Diversity and assessment of economic plants of Tehsil Takht Bhai, district Mardan, Pakistan

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Research

Abstract

Background: Plants play a vital role in the maintenance and economic development of an area. The current research work focuses on the investigation of economic tree species of Tehsil, Takht Bhai, and District Mardan.

Methods: For data collection different localities of Tehsil Takht Bhai were visited during 2021-2022. The plants were dried and identified with the help of Flora of Pakistan. Representative plant parts were mounted on herbarium sheets and submitted to herbarium of Center of Plant Biodiversity, University of Peshawar. The data for fuel wood was collected through standard procedures of ex-situ (artifact) and in-situ (inventory) methods. Wood depots, sawmills and farmers were visited, and information was collected from fruit markets, furniture industry, timber markets, and construction material owners through a questionnaire on the spot by interview method. The calorific value of fuel wood species was determined by Bomb Calorimeter.

Results: The plants were evaluated for their conservation status in which 7 spp. were exotic, 5 spp. were indigenous, 9 spp. were not evaluated, 2 spp. were of least concern and *Acacia nilotica* (L.) Willd. ex Delile was critically endangered. A total of 360000 mounds of fuel wood was sold out in summer season resulted into a revenue of PKR 241.2 million (m). The highest sale of 90000 mounds was recorded in case of *Populus euramericana* (Dode) Guinier, which generated 63 m of revenue. In winter season 438000 mounds of fuel wood was sold out that generated revenue of PKR 340.2 m. The highest sale of 105000 mounds was recorded in case of *P. euramericana*, which generated PKR 94.50 m of revenue. Maximum per annum revenue of PKR 157.50 m was generated from selling of *P. euramericana*. On priority basis, 50 % of the local people used *Acacia modesta* Wall. as fuel wood and 55 % of people used *Dalbergia sissoo* Roxb. ex DC. for furniture. The maximum income generated from fuel wood on basis of consumption priority was PKR 35.1 m and for furniture was PKR 33.66 m for these species respectively. It was also noted that *P. euramericana* was used for formation of pallets, which generates revenue of PKR 720 m per annum from 10 sites. Other economic uses include fodder (8 spp.), fruits (2 spp.), furniture (10 spp.), timber (10 spp.), constructional material (11 spp.), bed legs (7 spp.), chip boards (3 spp.), match industry (2 spp.), sport items (2 spp.), toothpicks (2 spp.), ice-cream sticks and pallets (1 sp.) each. The calorific value showed that *A. modesta* had highest value *i.e.,* 5500 kcal/kg while *Ailanthus altissima* (Mill.) Swingle had lowest value *i.e.,* 4400 kcal/kg. *P. euramericana* and *Eucalyptus camaldulensis* Dehn. were adopted by the locals as farm and agro forestry species.

Conclusion: From the current research, it was concluded that the inhabitants of the area rely heavily on plants for fuel wood as well as other economic purposes and also gain high revenue generation so sustainable use of plants should be made in order to support the socio-economic status of the local inhabitants.

Key words: Assessment, diversity, economic plants, fuel wood, Mardan, Pakistan, Takht Bhai.

Background

Plants play a vital role in the maintenance and economic development of an area (Hussain *et al*. 2012). From past studies, it was recorded that wood is the main source of energy which has been used for over 0.5 million years. Fuel wood is the only source in the rural areas used by the local people for cooking purposes, which has exerted pressure on the plant cover and ultimately caused deforestation in various parts of the world**.** The present study was carried out to explore the diversity and economic value of fuel wood and other economic species of the research area. The research was conducted on fuel wood and timber plant species of Kaghan Valley, Khyber Pakhtunkhwa, Pakistan and identified that 75 species including *Acacia modesta, Abies pindrow, Cedrus deodara, Pinus roxburghii, Pinus wallichiana, Populus alba, Quercus dialata, Quercus incana, Taxus fuana*, *Diospyros kaki, Malus pumila, Prunus domestica, Prunus armeniaca* and *Pyrus communis* (Jan *et al*. 2011). Following the same work, 112 plant species belonging to 97 genera and 51 families were identified from the study of flora and ethnobotany of Senhsa, District Kotli, Azad Jammu and Kashmir in which 56 species were herbs, 32 species were trees, 21 species were shrubs, and 3 species were climbers and the part of plant mostly used were leaves i.e. 77 species. These plants were used for different purposes such as fuel (24 spp.), fodder (53 spp.) and ornamental (14 spp.) (Ahmad *et al*. 2012). Another research was conducted about the wood of Utror and Gabral Valleys, Northern Pakistan and 27 plant species were reported which were used as fuel wood among which *Cedrus deodara, Quercus dilatata* and *Pinus wallichiana* were dominant species. It was also calculated that about 4809.86 tons of wood had been used for cooking and heating purposes (Hamayun *et al*. 2013). The ethnobotanical study of plant resources of Sheikh Maltoon, District Mardan, Pakistan identified 298 plant species. Of them 73 plant species were medicinal, 56 spp. were honeybee, 50 spp. were fodder and forage, 30 spp. were fuel wood, 20 spp. were vegetables, 19 spp. were for multi-purpose, 16 spp. were ornamental, 15 spp. were for thatching, 11 spp. were for fencing, and 8 spp. were used for making agricultural tools (Khan and Musharaf 2014). In addition 122 species were investigated from Tehsil Charbagh, Swat District, Khyber Pakhtunkhwa from its ethnobotanical study to show relation of plants with the local people of research area. Different uses of these plants were recorded including vegetable and food (25 spp.), fuel wood (26 spp.), furniture (18 spp.), fruit (17 spp.) and ornamental (10 spp.) (Khan *et al*. 2015). It was also investigated that how the plantations of *Eucalyptus* play an important role in the economy of local communities of District Malakand. *Eucalyptus* plantations provided benefits to the labor amounting PKR19451090/-, the grass production was increased, and the species were also used as fuel wood which had provided a great economic value to the local communities (Khan & Manan, 2016). The research was conducted on the ethnobotany and ecological characteristics of plant species of Tehsil Oghi, Mansehra, Pakistan. About 104 species were identified from the research area which were used as medicinal, 22 spp. as fruits, 37 spp. as fuel wood, 24 spp. as timber wood, 9 spp. as vegetables and 34 spp. as ornamental (Ahmed *et al*. 2018). The diversity and composition of indigenous tree species (*Pinus roxburghii* and *Acacia modesta*) at District Malakand, Pakistan showed that *Eucalyptus camaldulensis* and *Robinia pseudoacacia* are mostly grown in Pakistan because of their fast-growing rate which can add tremendous economic value to Pakistan (Khan & Ullah 2019). The consumption of fuel wood species and its effects on the vegetation of Baffa Town, Mansehra, Pakistan were studied which showed dominant fuel wood species of the area including *Acacia modesta*, *Melia azedarach* and *Olea ferruginea* (Khan *et al*. 2020). The consumption of fuel and timber wood species of District Charsadda, Pakistan reported that 17,280 tons of wood was harvested, and 15,307 tons of wood was consumed per year in the research area. *Morus nigra, Melia azedarach* and *Dodonaea viscosa* were reported as best fuel wood species and *Dalbergia sissoo*, *Morus alba* and *Melia azedarach* as best timber wood species (Shah *et al*. 2021). The main objective of this study was to investigate that how fuel wood species play a key role in supporting the livelihood of the local inhabitants.

Materials and Methods

Study Area

Tehsil Takht Bhai is a rural area which is located 15 Kilometers towards North of Mardan city, Khyber Pakhtunkhwa, Pakistan. The area is stretching from $34^{0}05/$ to $34^{0}32/$ latitudes and $71^{0}48/$ to $72^{0}25/$ longitudes, hence covering total area of 1632 Km^2. It is bounded by Buner District on North, Swabi District on East, Nowshera District on South and Charsadda District on West (Fig. 1). The research area has rich soil deposits supporting growth of diverse vegetables including tomato, okra, cucumber, apple gourd, bottle gourd, green chili and spinach, fruits including fig, orange, guava, strawberry, peach, pomegranate, apricot and cranberry and crops including wheat, maize, sugarcane, rice and tobacco. To the best of our abilities no published report was found on the present aspect of the tree species *i.e.*, (Ilyas *et al*. 2013, Shah *et al*. 2014, Khan & Badshah 2019, Khan and Ullah 2019, Khan *et al*. 2020, Ullah & Asad 2020, Parveen *et al*. 2021). The present study was carried out to explore the diversity and economic value of fuel wood and other economic species of the research area.

Climate

The climate is sub-humid, semi and sub-tropical which is extremely hot in summer (43.5 ^{0}C) and cold in winter (0.5 ^{0}C). Normally the rainy months are July, August, December and January, while maximum rainfall occurs in July and August. The maximum relative humidity is recorded in month of December *i.e.,* 73.33 %. The lowest elevation recorded is 350 m and the highest is 444 m asl (GoP, 2017).

Field visits, collection, identification, listing and mounting of plants

Field visits were arranged to different localities and thorough collection was made. The collected specimens were pressed in blotting paper and corrugated sheets were used to avoid fungal and insect attacks. The collected species were identified by authentic identification sources including fiscals of Flora of Pakistan *i.e.,* (Ali & Qaiser 1993-2021, Ali & Nasir 989-1991, Stewart, 1972, Nasir & Ali 1970-1989). A detailed checklist was prepared for all plant species belonging to different families. The plant species belonging to the same family were arranged alphabetically into genera and species in chronological order. Herbarium sheets of 11.5 x 16.6 inches size with a standard size label (2/3/4 x 4/1/4 inches) were used for mounting the leaves and the floral parts and the voucher specimens were deposited after assigning voucher numbers in the Center of Plant Biodiversity, University of Peshawar Herbarium (CPB).

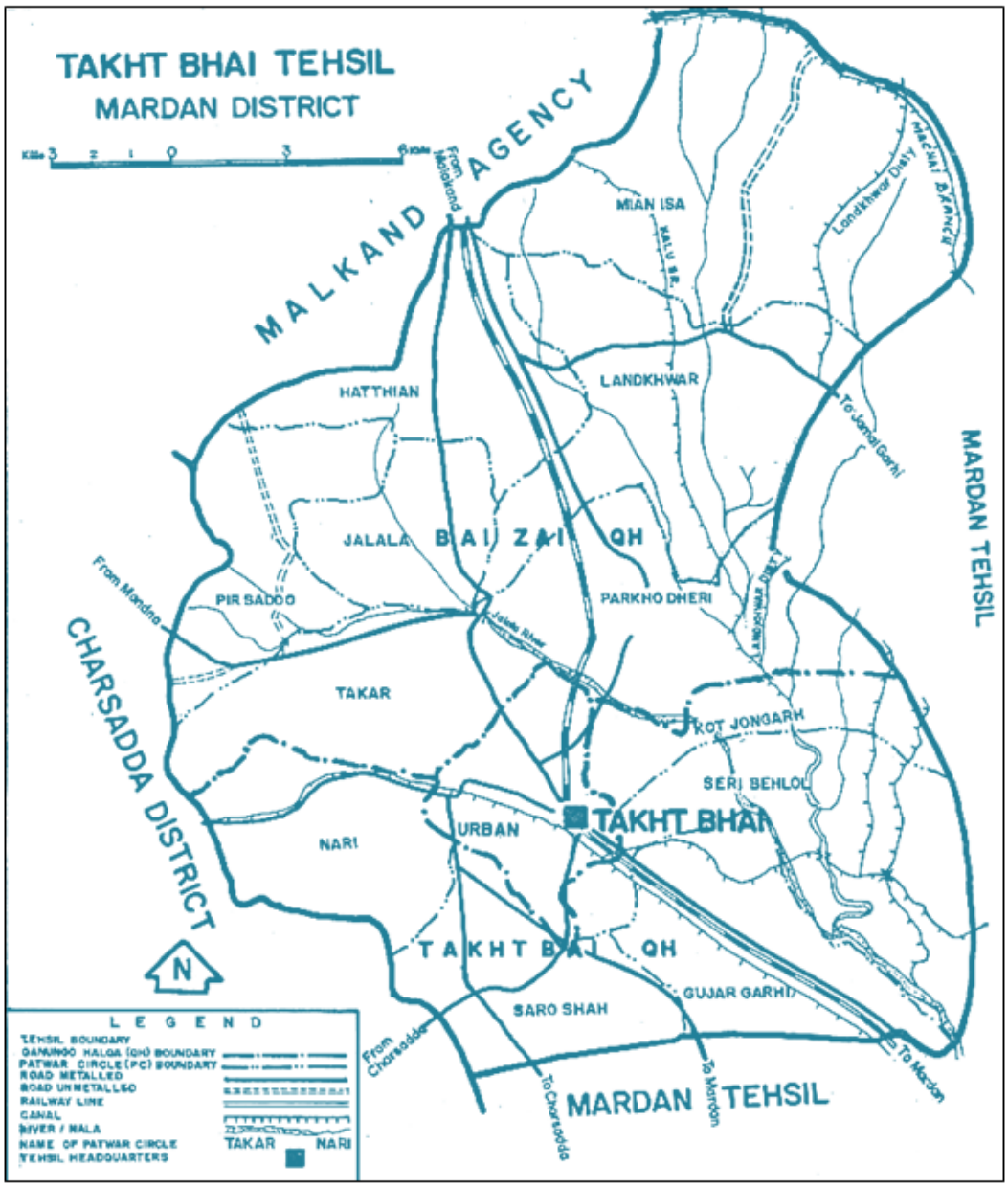

Figure 1. Map of the study area

Economic value assessment of fuel wood

For economic value assessment of fuel wood of Tehsil Takht Bhai, 10 localities including Takht Bhai Station, Fazal Abad, Gunjai, Sher Garh, Jalala, Jhandai, Seri Bahlol, Saro Shah, Hattian and Saleem Khan Kalay were visited. From each site, information was taken from at least 10 local people and the sampling size was 100. Respondents belonging to five age groups ranging from 20-30, 31-40, 41-50, 51-60 and 61 years and above were interviewed. The data was collected through the standard procedures of ex-situ (artifact) and in-situ (inventory) methods *i.e.,* (Stifhorn 1996-97, Ullah 2014, Ali & Qaiser 2009) were followed.

Fuelwood

Wood depots, sawmills and farmers were visited, and information was collected through a questionnaire on the spot by interview method. Data regarding rate per mound, sale per day, per week, per month and per annum for different species was investigated and noted. All the data collected from all the 10 localities was then interpreted accordingly. To ensure rational estimates, average rate was taken from each tree species.

Other Economic species

The data related to other economic uses of plants was collected by interviewing farmers and from fruit markets, furniture industry, timber markets, and construction material owners. The uses and economic assessment was noted as per information provided by the informants.

Determination of Calorific Value

Plant samples of all species under investigation were collected from 10 localities and were labeled. The collected samples were shifted to laboratory and were air dried. The dried samples were shifted to the Composite Wood Lab. of Pakistan Forest Institute (PFI), Peshawar, Pakistan and chips were prepared from these samples. The chips were converted into powder with the help of grinding machine (Thomas-Wiley Laboratory Mill Model 4, Made in USA). The powder of each plant was shifted for determination of the calorific value. Calorific value was determined with the help of Bomb Calorimeter (Parr Model C-6300) installed at Wood Mechanical Lab. of Forestry Product Research Division, Pakistan Forest Institute (PFI), Peshawar, Pakistan by the following formula (Gunther *et al.* 2012).

$$PCS = \frac{(C \cdot \mathbf{\Delta}T - b)}{m}$$

Where b = Qz + Qn + Qs

While b is the correction factor (Qz=energy released through ignition of wire and cotton thread. Qn= energy released during formation of Nitric Acid and Qs= energy released during formation of Sulphuric Acid from Sulphur and Nitrogen Oxides).

Results and Discussion

Diversity of fuel wood species

A total of 12 fuel wood species belonging to eight families and ten genera were reported from the research area. The dominant families were Fabaceae and Moraceae having two genera and three species each, while the rest of six families were presented by one genus and one species each. All the species collected were trees. The life form showed that 75% species were Megaphanerophytes and 25% were Mesophanerophytes (Table 1). The leaf size was dominated by Mesophylls with four species followed by Leptophylls and Microphylls with three species each and Macrophylls with two species (Table 1). The indigenous and exotic data showed that among the 12 species, seven were Exotic and five were Indigenous. The conservation status showed that nine species were Not Evaluated, two species were Least Count, and one species was Critically Endangered (Table 1).

Socioeconomic studies of fuel wood species for summer season

During summer season, the socio-economic studies of fuel wood species reported that the rate per mound was dominated by *D. sissoo* with PKR 850/- and the maximum number of mounds per day was 500 for *P. euramericana*. The number of mounds per 6 months was dominated by *P. euramericana* with 90000 mounds followed by *E. camaldulensis* with 72000 mounds and *D. sissoo* and *A. modesta* with 36000 mounds each. The data showed that the highest sale per day recorded for *P. euramericana i.e.,* PKR 350000/- followed by *E. camaldulensis* PKR 240000/- and *D. sissoo* PKR 170000/-. The total sale per 6 months showed that *P. euramericana* was pouring highest revenue *i.e.,* PKR 63.00 m followed by *E. camaldulensis* Dehn. PKR 43.20 m and *D. sissoo* PKR 30.60 m. (Table 2, Figs. 2 and 3).

Table 1. Family, scientific, local name, habit, life form, leaf size, indigenous, exotic and conservation status of fuel wood species

Family	Scientific name	Local name	Habit	Life form	Leaf size	Indigenous /Exotic	Conservation status	Vouch. Numbers
Fabaceae	*Acacia modesta* Wall.	Palosa	T	Mp	Lep	Ind.	NE	*S. Parveen* 1 (CPB)
	Acacia nilotica (L.) Willd. ex Delile	Kikar	T	Mp	Lep	Ind.	CR	*S. Parveen* 2 (CPB)
	Dalbergia sissoo Roxb. ex DC.	Shawa/Sheesham	T	Mp	Mic	Ind.	LC	*S. Parveen* 3 (CPB)
Malvaceae	*Bombax ceiba* L.	Sumbal	T	Mp	Mes	Exo.	NE	*S. Parveen* 4 (CPB)
Meliaceae	*Melia azedarach* L.	Toora shandai	T	Mesp	Mes	Exo.	NE	*S. Parveen* 5 (CPB)
Moraceae	*Broussonetia papyrifera* (L.) VeExo.	Gul tooth	T	Mp	Mes	Exo.	NE	*S. Parveen* 6 (CPB)
	Morus nigra L.	Toor tooth	T	Mp	Mac	Exo.	NE	*S. Parveen* 7 (CPB)
	Morus alba L.	Speen tooth	T	Mp	Mac	Ind.	NE	*S. Parveen* 8 (CPB)
Myrtaceae	*Eucalyptus camaldulensis* Dehn.	Lachi	T	Mp	Mic	Exo.	NE	*S. Parveen* 9 (CPB)
Salicaceae	*Populus euramericana* Guinier	Sufaida	T	Mesp	Mes	Exo.	LC	*S. Parveen* 10 (CPB)
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	Angreezi shandai	T	Mesp	Mic	Exo.	NE	*S. Parveen* 11 (CPB)
Tamaricaceae	*Tamarix aphylla* (L.) Karst.	Ghaz	T	Mp	Lep	Ind.	NE	*S. Parveen* 12 (CPB)

Key: T= Tree, Mp= Megaphanerophytes, Mesp = Mesophanerophytes, Lep = Leptophylls, Mes = Mesophylls, Mic = Microphylls, Mac = Macrophylls, Ind= Indigenous, Exo= Exotic, CR= Critically Endangered, LC= Least Count, NE= Not Evaluated

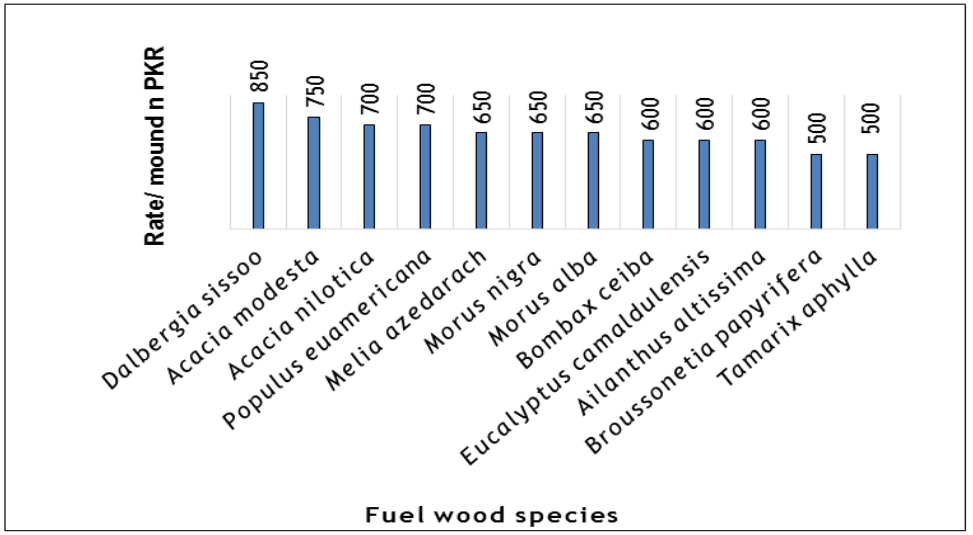

Figure 2. Rates per mounds of fuel wood species for summer.

Table 2. Summer season data including family, scientific name, local name, rate per mound, no. of mounds per day, no. of mounds per 6 months, sale per day, sale per week, sale per month and sale per 6 months.

Family/Scientific name	Local name	Rate per mound	No. of mounds/day	No. of mounds/ 6 months	Sale/day (in PKR)	Sale/ Week (in PKR)	Sale/month (in PKR)	Sale/6 months (m PKR)
Fabaceae *Acacia modesta* Wall.	Palosa	750	200	36000	150000	1050000	4500000	27.00
Acacia nilotica (L.) Willd. ex Delile	Kikar	700	50	9000	35000	245000	1050000	6.30
Dalbergia sissoo Roxb. ex DC.	Shawa/ Sheesham	850	200	36000	170000	1190000	5100000	30.60
Malvaceae *Bombax ceiba* L.	Sumbal	600	50	9000	30000	210000	900000	5.40
Meliaceae *Melia azedarach* L.	Toora shandai	650	100	18000	65000	455000	1950000	11.70
Moraceae *Broussonetia papyrifera* (L.) Vent.	Gul tooth	500	100	18000	50000	350000	1500000	9.00
Morus nigra L.	Toor tooth	650	150	27000	97500	682500	2925000	17.55
Morus alba L.	Speen tooth	650	150	27000	97500	682500	2925000	17.55
Myrtaceae *Eucalyptus camaldulensis* Dehn.	Lachi	600	400	72000	240000	1680000	7200000	43.20
Salicaceae *Populus euramericana* Guinier	Sufaida	700	500	90000	350000	2450000	10500000	63.00
Simaroubaceae *Ailanthus altissima* (Mill.) Swingle	Angreezi shandai	600	50	9000	30000	210000	900000	5.40
Tamaricaceae *Tamarix aphylla* (L.) Karst.	Ghaz	500	50	9000	25000	175000	750000	4.50

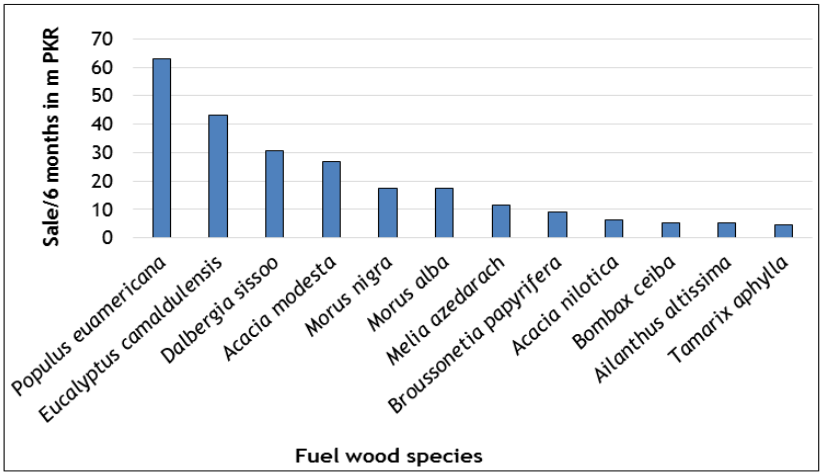

Figure 3. Sale per 6 months (m PKR of fuel wood species for summer.

Socioeconomic studies of fuel wood species for winter season

The socio-economic studies of fuel wood species in winter season reflected that *D. sissoo* had the highest rate per mound *i.e.,* PKR 850/- and the number of mounds of fuel wood species per day was dominated by *P. euramericana* which is 700 mounds. In addition the number of mounds of fuel wood species per 6 months were also calculated which was dominated by *P. euramericana i.e.,* 105000 mounds followed by *E. camaldulensis* 90000 mounds and *A. modesta* 54000 mounds. The highest sale per day of fuel wood was for *P. euramericana i.e.,* PKR 525000/- which was followed by *E. camaldulensis* PKR 420000/- and *A. modesta* PKR 240000/-. The total sale per 6 months was also calculated which was dominated by *P. euramericana i.e.,* PKR 94.50 million followed by *E. camaldulensis i.e.,* PKR 75.60 m and *A. modesta* PKR 43.20 m (Figs. 4 and 5, Table 3).

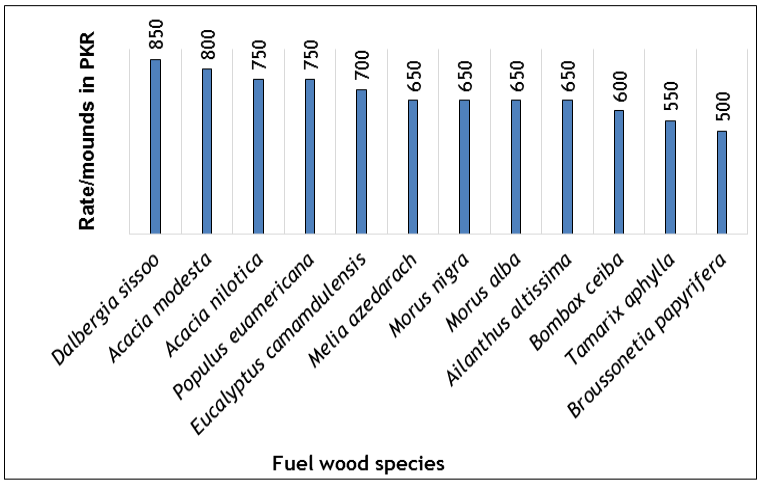

Figure 4. Rates per mound in PKR of fuel wood species in winter season.

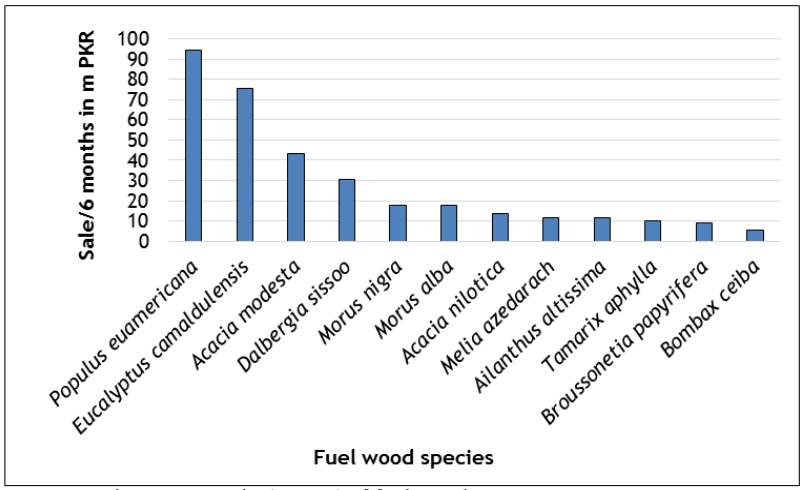

Figure 5. Sale per 6 months (m PKR) of fuel wood species in winter season.

Table 3. Winter season data including family, scientific name, local name, rate per mound, no. of mounds per day, no. of mounds per 6 months, sale per day, sale per week, sale per month and sale per annum.

Scientific name	Local name	Rate/mound	No. of mounds/day	No. of mounds/ 6 months	Sale/day (in PKR)	Sale/ Week (in PKR)	Sale/ month (in PKR)	Sale/6 months (m PKR)
Fabaceae *Acacia modesta* Wall.	Palosa	800	300	54000	240000	1680000	7200000	43.20
Acacia nilotica (L.) Willd. ex Delile	Kikar	750	100	18000	75000	525000	2250000	13.50
Dalbergia sissoo Roxb. ex DC.	Shawa/ Sheesham	850	200	36000	170000	1190000	5100000	30.60
Malvaceae ***Bombax*** *ceiba* L.	Sumbal	600	50	9000	30000	210000	900000	5.40
Meliaceae *Melia azedarach* L.	Toora shandai	650	100	18000	65000	455000	1950000	11.70
Moraceae *Broussonetia papyrifera* (L.) Vent.	Gul tooth	500	100	18000	50000	350000	1500000	9.00
Morus nigra L.	Toor tooth	650	150	27000	97500	682500	2925000	17.55
Morus alba L.	Speen tooth	650	150	27000	97500	682500	2925000	17.55
Myrtaceae *Eucalyptus camaldulensis* Dehn.	Lachi	700	600	90000	420000	2940000	12600000	75.60
Salicaceae *Populus euramericana* Guinier	Sufaida	750	700	105000	525000	3675000	15750000	94.50
Simaroubaceae *Ailanthus altissima* (Mill.) Swingle	Angreezi shandai	650	100	18000	65000	455000	1950000	11.70
Tamaricaceae *Tamarix aphylla* (L.) Karst.	Ghaz	550	100	18000	55000	385000	1650000	9.90

Fuel wood species for both summer and winter

When both the summer and winter data of fuel wood species was compared. It was observed that the sale of some fuel wood species increased in the winter season as compared with that of summer season which includes *A. modesta*, *A. nilotica* and *P. euramericana*, *E. camaldulensis*, *A. altissima* and *T. aphylla*. The maximum sale of fuel wood species per annum was dominated by *P. euramericana i.e.,* PKR 157.50 m followed by *E. camaldulensis* PKR 118.80 m and *A. modesta* PKR 70.20 m (Figs. 6 and 7, Table 4).

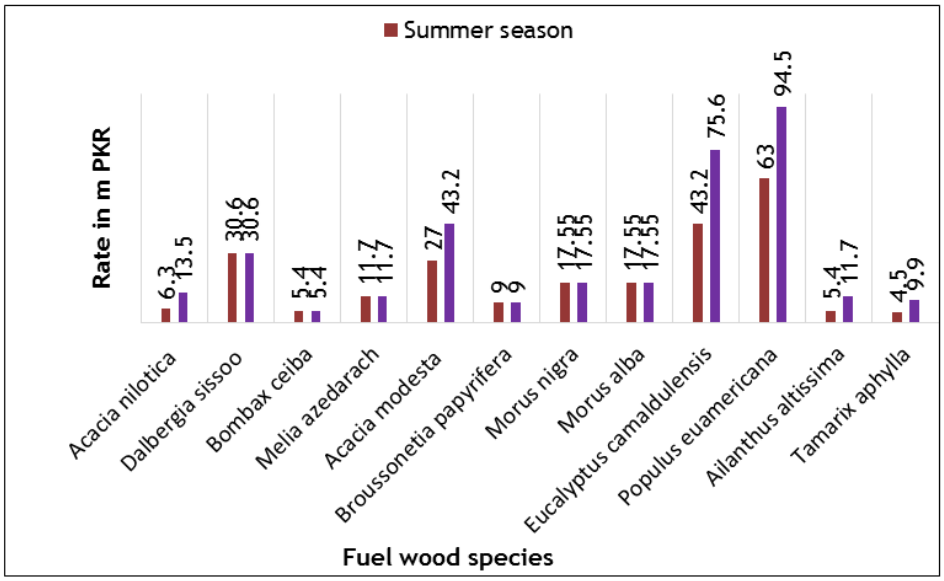

Figure 6. Rate comparisons of fuel wood species of both summer and winter season.

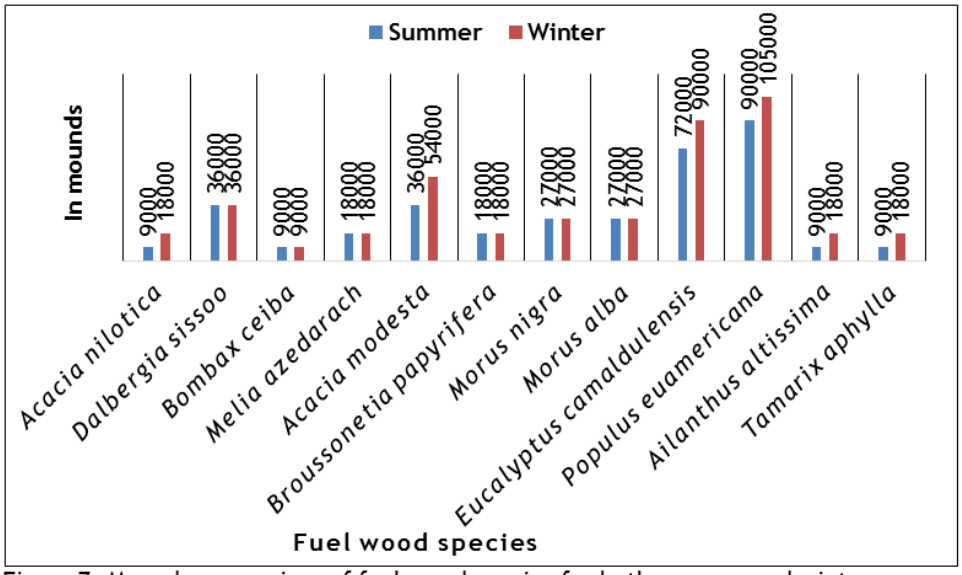

Figure 7. Mounds comparison of fuel wood species for both summer and winter season.

Economic uses of other economic plants

From the study it was concluded that out of total 12 species, 8 species were used as fodder, 2 spp. as fruits, 10 spp. as furniture, 10 spp. as timber and 11 spp. were used as construction material. In addition some other economic uses were also found which included bed legs (7 spp.), chip board industries (3 spp.), match industry (2 spp.), sport industries (2 spp.), Toothpicks (2 spp.), ice cream sticks (1 sp.) and pallets (1 sp.) (Table 5, Fig. 8).

Table 4. Combined data for summer and winter season including family, scientific name, local name, summer season data, winter season data and sale per annum.

Family	Scientific name	Local name	Summer season data	Winter season data	Sale/annum (m PKR)
Fabaceae	*Acacia modesta* Wall.	Palosa	27.00	43.20	70.20
	Acacia nilotica (L.) Willd. ex Delile	Kikar	6.30	13.50	19.80
	Dalbergia sissoo Roxb. ex DC.	Shawa/Sheesham	30.60	30.60	61.20
Malvaceae	*Bombax ceiba* L.	Sumbal	5.40	5.40	10.80
Meliaceae	*Melia azedarach* L.	Toora shandai	11.70	11.70	23.40
Moraceae	*Broussonetia papyrifera* (L.) Vent.	Gul tooth	9.00	9.00	18.00
	Morus nigra L.	Toor tooth	17.55	17.55	35.10
	Morus alba L.	Speen tooth	17.55	17.55	35.10
Myrtaceae	*Eucalyptus camaldulensis* Dehn.	Lachi	43.20	75.60	118.80
Salicaceae	*Populus euramericana* Guinier	Sufaida	63.00	94.50	157.50
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	Angreezi shandai	5.40	11.70	17.10
Tamaricaceae	*Tamarix aphylla* (L.) Karst.	Ghaz	4.50	9.90	14.40
	Total (m PKR)		241.2	340.2	581.4

Table 5. Family, scientific name, local name and other economic uses of species including fodder, fruit, furniture, timber and construction material

Family	Scientific name	Local name	Economic Uses					
			Fod	Fru	Fur	Tim	Con. Mat	O. uses
Fabaceae	*Acacia modesta* Wall.	Palosa	+	-	+	+	+	Agricultural implements, bed legs
	Acacia nilotica (L.) Willd. ex Delile	Kikar	-	-	+	+	+	Match industry, bed legs
	Dalbergia sissoo Roxb. ex DC.	Shawa/Sheesham	-	-	+	+	+	Beds, sport industries, toothpicks, Ice-cream sticks
Malvaceae	*Bombax ceiba* L.	Sumbal	-	-	-	-	+	Match industry
Meliaceae	*Melia azedarach* L.	Toora shandai	+	-	+	+	+	Bed legs
Moraceae	*Broussonetia papyrifera* (L.) Vent.	Gul tooth	+	-	+	+	+	Chip board industry
	Morus nigra L.	Toor tooth	+	+	+	+	+	Bed legs
	Morus alba L.	Speen tooth	+	+	+	+	+	For making baskets, bed legs
Myrtaceae	*Eucalyptus camaldulensis* Dehn.	Lachi	+	-	+	+	+	Toothpicks, chip industry, bed beams
Salicaceae	*Populus euramericana* Guinier	Sufaida	+	-	+	-	+	Pallets, bed beams
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	Angreezi shandai	+	-	+	+	+	Sports industries, chip industry
Tamaricaceae	*Tamarix aphylla* (L.) Karst.	Ghaz	-	-	-	+	-	-
		Total	8	2	10	10	11	

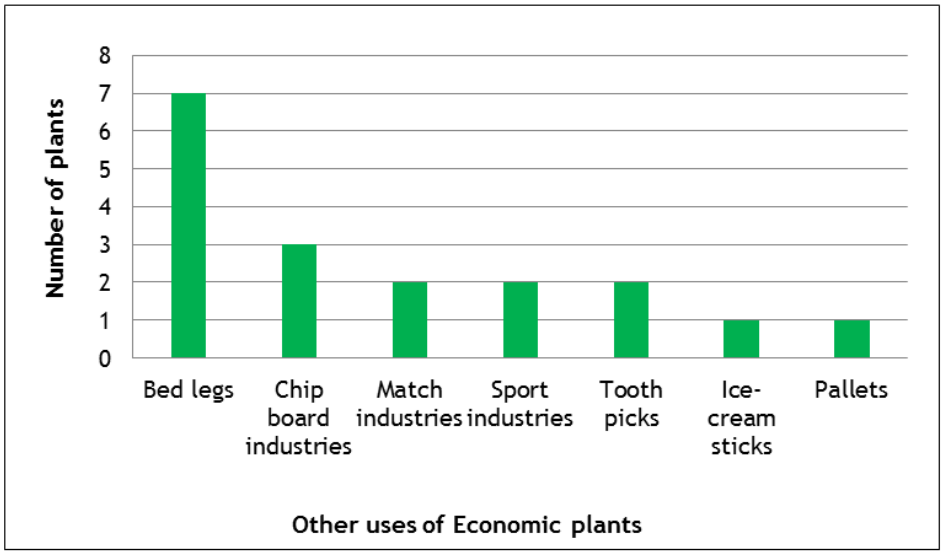

Figure 8. Other uses of economic plants.

Calorific values of fuel wood species

All plant species were evaluated for their calorific values. The highest calorific value was found for *A. modesta i.e.,* 5500 kcal/kg followed by *M. azedarach* 5100 kcal/kg, *P. euramericana* 5000 kcal/kg, *A. nilotica* and *D. sissoo* 4900 kcal/kg each, *T. aphylla* 4835 kcal/kg, *M. nigra* and *M. alba* 4770 kcal/kg each, *B. papyrifera* 4650 kcal/kg, *B. ceiba* 4500 kcal/kg, *E. camaldulensis* 4425 kcal/kg and *A. altissima* 4400 kcal/kg (Fig. 9, Table 6).

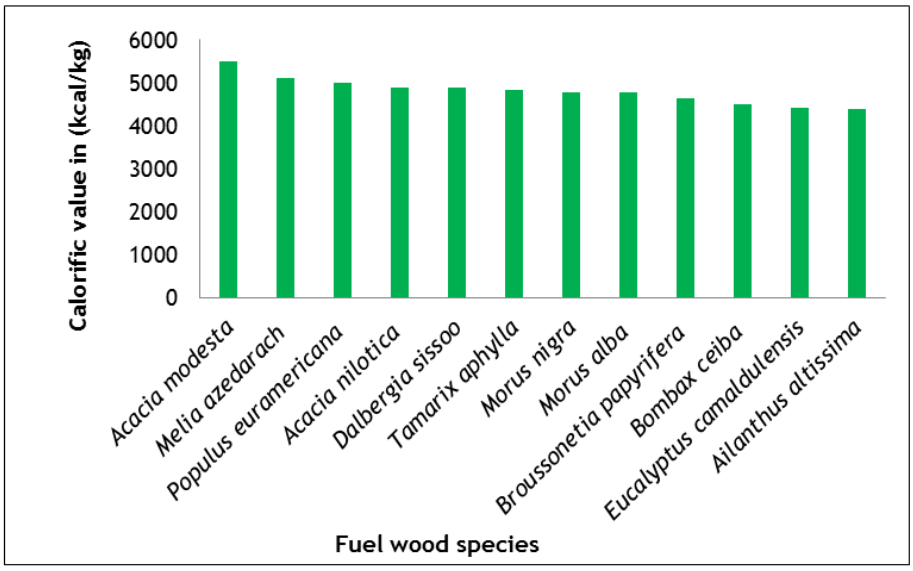

Figure 9. Calorific value of fuel wood species.

Fuel wood consumption priority and price pattern

The consumption priority of fuel wood species was also investigated from the local inhabitants of the research area. The data showed that 50 % of the local people give priority to *A. modesta*. On the basis of consumption priority the maximum price was recorded for *A. modesta* PKR 35.1 m followed by *P. euramericana* PKR 7.87 m and *E. camaldulensis* PKR 5.94 m.

Furniture use-age priority and price pattern

The study of plant species which were given more priority by local people of the research area for furniture use was also conducted. From this study it was concluded that mostly *D. sissoo* was given importance for furniture use *i.e.,* 55 %. The price pattern on the basis of use-age was dominated by *D. sissoo i.e.,* PKR 33.66 m followed by *P. euramericana* PKR 15.75 m and *E. camaldulensis* PKR 11.88 m (Fig. 10).

Table 6. Calorific value of fuel wood species growing in the research area

Botanical name/family	Local name	Calorific value (in kcal/kg)
Fabaceae *Acacia modesta* Wall.	Palosa	5500
Acacia nilotica (L.) Willd. ex Delile	Kikar	4900
Dalbergia sissoo Roxb. ex DC.	Shawa/sheesham	4900
Simaroubaceae *Ailanthus altissima* (Mill.) Swingle	Angreezi shandai	4400
Malvaceae *Bombax ceiba* L.	Sumbal	4500
Myrtaceae *Eucalyptus camaldulensis* Dehn.	Lachi	4425
Meliaceae *Melia azedarach* L.	Toora shandai	5100
Moraceae *Morus alba* L.	Speen tooth	4770
Morus nigra L.	Toor tooth	4770
Broussonetia papyrifera (L.) Vent.	Gul tooth	4650
Salicaceae *Populus euramericana* Guinier	Sufaida	5000
Tamaricaceae *Tamarix aphylla* (L.) Karst.	Ghaz	4835

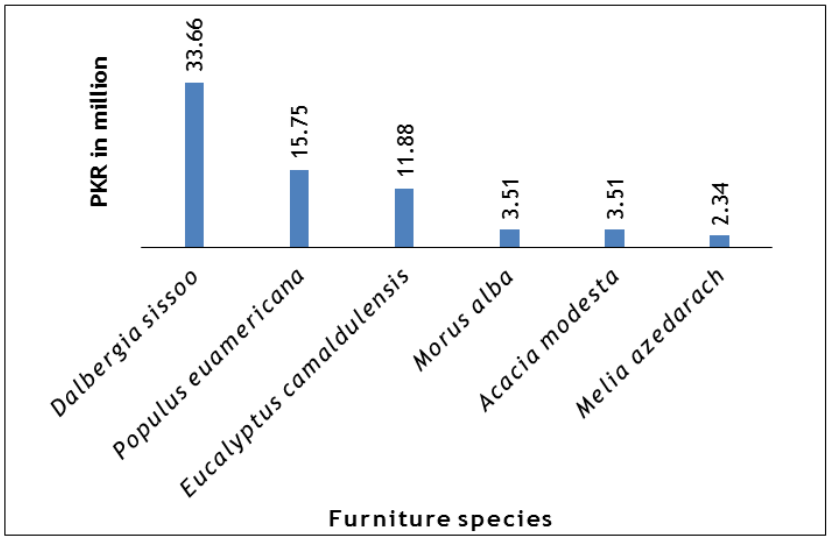

Figure 10. Price pattern of furniture species on priority basis.

Export chain of pallets

In present research study, it was noted that one of the important commercial product is pallets preparation from *P. euramericana*, which is transported to Karachi and Quetta and then exported to various countries including Canada, Africa, UK, UAE and Australia that attract foreign exchange. The total revenue generated from pallets exports at 10 sites was PKR 720 m (Fig. 11). Some other studies were also conducted to show the importance of fuel wood. The findings of current study are supported by that of Ullah *et al.* (2020) as they also observed that the fuel wood species can be helpful to improve the socio-economic life of the people and also its consumption for other purposes such as for making furniture, chip boards, construction and for ornamental purposes. Some of the species are also used as fodder and timber. The economic importance of fuel wood species showed that the highest sale per annum was for *P. euramericana*, *E. camaldulensis* and *A. modesta.* Previously, the flora of Baffa Town at Mansehra was studied which reported 22 fuel wood species and the maximum price was recorded for *A. modesta*, *M. azedarach* and *Olea ferruginea* (Khan *et al.* 2020). It was also found that 30000 mounds of wood were sold per annum from 3 sale points. The consumption of wood species of District Charsadda also showed the dominant fuel wood species *i.e., M. nigra, M. azedarach* and *D. viscosa* and timber wood species were *D. sissoo*, *M. alba* and *M. azedarach* (Shah *et al.* 2021).

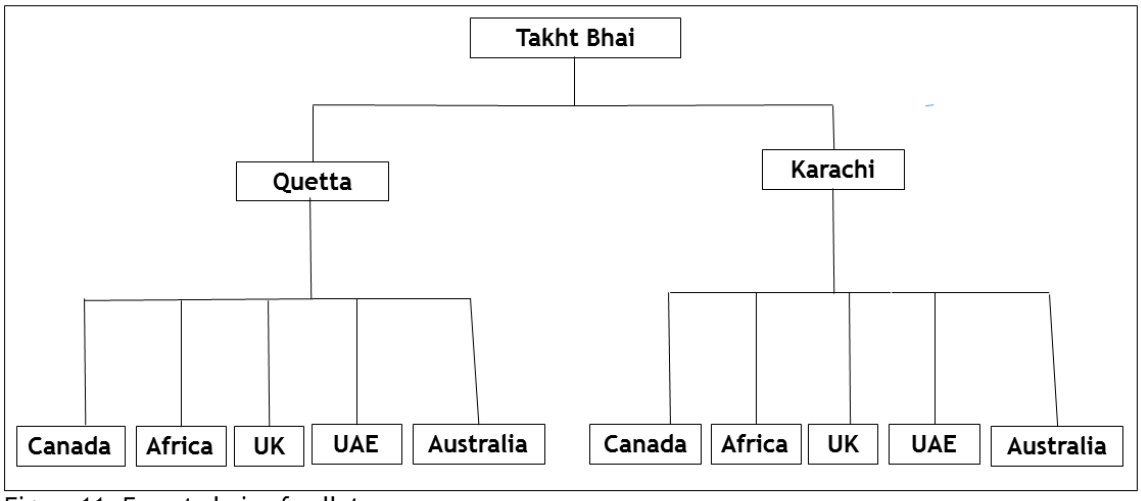

Figure 11. Export chain of pallets.

The data of fuel wood species was recorded for both summer and winter season. The results of both seasons were compared which shows that some fuel wood species rates become maximum in winter than in summer season. Major part of the research area is rural and in very few areas natural gas facility is available and even at many places there is no natural gas. Due to gas load shedding and shortage of LPG in winter season the fuel wood consumption at rural as well as urban areas become more that's why the demand for fuel wood increase in winter. Due to these reasons the fuel wood sales become maximum in winter as compared to summer season. In the current study, it was also observed that fuel wood species and species used for furniture were given more priority. It was concluded that *A. modesta* was the fuel wood specie which was given more priority by local people because its calorific value was high as compared to other fuel wood species. Since it generates more energy, so it can be easily utilized for cooking and heating purposes. As there is more demand of this species, it can generate more income. On the other hand, for furniture use the species *i.e., D. sissoo* was given priority and it was sold in high quantity so resulted in more income. It is because that the wood of this species is hard and can survive for several generations. Also it has reasonable price, so the local people of the area can easily purchase it. Because of hardness of this wood, it can be given different shades, and also it can be protected from termites.

The calorific value of the fuel wood species was calculated which showed that highest calorific value was found for *A. modesta*. The properties including anatomical, mechanical and physical of tree species of Punjab were studied by Mahmood *et al.* (2016) in which calorific value was calculated with the help of bomb calorimeter. The results showed that *E. camaldulensis* had the highest calorific value *i.e.,* 4900 kcal/kg (Mahmood *et al.* 2016). Following the same work, another research was also made on *E. camaldulensis* for its energy purposes which also showed that it has high calorific value *i.e.,* 4900 kcal/kg (Butt *et al.* 2022). The calorific value of the fuel wood species is very important because it helps in identification of the best quality species use as a fuel. The fuel wood species with maximum calorific value can be considered best for fuel wood purpose. Information will be provided to the local people for more plantations of such species, resultantly it will enhance socio-economic condition of the people of the area. During field visits and data collection it was observed that due to its fast growth and market value some species are specifically adopted for commercial growth purpose. The major species used for this purpose are *P. euramericana* and *E. camaldulensis*. The local inhabitants have adopted these species for farm and agro -forestry. Both the species are used for farm as well as agro-forestry. The locals have adopted *Populus* for this purpose as a priority and about 60% local people cultivate this species for farm and agro-forestry purposes. While the *Eucalyptus* has been adopted as a second priority for this purpose and about 40% people cultivate this species for farm and agro-forestry. It has been noticed that the farm forestry has created a pressure on the cultivated fertile land and major portion of agricultural land has been converted into farm forestry. Farm forestry has resulted into severe introduction and adoption of these exotic species, which has replaced the local flora and also squeezed the agricultural land to a considerable area beside its fast growth and economic value, these species, have issues related to biodiversity and conservation.

Conclusion and Recommendations

It was concluded that 12 species were used by the inhabitants of the area for fuel wood purpose. All these species generate huge revenue amounting to PKR 581.4 m per annum to support livelihood of local residents and provide employment opportunities for people. These species are used for furniture, fodder, fruits, timber, construction

material, bed legs, chip boards, sport items, toothpicks, ice cream sticks and pallets. Pallets were prepared from *P. euramericana* and exported to various countries and a huge foreign exchange amounting to PKR 720 m per annum is generated. The fuel wood species are exploited on the basis of their calorific values and *A. modesta* was the most preferred fuel wood species. *D. sissoo* is under severe exploitation for making furniture. Due to its high economic value, fast growth and requirement of less care and labor for the growth, the inhabitants of the research area have adopted *P. euramericana* and *E. camaldulensis* for agro- and farm-forestry purposes. This practice has resulted into conversion of fertile agricultural land into farm-forestry. The Conservation status showed that one species *i.e., A. nilotica* was critically endangered, while seven species were exotic and five were indigenous. The local inhabitants are not aware about the importance and sustainable utilization of the fuel wood and other economic species due to which the number of indigenous plants are decreased with a reckless rate in the recent decades. It was recommended that the area has rich diversity of fuel wood and other economic plants, which needs proper and sustainable utilization. Local industries must be established, and pallets export must be encouraged. Due to its fuel wood role *A. modesta* regeneration and plantation must be ensured. The mass level plantation of *D. sissoo* must be carried out and this species must be adopted as an industrial species. Furniture industries must be established at the research area, which will provide job opportunities to the local residents. While adopting *P. euramericana* and *E. camaldulensis* for agro- and farm-forestry care must be taken that these species may not invade or replace the local flora and fertile agricultural land. The critically endangered species *A. nilotica* must be conserved by the active role of researchers and government officials. Community Based Organizations (CBOs) must be established and be involved in awareness campaigns of inhabitants regarding the importance of fuel wood and economic plants.

Declarations

List of abbreviations: T-Tree, Mp-Megaphanerophytes, Mesp- Mesophanerophytes, Lep- Leptophylls, Mes- Mesophylls, Mic- Microphylls, Mac-Macrophylls, Ind- Indigenous, Exo- Exotic, CR- Critically Endangered, LC- Least Count, NE- Not Evaluated, Fod- Fodder, F- Fruit, Fur- Furniture, Tim- Timber, Con. Mat- Construction material, += Yes, - = No.

Ethics approval and consent to participate: Before taking the interview, the consent of the interviewees was taken and after that the interviews were conducted.

Availability of data and materials: The plants were collected, dried, identified and mounted on the herbarium sheets and were deposited in the Herbarium of Center of Plant Biodiversity, University of Peshawar (CPB).

Competing interests: No competing interests.

Funding: No funding was used for this research.

Author's contribution: Sadia Parveen conducted field visits to the research area for collection of plants, data collection, wrote first draft of paper and performed lab. work. Asad Ullah selected the research topic, carried out identification of plants, sorted the paper and made typographic corrections.

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