that is secure (Fig. 4).

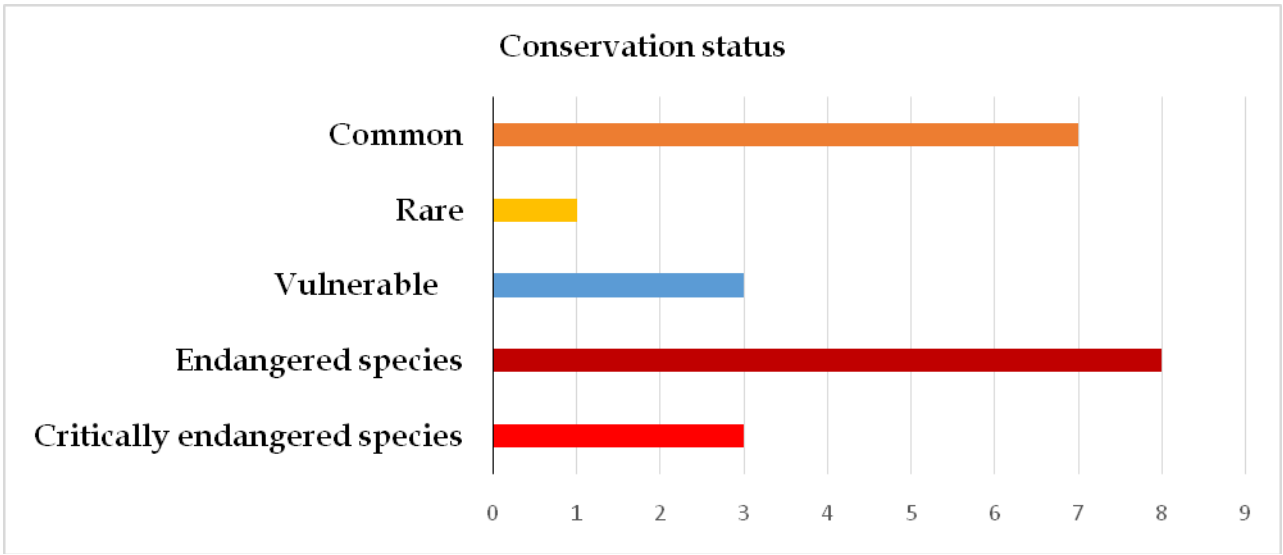

Fig. 4 Conservation status of reported fuel wood species.

The primary data was cross checked by literature review in order to validate the above mentioned results (Table 2).

Table 2 Conservation of fuel wood species on the basis of literature review.

S.No	Specie Name	Local name	Family	Conservation Status
1	*Acacia modesta Wall.*	Palosa	Papalionaceae	Rare[1], Infrequent[5]
2	*Morus spp L.*	Toot	Moreaceae	Endangered[1], Rare[5]
3	*Melia azedarach L.*	Bekanrha/Darak	Meliaceae	Vulnerable[1], Rare[5]
4	*Eucalyptus citrodora*	Gond	Myrtaceae	Common
5	*Pinus roxburghii Sarg.*	Chear	Pinaceae	Endangered[2], Rare[4]
6	*Olea ferruginea Royle*	Kau	Oleaceae	Endangered[2], Rare[5]
7	*Robinia pseudo-acacia L.*	Kikar	Papilionaceae	Endangered[2]
8	*Ficus palmata Forssk.*	Phag	Moraceae	Common
9	*Alienthus alticema*	Darava	Simarubaceae	Vulnerable[2]
10	*Dodonaea viscosa (L.) Jacq.*	Bansatra	Acanthaceae	Endangered[1]
11	*Prunus domestica L.*	Khobni	Roseaceae	Common
12	*Populus alba*	Shafada	Salicaceae	Critically Endangered[3,6]
13	*Alnus nitida*	Shrole	Betulaceae	Endangered[2]
14	*salix acmophylla*	Bainsa	Salicaceae	Common
15	*Pistacia integerrima*	Kankra	Anacardiaceae	Critically Endangered[3,6], Vulnerable[4]
16	*Celtis australis*	Batkar	Ulmaceae	Endangered[2]
17	*ficus banglinces*	Boar	Moraceae	Common
18	*Quercus incana*	Reen	Fagaceae	Endangered[2,4]
19	*Glochidion veltuinum*	Kambeela	Euphorbiaceae	Critically Endangered[6]
20	*Broussonetia papyrifera*	Lavane toot	Moraceae	Common
21	*Ziziphus jubjuba*	Ber	Rhamnaceae	Common
22	*Dalbergii sisso*	Tahli	Papilionaceae	Vulnerable[1], Rare[5]

1: Khan and Hussain, 2013, 2: Shah and Hussain, 2012, 3: Haq, 2012, 4: Jan et al., 2014, 5: Khan et al., 2011, 6: Haq, 2011

4 Discussion

Human life mostly depends on the plants for their daily life uses. Plants provide a number of services in the form of shelter, food, medicine and source of energy. Wood is cheaper and environment friendly and renewable source of energy as compare to fossil fuel. In Pakistan most industrial fuel wood is exploited by the tobacco industry for curing leaves and brick industry to supplement its use of coal (Shahid, 2000). The study area is the centre of fuel wood trade. Tobacco curing is done in Baffa that needs huge quantity of fire wood. Besides fuel wood is also utilized enormously for cooking and heating purposes especially in severe winter. For the estimation of fuel wood consumption in the study area eighteen sale points were selected from which 22 fire plants species belonging to 16 families were recorded. As there is no alternate source of fuel so people mostly utilized or consumed the reported plants species. The unwise and unsustainable use of fire wood

species disturbs the natural flora. The over exploitation of a particular species may be due to quality, price and availability.

Different types of fire wood species were preferred for fuel purposes in Baffa town like *Acacia modesta , Olea ferruginea, Melia azedarach, Dalbergii sisso and Quercus incana* because of their high fuel value. These fuel wood species have high value of heat and their burnt remains provide heat for longer time as compared to other fuel wood species like *Celtis australis, Broussonetia papyrifera* and *Populus ciliata.* The principal criterion employed by Hussain et al. (2017) to determine fuel wood preferred species was that species possessed good fuel characteristics such as high calorific value, produces less smoke and also had enough wood hardness.

4.1 Pressure on the adjacent forests

According to Chettri et al. (2007), firewood extraction from the forests has a definite impact on tree structure, regeneration and woody biomass productivity. In Baffa town, wood sale points are supplied with extensively fire wood from adjacent forests. This overexploitation of fuel wood species disrupts the ecosystem. As there is no alternative fuel source and people mainly dependent on the fuel wood that causes pressure on the forest due to unsustainable use of fire wood species. The local community utilized and consumed the fuel wood species which is brought by the local transportation i.e., Jeeps, mules and donkeys. The distribution of forest resources for traditional use as fuelwood is increasingly affecting biodiversity and decreasing forest cover (Maes and Verbist, 2012). Thus, there is a dire need for an enhanced understanding of the wise use of the resource to enable conservation strategies to be better adapted at local level (Abbot and Mace, 1999).

4.2 Preference of tree wood

The study area is gifted with trees species like *Acaccia modesta Morus sp., Melia azadarache* and *Euclyptus citrodora.* Tree wood is found excessively at the sales centers. In Baffa, the tree fuel wood was preferred over shrubby plants due to higher heat contents. As fuel wood is also utilized in tobacco burners which needs high amount of heat for long time.

4.3 Conservation status

The plant species used as a fuel wood in the study area were evaluated through field visits and literature survey regarding their conservation status. Some of the recorded plant species were in very critical stage. Burning wood species found in all sale points were assessed in the light of other studies conducted time to time in adjacent areas according to IUCN categories of threatened species.

4.3.1 Endangered species

According to IUCN (International Union of conservation of Natural Resources) different plant species used for fuel have become endangered. Some of endangered species of the study area are *Morus sp., Dodonaea viscosa* (*L.*) *Jacq.* (Khan and Hussain, 2013). and *Pinus roxburghii Sarg., Olea ferruginea Royle ,Robinia pseudo-acacia L., Alnus nitida, Celtis australis, Quercus incana* were also reported endangered species (Shah and Hussain 2012). *Populus alba, Pistacia integerrima* were also endangered species *(*Haq, 2012), *Quercus incana* was also counted to endangered species (Jan et al., 2014), whereas according to the study of Farooq et al., (2019) *Quercus incana* was found rare.

4.3.2 Critically endangered [s]pecies

Populus alba, Pistacia integerrima were declared critically endangered species (Haq, 2011, 2012*).*

4.3.3 Rare species

Acacia modesta was regarded as rare species (Khan and Hussain, 2013) followed by *Pinus roxburghii* (Jan et al., 2014). *Melia azedarach L., Morus spp L., Olea ferruginea* and *Dalbergii sisso* were also found rare species according to Khan et al. (2011).

4.3.4 Vulnerable plant species

Melia azedarach L. and *Dalbergii sisso* were vulnerable plant species (Khan and Hussain, 2013) followed by *Alienthus alticema* (Shah and Hussain, 2012). *Pistacia integerrima* was also observed as vulnerable plant species (Jan et al., 2014).

4.3.5 Infrequent plant species

Acacia modesta was found infrequent plant species according to Khan et al. (2011). The conservation status of these species clearly depicts their over exploitation and depletion alarmingly.

5 Conclusion

The findings of current study show that people rely mostly on fire wood for cooking and heating, The marketing of burning wood is an important socio economic activity of the area. In severe winter the use of fuel wood increases many folds for heating purposes. Likewise an huge amount of burning wood is used in tobacco processing in the area. The most preferred fuel wood species are *Acacia modesta, Olea ferruginea, Melia azedarach, Dalbergii sisso and Quercus incana* are extracted extensively from the surrounding forests thus disrupting the vegetation structure and dynamics. The fire wood flora faces threatening in its habitat. The wise management of fuel wood consumption is urgently required on scientific grounds. Fuel wood is not only a renewable resource of energy but also a mean of earning for rural population. Therefore, it should not be exhausted. This valuable ecosystem service should be regulated wisely for sustainable energy requirements. It is recommended that fuel wood species should be extracted from natural habitat on rotation basis keeping in view of their occurrence and regeneration potential so that ecosystems could continue to provide this service sustainably

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